FRONTEX
EUROPEAN BORDER AND COAST GUARD AGENCY

FROM LAB TO FIELD:

Challenges and Opportunities for Operationalising Border Security Research

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Challenges and Opportunities for Operationalising Border Security Research

Executive Summary

This study examines how border security research is set up, managed and operationalised in and beyond Europe

Today, the European Union (EU) faces a range of pressures on its external and internal borders. Research and innovation (R&I) can help border guards ('end users') understand and respond to these threats, which include illegal border-crossings, people-smuggling activities, weapons smuggling, trafficking in human beings (THB) and terrorism. A number of R&I funding mechanisms (such as the Horizon 2020 (H2020) programme) support border security policy priorities at the EU level,[1] and an important part of Frontex's mandate involves monitoring and contributing to research developments.

Despite the millions of euros invested in EU border security each year, challenges remain in translating R&I into operational practice. There is already evidence to suggest that the 'pull-through' of research can be difficult, given that research providers often lack understanding of the operational context and long-term research can lose its relevance over time. Given these challenges, Frontex is interested in developing a better understanding of how border security is set up, managed and operationalised within and beyond Europe, with a view to exploring how these processes could be improved in the EU.

To support this overarching objective, Frontex commissioned a study to look at the following research questions (RQs):

- **RQ1:** How is R&I in the area of border security set up, conducted and operationalised by EU organisations and Member States (MS)?
- **RQ2:** What approaches are used in the United States (US), Canada and Australia to fund and apply research in this area?[2]
- **RQ3:** What 'good practices' from these different approaches could be incorporated into the EU approach?

The study team used two main methods to address these research questions: case studies (drawing on literature reviews, research interviews and surveys) and workshops. To address RQ1–2, a first set of case studies focused on good practices and challenges in relation to border security research in the EU, the US, Canada and Australia, and (to a lesser extent) in Turkey, Egypt, Morocco and Tunisia. Based on this preliminary investigation, we conducted a more in-depth analysis of functional roles in R&I to address RQ3. To do this, a second set of case studies was undertaken, focusing on six organisations: the European Space Agency (ESA), the European Institute of Innovation & Technology (EIT), US Defense Innovation Unit – Experimental (DIUx), the US Department of Homeland Security (DHS) Small Business Innovation Research (SBIR), the US Homeland Security Innovation Programs (HSIP), and US Centers of Excellence (COEs).

Complementing the case study analysis and in support of RQ3, the study team held an external stakeholder workshop in order to analyse the different types of functional role that Frontex could play to support the operationalisation of border security research. Three internal analysis workshops were also held with a RAND Experts Group in order to develop and refine a 'research and innovation pathway' designed to map the processes that link border security research and its implementation by border guards.

1 European Union (2015), European Commission (2015e).

2 At the client's request, the study analysis focuses on the EU, US, Canada, Australia and – to a lesser extent – on Turkey and three North African countries: Egypt, Morocco and Tunisia.

A 'research and innovation pathway' is used to frame the study analysis

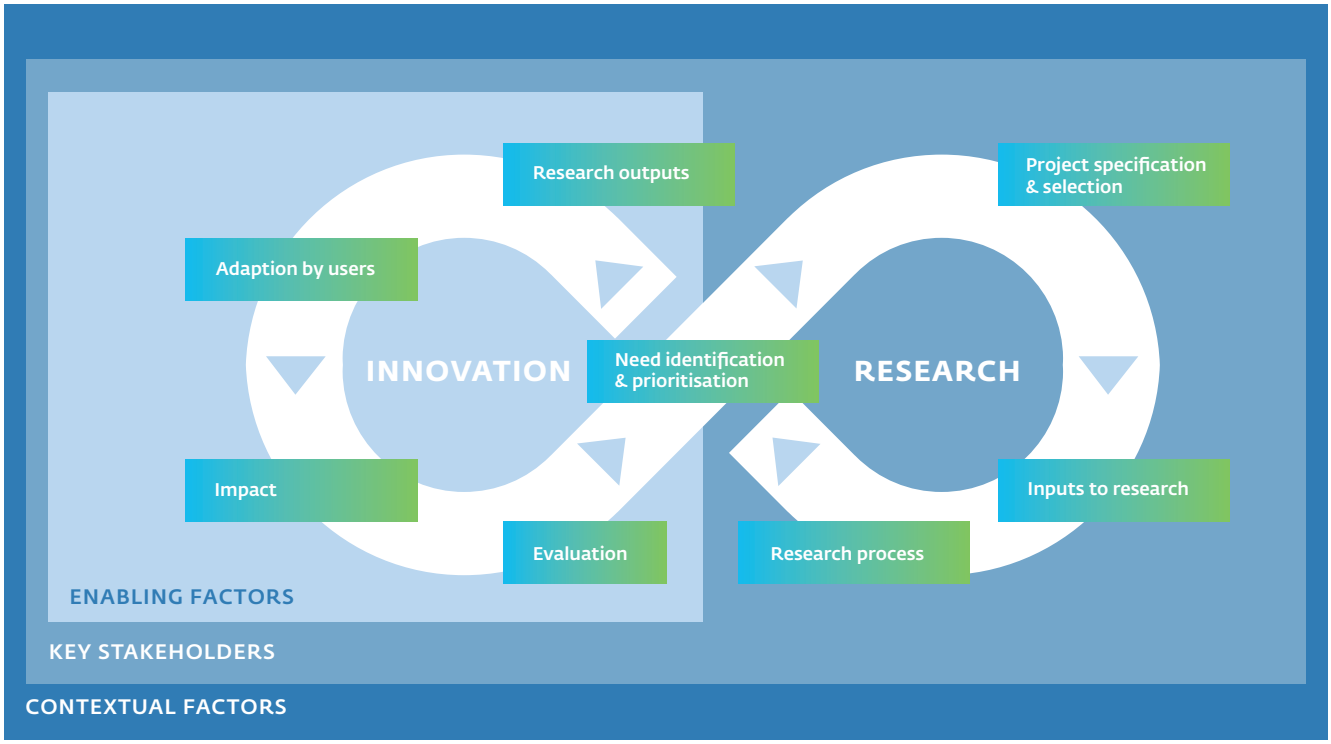
In relation to research and innovation, a series of sequential steps can be identified that connect the identification of a capability gap to the adoption of a solution by end users. As part of this study, a research and innovation pathway was developed which draws on existing literature on research and innovation but is intended to be specific to the situation and needs of Frontex (see Figure 1 below).

Several steps follow the identification of a need to form a 'research and innovation pathway'. These include:

- **Project specification and selection:** the creation of technical specifications for research and selection of suppliers;
- **Inputs to research:** the components that provide a basis for the research process (e.g. funding, personnel);
- **Research processes:** all activities related to research dlivery;
- **Research outputs:** products that result from project activities (e.g. toolkits, technologies/prototypes);
- **Adoption by end users:** integration of research outputs into operational practice;
- **Impact:** the extent to which research improves operational practice, enhances understanding of policy issues and builds capacity; and
- **Evaluation:** identifying gaps and restarts the cycle described in the steps above.

As Figure 1 shows, research and innovation do not happen in a vacuum: these processes are shaped by key stakeholders (including policy makers, research providers and end users), by drivers of innovation, and by the wider political, technological and social environment in which they take place.

Figure 1 **The research and innovation pathway**



Source: RAND Europe analysis.

The case studies highlight good practices and challenges for R&I

Based on the case studies, the report identifies good practices that relate to both the 'research' and 'innovation' parts of the R&I pathway. These are:

- **End user involvement:** Engaging end users in research planning and delivery can help ensure that operational requirements inform funding allocation and research prioritisation. This can lead to their successful uptake in the field. *Case study examples: EU, Canada, ESA.*
- **Engagement with leadership:** Involving senior representatives of border guard agencies and government departments in research processes can help strengthen the profile of border security research, signalling senior commitment. *Case study example: Australia.*
- **Flexible funding models:** To remain adaptable to changing threats and operational requirements, more agile funding models can help ensure that research is responsive to emerging issues and continues to have practical value for end users. *Case study examples: EU, Australia, DIUx.*
- **Coordinated research processes:** Having a centralised entity or set of processes aimed at coordinating research efforts can help avoid duplication of effort, as well as supporting situational awareness of ongoing border security research activities. *Case study example: US.*
- **Networks of industry and research experts:** Engagement between industry and academic stakeholders can support the development of R&I solutions with practical value, leveraging both research expertise and technology development knowledge. *Case study examples: SBIR, COE, EIT.*
- **Evaluation of research processes:** Regular monitoring and evaluating of existing research processes can ensure that they remain fit for purpose over time. *Case study examples: EU, US.*

While the case studies highlight areas of good practice for R&I, various challenges can also be identified:

- **Poorly defined 'impact' criteria:** While a central objective of research programmes across the case study countries is to achieve research impact, 'impact' is often poorly defined and lacks a clear set of assessment criteria. *Case study example: EU.*
- **Disconnect between research and operational practice:** Despite ongoing efforts to strengthen links between border security research and operational practice, not all research products are successfully translated into operational practice. *Case study example: EU.*
- **Lack of end user interest in research:** Despite improvements in engaging end users in research, in some cases end users' unfamiliarity with financial rules, intermittent project engagement and lack of research engagement remain areas for improvement. *Case study examples: EU, Turkey.*
- **Poor information exchange:** While a good understanding of the links between stakeholder networks and research results is important, challenges remain in disseminating this information due to, for example, shortcomings in interagency cooperation. *Case study example: ESA.*
- **Intellectual Property (IP) constraints:** When project IP rights remain with developers in the EU, this can make it difficult for research products to be applied in practice by border guards. *Case study examples: US, EU.*
- **Lack of available resources:** A shortage of funding and personnel for operationalising research activities is a constraint affecting several case study countries and regions. To obtain available funding, it is important to demonstrate the value of research through, for example, securing the buy-in of senior 'champions' within relevant agencies. *Case study examples: EU, Canada.*

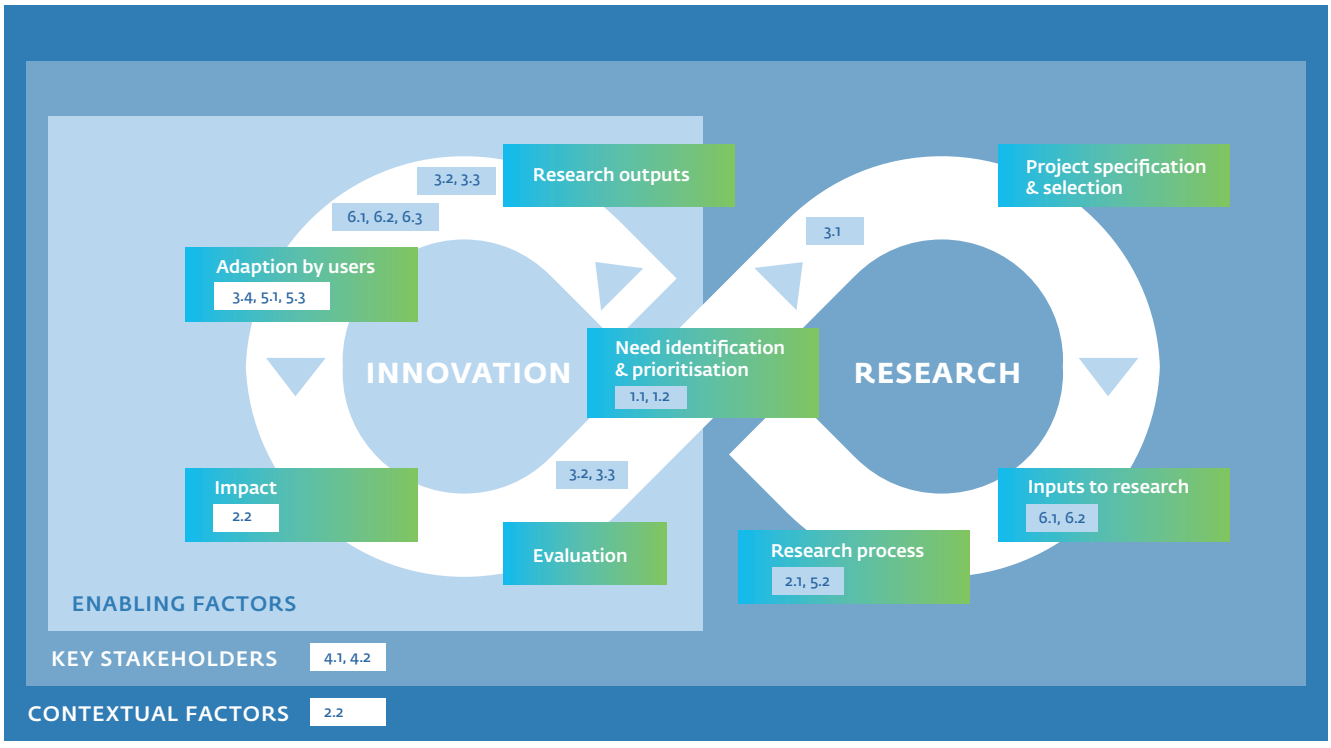
Organisations can adopt various functional roles across the R&I pathway

Following the scoping of good practices and challenges, we conducted a more in-depth analysis of R&I functional roles, drawing on all the case studies conducted, in order to inform a set of recommendations for Frontex. The roles identified include:

- Coordinating requirement identification and setting:
  - Role 1.1: Performing horizon scanning to identify threats and innovation opportunities
  - Role 1.2: Analysing the operational needs of end users.
- Providing thought leadership:
  - Role 2.1: Conducting research in house
  - Role 2.2: Influencing policy developments.
- Facilitating information provision and knowledge transfer:
  - Role 3.1: Centralising information on R&I opportunities
  - Role 3.2: Sharing information on operational impacts of research
  - Role 3.3: Facilitating knowledge transfer
  - Role 3.4: Delivering training and education for end users.
- Providing an 'honest broker' function:
  - Role 4.1: Facilitating cooperation between industry, academia and practitioners
  - Role 4.2: Supporting coordination between industry, academia, nations and investors.
- Hosting innovation:
  - Role 5.1: Running technology demonstrations
  - Role 5.2: Running prize competitions or 'grand challenges'
  - Role 5.3: Launching an innovation incubator.
- Facilitating access to funding:
  - Role 6.1: Providing direct R&I funding
  - Role 6.2: Facilitating access to available funding instruments
  - Role 6.3: Using procurements to 'pull' innovative solutions from the market.

Mapping the roles described above onto the research and innovation pathway (see Figure 2 below) shows that most are enablers or connectors between the different steps of the pathway. Some activities appear in multiple locations: for example, direct funding could be provided for the research itself or to support operationalisation of research outputs by sponsoring capability demonstrations.

Figure 2 **Functional roles and the research and innovation pathway**



Source: RAND Europe analysis.

This report presents a set of recommended interventions for Frontex

The study leverages findings on good practices, challenges and the functional roles played by other organisations to generate three overarching recommendations, each of which suggests a number of interventions which could be undertaken by Frontex. Drawing on the study findings, these interventions are designed to assist Frontex in developing new solutions or expanding existing initiatives for the setup, management and operationalisation of border security research. These recommendations and interventions are listed in Table 1, along with supporting activities for Frontex and relevant examples from the study analysis. Chapter 5 outlines further practical considerations relating to key actors, benefits, risks, time and cost.

Table 1 **Recommended interventions for Frontex**

Recommendation 1:	
Frontex should facilitate access to information, knowledge and networks for relevant national and EU institutions, industry, academia and investors	
Intervention 1.1: Creating a centralised repository of information on research, funding opportunities and successful implementation of outputs.	**Supporting activities:** ■ (Further) developing a web platform (e.g. Border Tech-Net – BTN) ■ Preparing analysis briefs on R&I activities for MS ■ Creating an online discussion forum for R&I providers and recipients ■ Facilitating access to a centralised contact book of border security R&I experts. **Relevant examples:** Frontex BTN, ESA web portal.
Intervention 1.2: Systematically capturing lessons identified to inform the future setup, management and operationalisation of research projects.	**Supporting activities:** ■ Introducing a requirement for project teams to submit electronic project evaluation forms ■ Discussing lessons internally every 6 or 12 months to identify areas for improvement ■ Championing a wider 'lessons learned' R&I initiative (e.g. annual conference) with other EU institutions. **Relevant examples:** NATO Lessons Learned Portal.
Intervention 1.3: Brokering connections between R&I providers and recipients.	**Supporting activities:** ■ Creating a form of 'industry advisory group' ■ Leveraging networks, communities and centres already established by other EU agencies ■ Establishing a Frontex-led network of COEs. **Relevant examples:** NATO Industrial Advisory Group, ESA network of business incubation centres, US COE.
Recommendation 2:	
Frontex should establish mechanisms to ensure that research projects are designed, selected and implemented to be relevant for identified operational needs	
Intervention 2.1: Systematically collecting information on border security technology development.	**Supporting activities:** ■ Setting up an internal horizon-scanning function that produces a quarterly 'key trends' document ■ Leveraging wider EU horizon-scanning activities by partnering with other institutions ■ Requesting that MS with horizon-scanning experience share outputs that Frontex can combine and circulate to its stakeholder community ■ Commissioning a horizon-scanning provider to produce a quarterly or biannual analysis. **Relevant examples:** DHS Science & Technology directorate (S&T).
Intervention 2.2: Centralising information on national operational requirements to support harmonisation.	**Supporting activities:** ■ Requesting that MS share information on national operational requirements ■ Sharing a list of aggregated requirements (cleared of any sensitive information) through, for example, a restricted area of BTN ■ Performing high-level market analysis to identify existing solutions and sharing with MS ■ Connecting MS with shared requirements so they can consider joint procurement. **Relevant examples**: DHS Science and Technology Resource Allocation Strategy (STRAS), USCG Idea Submission Review.
Intervention 2.3: Adopting a 'research champion' role to inform policy and decision making in EU institutions.	**Supporting activities:** ■ Using business cases to present recommendations for border security research prioritisation at the EU level ■ Engaging with EU institutions to collect information on ongoing research and funding ■ Feeding this information back through a regular publication or a centralised webpage. **Relevant examples:** Frontex BTN, US Defense Innovation Board.
Intervention 2.4: Integrating traditional research selection processes with innovative approaches.	**Supporting activities:** ■ Implementing (i) more traditional public procurement procedures; and (ii) alternative processes like prizes, grants and challenges in accordance with existing regulations. **Relevant examples**: EIT annual 'EIT Awards', US Defense Advanced Research Projects Agency (DARPA) Grand Challenges.
Recommendation 3:	
Frontex should facilitate the uptake and operationalisation of research outputs by end users	
Intervention 3.1: Establishing mechanisms for maintaining continuous engagement of end users.	**Supporting activities:** ■ Creating cross-organisational project teams involving, for example, one manager from Frontex, a border guard representative and the contractor ■ Involving end users in technology demonstrations to test systems or to demonstrate the added value of research outputs ■ Sponsoring pilot programmes designed to demonstrate the benefit of new R&I solutions. **Relevant examples:** DHS S&T Integrated Product Teams, SBIR technology demonstrations, H2020 technology demonstrations.
Intervention 3.2: Facilitating access to funding for the commercialisation of research outputs.	**Supporting activities:** ■ Providing direct funding for the commercialisation of technology (e.g. through Public Procurement of Innovative Solutions, Pre-Commercial Procurement) ■ Sharing information on available EU funding instruments ■ Offering a quality assurance process for business cases and research proposals aimed at further developing R&I solutions ■ (Further) building connections with investors. **Relevant examples:** US HSIP programme events and industry days, EIT Knowledge and Innovation Communities.

Challenges and Opportunities for Operationalising Border Security Research

Final Report

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Abbreviations

BIC	Business Incubation Centre
bn	Billion
BTI	Borders, Trade and Immigration Institute
BTN	Border Tech-Net
CBSA	Canada Border Service Agency
CG-STIC	USCG S&T Transition and Innovation Center
COE	Centre of Excellence
COSME	Competitiveness of Enterprises and SMEs
CSS	Centre for Security Science
DARPA	Defense Advanced Projects Research Agency
DeVenCI	Defence Venture Catalyst Initiative
DHS	Department of Homeland Security
DHS SBIR	Department of Homeland Security Small Business Innovation Research
DIBP	Department of Immigration and Border Protection
DIUx	Defense Innovation Unit – Experimental
DoD	Department of Defense
DOTMLPFI	Doctrine, Organisation, Training, Materiel, Leadership and Education, Personnel, Facilities, and Interoperability
DRDC	Defence Research and Development Canada
EBCG	European Border and Coast Guard
EDTIB	European Defence Technological and Industrial Base
EFSI	European Fund for Strategic Investments
EIT	European Institute of Innovation and Technology
EMITS	Electronic Mailing Invitation to Tender System
ESA	European Space Agency
ESIF	European Structural and Investment Funds
EU	European Union
Europol	European Union Agency for Law Enforcement Cooperation
EUROSUR	European Border Surveillance System
FP	Framework Programme
FP7	Seventh Framework Programme for Research and Technological Development
GAO	(US) Government Accountability Office
H2020	Horizon 2020
HSIP	Homeland Security Innovation Programs
IBM	Integrated Border Management
IITT	Intended Invitation to Tender
IPR	Intellectual Property Rights
IPT	Integrated Product Teams
IS	Islamic State
ISF	Internal Security Fund
ISR	Idea Submission Review
ITT	Invitation to Tender
KIC	Knowledge and Innovation Community
KPI	Key Performance Indicator
m	Million
M&E	Monitoring and Evaluation
MS	Member State(s)
NATO	North Atlantic Treaty Organisaton
NFPOC	National Frontex Point of Contact
NIAG	NATO Industrial Advisory Group
NLLP	NATO Lessons Learned Portal
PCP	Pre-Commercial Procurement
PPI	Public Procurement of Innovative Solutions
PPP	Public-private partnership
QHSR	Quadrennial Homeland Security Reviews
R&D	Research and Development
R&I	Research and Innovation
RCMP	Royal Canadian Mounted Police
RDU	Research and Development Unit
RQ	Research Question
RTD&E	Research, Development, Test and Evaluation
S&T	Science and Technology
S&T (US)	Science and Technology Directorate
SBIR	Small Business Innovation Research
SME	Small to Medium-sized Enterprise
STRAS	Science and Technology Resource Allocation Strategy
THB	Trafficking in Human Beings
TRADOC	US Army Training and Command
TRL	Technology Readiness Level
US	United States
USCG	United States Coast Guard
WP	Work Package

Glossary of key terms

Table 0.1 provides expanded definitions of the key terms used in this document.

Table 0.1 **Glossary of key terms**

Term	Definition	Source
Applied research	'Applied research' is designed to solve practical problems of the modern world, rather than to acquire knowledge for knowledge's sake. This contrasts with 'basic research' (see below).	Lawrence Berkeley National Library (n.d.).
Basic research	'Basic research' (also referred to as 'fundamental' or 'pure' research) is driven by interest in expanding knowledge, rather than a focus on creating or inventing products. This contrasts with 'applied research' (see above).	Lawrence Berkeley National Library (n.d.).
Capital	'Capital' refers both to the equipment and physical assets held by firms to produce their goods/services, and to funding for the creation of ideas and for packaging and delivering this knowledge as innovation.	Freeman et al. (2015).
Dissemination	'Dissemination' involves sharing research results with potential end users (definition below).	European Commission (n.d.-a).[1]
Drivers	'Drivers' are the motivations that guide innovation. Drivers for innovation will vary by sector depending on the incentives and perceived benefits of innovation; for border security, drivers include enhancing border management capability, whereas for companies the key driver is typically profit.	Freeman et al. (2015).[2]
Effectiveness	'Effectiveness' is a measure of how successful an intervention has been in achieving or progressing towards its objectives.	European Commission (2015b).
End user	An 'end user' is the ultimate user or customer of a product or service. End users in the context of this study refer to the individuals working in national or multinational authorities responsible for border management. The terms 'end user' and 'border guard' are used interchangeably throughout this document.	Robinson et al. (2011).
Exploitation	'Exploitation' involves using R&I results for commercial purposes, in public policymaking and in policy implementation.	European Commission, (n.d.-a.)
High-technology research	'High-technology' or 'high-tech' research refers to highly sophisticated and advanced technology.	Collins (n.d.)
Impact	While definitions vary, 'impact' can be defined as the extent to which research improves operational practices, contributes to an enhanced understanding of policy issues, and builds capacity through skills development.	ESRC (n.d.).
Innovation	'Innovation' refers to a process that is able to transform new ideas into products, services and processes, also encompassing the process of invention with a focus on ensuring that such new ideas are applied to the benefit of end users.	Freeman et al. (2015).
Inputs	'Inputs' are the raw materials that provide a basis for the research process (e.g. money, technical expertise, relationships, personnel).	RAND Europe analysis.
Interoperability	'Interoperability' refers to the ability of countries to act together coherently, effectively and efficiently to achieve tactical, operational and strategic objectives. In the context of border security, it enables border guard authorities and/or systems to adopt common procedures and to share infrastructure.	NATO (2012).

1 European Commission (n.d.-a).
2 Freeman et al. (2015).

Term	Definition	Source
Low-technology research	'Low-technology' or 'low-tech' refers to machines or systems that do not use modern or sophisticated technology.	Collins (n.d.).
Outputs	'Outputs' are the products that result from project activities (e.g. research publications, toolkits, research briefings).	RAND Europe analysis.
Operationalisation	The integration of research findings into operational practice.	RAND Europe analysis.
Needs	'Needs' refer to the issues that applied research is designed to address (e.g. capability gaps, security threats).	RAND Europe analysis.
Public-private partnerships	'Public-private partnerships' (PPPs) are long-term contracts between two units, whereby one unit acquires or builds an asset or set of assets, operates it for a period and then hands the asset over to a second unit. Such arrangements are usually between a private enterprise and government but other combinations are possible, for example with a public corporation as either party or a private non-profit institution as the second party.	European Commission (n.d.-d).
Research	'Research' is a detailed study of a subject, especially in order to discover (new) information or reach a (new) understanding.	Cambridge dictionary (n.d.-b).
Research and development	'Research and development' (R&D) is work directed toward the introduction, innovation and improvement of products and processes.	Cambridge dictionary (n.d.-a).
Research and innovation pathway	The 'research and innovation (R&I) pathway' is the R&I cycle encompassing need identification and prioritisation, project specification and selection, inputs to research, the research process, and adoption of research outputs by end users.	RAND analysis.
Talent	'Talent' refers to the (human) technical and managerial expertise necessary to support successful innovation processes.	Freeman et al. (2015).
Technology Readiness Level	Technology Readiness Levels (TRLs) are indicators of the maturity of particular technologies. There are nine TRLs, with TRL 1 being the lowest and TRL 9 being the highest. The following definitions apply: ■ TRL 1: Basic principles observed. ■ TRL 2: Technology concept formulated. ■ TRL 3: Experimental proof of concept. ■ TRL 4: Technology validated in lab. ■ TRL 5: Technology validated in relevant environment. ■ TRL 6: Technology demonstrated in relevant environment. ■ TRL 7: System prototype demonstration in operational environment. ■ TRL 8: System complete and qualified. ■ TRL 9: Actual system proven in operational environment.	European Commission (2017c).

Preface

This is the final report of an 11-month study commissioned by the European Border and Coast Guard Agency (Frontex), which examines how border security research is set up, managed and operationalised in and beyond the European Union (EU). This report provides an overview of good practices and challenges for border security research in the EU, the United States (US), Canada and Australia, with a secondary focus on Turkey and three North African countries – Morocco, Tunisia and Egypt. It also explores ways in which research can be more effectively operationalised through innovation, before presenting a set of practical recommendations for Frontex.

RAND Europe is an independent, not-for-profit policy research organisation that aims to improve policy and decision making in the public interest through research and analysis. RAND Europe's clients include European governments, institutions, NGOs and other organisations with a need for rigorous, independent, interdisciplinary analysis.

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The study team would like to thank the policy officials, border security practitioners, academic experts, and industry representatives who took part in research interviews. Appendix A of the Technical Annex lists their affiliations and, in some cases, their names: some interviewees' identities have been anonymised at their request. Thanks are also due to the Member State (MS) and industry survey participants for their valuable insights, as well to those who attended the stakeholder workshop held in Warsaw, Poland, on 5 September 2017.

Within RAND Europe, the team is appreciative of the valuable contributions of Jennifer Moroney and the experts group, comprising Alex Hall, Sonja Marjanovic, Jon Freeman and Catriona Manville. Finally, the team is very grateful to the quality assurance reviewers Emma Disley and James Black for their constructive feedback.

1. Introduction

This report presents the results of a RAND Europe study examining the setup and management of border security research within and beyond the European Union (EU). Commissioned by the European Border and Coast Guard Agency (Frontex)[3] in December 2016, this study aims to inform possible alternatives to the current model of contracting and managing border security research, and explore the role that Frontex could play in facilitating uptake of research outputs by end users ('border guards').[4] This chapter provides an overview of the study context, its purpose and scope, and the research approach employed.

1.1. Study context

1.1.1. Diverse threats highlight the need to strengthen EU border security

Today, the EU faces a range of pressures on its external and internal borders. In 2016, Member States (MS) reported more than half a million detected illegal border crossings. While this figure represents a significant decrease from the number of illegal crossings detected in 2015 (over a million), it is markedly higher than any annual total between 2010 (around 100 000) and 2014 (around 290 000).[5] An increase in people-smuggling activities has contributed to this continued pressure on EU borders, with 96 per cent of immigrants arriving in the Central Mediterranean region in 2016 stating that they had used the services of illegal smuggling networks.[6] According to the European Union Agency for Law Enforcement Cooperation (Europol), many of the organised crime groups involved in migrant smuggling are 'polycriminal' and engage in a range of other criminal activities, including document counterfeiting, property crime, drug trafficking, excise fraud, and trafficking in counterfeit goods. Other forms of organised crime posing security problems at EU borders include weapons smuggling and trafficking in human beings (THB).[7]

Recent attacks in France,[8] Germany[9] and Belgium[10] also highlight that terrorist threats are becoming more international and cross-border in nature.[11] In particular, the Syrian conflict has attracted thousands of so-called 'foreign fighters' from Europe, many of whom are likely to return as the Islamic State (IS) continues to lose territory.[12] As some of these individuals may pose a threat to internal security, the role of Frontex[13] and European border authorities in monitoring their cross-border movements is increasingly important.[14]

Given the scale, severity and cross-border nature of these security threats, integrated border management (IBM) remains a strategic priority for the EU. IBM is a concept that consists of five elements:

- Border control (checks and surveillance);
- Detection and investigation of cross-border crime;
- Inter-agency cooperation for border management and international cooperation;
- Coordination and coherence of activities of MS and institutions; and
- Four-tier access control model': this model supports the detection and investigation of cross-border crime through a combination of measures in third countries, cooperation with neighbouring countries, border control at the external border, and control measures within the Schengen area.[15]

By assigning strategic importance to border security, the EU aims to ensure that EU citizens' freedom and security are protected in full compliance with the Union's values, including the rule of law and fundamental rights.[16] Border security is central to two of the European Commission's *Ten Priorities for Europe*,[17] and two of the three strategic priorities set out in the *European Agenda on Security*.[18] Under the *European Agenda on Migration*,[19] a number of measures have been taken to reinforce the security of the EU's external

3 While Frontex is now officially named the 'European Border and Coast Guard Agency', it is still widely referred to as 'Frontex'. In this report, 'Frontex' and 'the Agency' are used interchangeably to refer to the organisation.

4 An 'end user' in the context of this study refers to the national or multinational authority responsible for border management. The terms 'end user' and 'border guard' are used interchangeably throughout this document.

5 Frontex (2017).

6 Europol (2017).

7 Frontex (2017).

8 The Guardian (2017); BBC (2016); BBC (2015a); BBC (2015b).

9 The Guardian (2016); The Telegraph (2016a); The Telegraph (2016b).

10 France 24 (2017).

11 European Commission (2015c).

12 Frontex (2017).

13 Established in 2004, Frontex promotes, coordinates and develops European border management in line with the EU fundamental rights charter and the concept of Integrated Border Management. See Frontex (n.d.).

14 While Frontex (2017) highlights IS as the main terrorist threat to EU borders, al-Qaeda, its affiliates and other terrorist groups may similarly pose a threat to border security.

15 Council of the European Union (2006).

16 European Commission (2015d).

17 These priorities are 'justice and fundamental rights' and 'migration'. See European Union (2015).

18 These priorities focus on supporting a strong EU response to terrorism and foreign fighters and on tackling serious and organised crime, which both pose cross-border challenges. See European Commission (2015e).

19 European Commission (2017a).

borders and to support the national border guards deployed by MS. One such measure was the creation in October 2016 of a European Border and Coast Guard (EBCG), comprising Frontex and the various national authorities responsible for border management at the MS level.[20]

To support these strategic objectives, the funding, personnel and remit of Frontex have been increased since the EBCG came into force in 2016. EU funding for Frontex is set to increase from €281m in 2017 to €322m in 2020, with the number of staff members expected to rise from 400 in 2016 to 1 000 by 2020.[21] The role and activities of the Agency have been strengthened with, for example, a new Rapid Reaction Pool of 1 500 border guards and other officers being placed at the Agency's immediate disposal since December 2016, alongside a Rapid Reaction Equipment Pool consisting of helicopters, vessels and other equipment to carry out rapid border interventions.[22]

Additional measures have been taken to improve situational awareness at the EU's external borders and to support the detection of cross-border crime. For example, under the EU's earth-observation programme 'Copernicus', the European Commission has agreed to provide €46.7m to Frontex between 2015 and 2020 in order to implement satellite services dedicated to border surveillance.[23] With the agreement finalised on 10 November 2015, the European Commission has entrusted Frontex with the border surveillance component of the Copernicus programme. This involves supporting the European Border Surveillance System (EUROSUR) by providing real-time data on activities on land and sea around EU borders. Satellite data has already been used in combination with ship reporting systems to identify smugglers and save lives at sea.[24]

1.1.2. Research is important for border security

Research[25] can help security officials understand and respond to these threats to border security, as well as supporting the development of evidence-based security policies and operational tools.[26]

An important part of Frontex's mandate involves monitoring and contributing to research developments relevant to the Agency's area of operations in order to bridge the gap between technological and research advancements and the needs of border control authorities. Responsibility for monitoring developments in these areas lies with the Research and Development Unit (RDU).[27] Through projects, workshops and conferences, the RDU aims to facilitate engagement and exchange of information between border management authorities and providers of research, including research institutes, universities and industry. Frontex is also responsible for keeping MS and the European Commission up to date with developments, and provides input to policy development.[28]

Beyond the border security research projects awarded directly by Frontex, several EU funding mechanisms for research and innovation[29] support the priorities of the *European Agenda on Security*.[30] These priorities focus on countering terrorism, organised crime and cybercrime as interlinked areas with a strong cross-border dimension.[31] Horizon 2020 (H2020), which replaced the Seventh Framework Programme (FP) for Research and Technological Development (FP7) (2007–2013), is the biggest EU R&I programme, with around €80bn of funding available over seven years (2014–2020).[32] Border security research sits within the 'Secure Societies' strand of the H2020 programme,[33] with a maximum amount of €73m and €55m available for border security research projects in 2014–2015 and 2016–2017, respectively.[34] 'Secure Societies' was set up to focus on 'multidisciplinary, mission-oriented research' which combines 'end users and suppliers in project definition and execution'.[35]

1.1.3. Challenges remain in incorporating research into operational practice

Despite the millions of euros invested in EU border security research each year, challenges remain in achieving 'impact' through research; that is, improving operational practices, contributing to an enhanced understanding of policy issues, and building capacity through skills development.[36] There is already some evidence to suggest that the 'pull-through' of border security research can be challenging and that many promising insights are never incorporated into practice. In some cases, research projects can be 'overtaken by events' and lose their relevance over time, particularly given that EU research funding tends to be long-term in nature, while political priorities and personnel can change more rapidly. A lack of understanding among research providers of the operational context and constraints affecting end users can also reportedly limit the relevance of research outputs to the end user community.[37]

20 European Union (2016).
21 European Commission (2015a).
22 European Commission (2016b).
23 Frontex (2015).
24 For example, 350 people were rescued after Copernicus helped identify four rubber dinghies leaving the coast of Libya on 7 October 2015. See Copernicus (n.d.-a).

25 'Research' is the detailed study of a subject, especially in order to discover information or reach a new understanding (see 'Glossary of key terms', and fuller definition provided in Chapter 3). While a core focus of this report is the integration of research findings into operational practice across these case studies, the report focuses on both 'basic research', which is driven by interest in expanding knowledge rather than on developing new products, and 'applied research', which is designed to address practical problems.
26 European Commission (2015a).
27 European Union (2011).
28 European Union (2011).
29 'Innovation' refers to a process that is able to transform new ideas into products, services and processes, also encompassing the process of invention with a focus on ensuring that such new ideas are applied to the benefit of end users. See Chapter 3 and the glossary of key terms.
30 European Commission (2015d).

31 European Commission (2015a).
32 European Commission (n.d.-a).
33 European Commission (n.d.-b).
34 European Commission (2015e); European Commission (2016a).
35 European Security Research Advisory Board (2006).
36 Economic and Social Research Council (ESRC) (2017).
37 Startup project meeting at Frontex offices, Warsaw, 19 January 2017. See Section 3.2 for a more in-depth discussion of these challenges and constraints.

1.2. Purpose and scope

Given the challenges inherent in pulling through operationally relevant research, Frontex is interested in developing a better understanding of how border security research is set up, managed and operationalised by agencies operating at the national level within and beyond the EU. This is intended to increase awareness of alternative or new ways of setting up, managing and using research outcomes that enable the faster integration of relevant research, make research more focused on operational needs, and ensure that its potential for positive impact on EU and MS border security is fully realised.

To support this overarching objective, this study addresses three research questions (RQs):[38]

- RQ1: How is research and innovation in the area of border security set up, conducted and operationalised by EU organisations and MS?
- RQ2: What approaches are used in the US, Canada and Australia to fund and apply research in this area?[39]
- RQ3: What 'good practices' from these different approaches could be incorporated into the EU approach?

While a central focus of the study is on the integration of research findings into operational practice, this report focuses on both 'basic research', which is driven by interest in expanding knowledge rather than on developing new products,[40] and 'applied research', which is designed to address practical problems of the modern world rather than to acquire knowledge for knowledge's sake.[41]

1.3. Research approach

To achieve the objectives of the study, the project team deployed a structured approach combining data-collection activities with a rigorous analytical process. Figure 1.1 presents the overall research approach, which is structured around three Work Packages (WP) linked to the three RQs above.

The RAND Europe project team used two main research methods to conduct this study: case studies (drawing on document reviews, research interviews and – for WP1 only – surveys) and workshops. As shown in Figure 1.1, the case studies were conducted in two separate phases and with different purposes.

Case studies

In the first phase of the study, the WP1–2 case studies were used to answer the first two research questions (RQ1 and RQ2) described in Section 1.2. As part of this analysis, these case studies helped generate a high-level understanding of good practices and common challenges relating to the operationalisation of border security research. As per WP1 and WP2, this first set of case studies focused exclusively on institutions or organisations involved in border security research in the following countries and regions: the EU, the US, Canada, Australia, Turkey and selected parts of North Africa (Egypt, Morocco and Tunisia).[42] These case studies are presented in Figure 1.2 on page 26, along with an overview of the main governmental actors and EU institutions responsible for the setup and management of border security research. Detailed descriptions of the EU and non-EU case studies are presented in Chapters 2 and 3, respectively, of the Technical Annex.

In the second phase of the study (WP3), to inform the development of recommendations for Frontex, the project team conducted a more in-depth investigation of six organisations also operating in other domains – namely defence and space – with a view to understanding different functional roles for R&I.

The case studies conducted in WP3 focused on the following six organisations:

- **European Space Agency (ESA):** The ESA is the coordinating entity for European civilian space activities. It is an intergovernmental organisation of 22 MS, dedicated to the exploitation of space science, research and technology.
- **European Institute of Innovation & Technology (EIT):** The EIT is an independent EU body set up to support innovation in Europe. The EIT brings together universities, research labs and companies to form partnerships ('Knowledge and Innovation Communities').
- **Defense Innovation Unit – Experimental (DIUx):** Headquartered in Silicon Valley in California, DIUx is a US Department of Defense (DoD) organisation focused on accelerating commercial technology development for the US military.
- **Department of Homeland Security (DHS) Small Business Innovation Research (SBIR):** The DHS SBIR programme aims to increase small business participation in US federal research that has the potential for commercialisation.
- **Homeland Security Innovation Programs (HSIP):** The HSIP aims to generate innovation in hubs across the US in order to solve DHS's most complex challenges through outreach to investors and funding for innovative start-ups.
- **Centers of Excellence (COEs):** COEs refer to a coordinated, university-based programme that aims to harness expertise from US academic institutions in order to support research efforts and deliver tools, technologies, knowledge products, training and expertise for the homeland security enterprise.

The WP3 case studies were selected at an internal analysis session. At this session, the study team identified research organisations for further, more in-depth analysis from the first phase of the study (SBIR, HSIP and COE), before agreeing on organisations from other sectors with

38 More detailed information in response to RQ1, RQ2 and RQ3 can be found in Chapters 2, 3 and 4, respectively, of the Technical Annex.

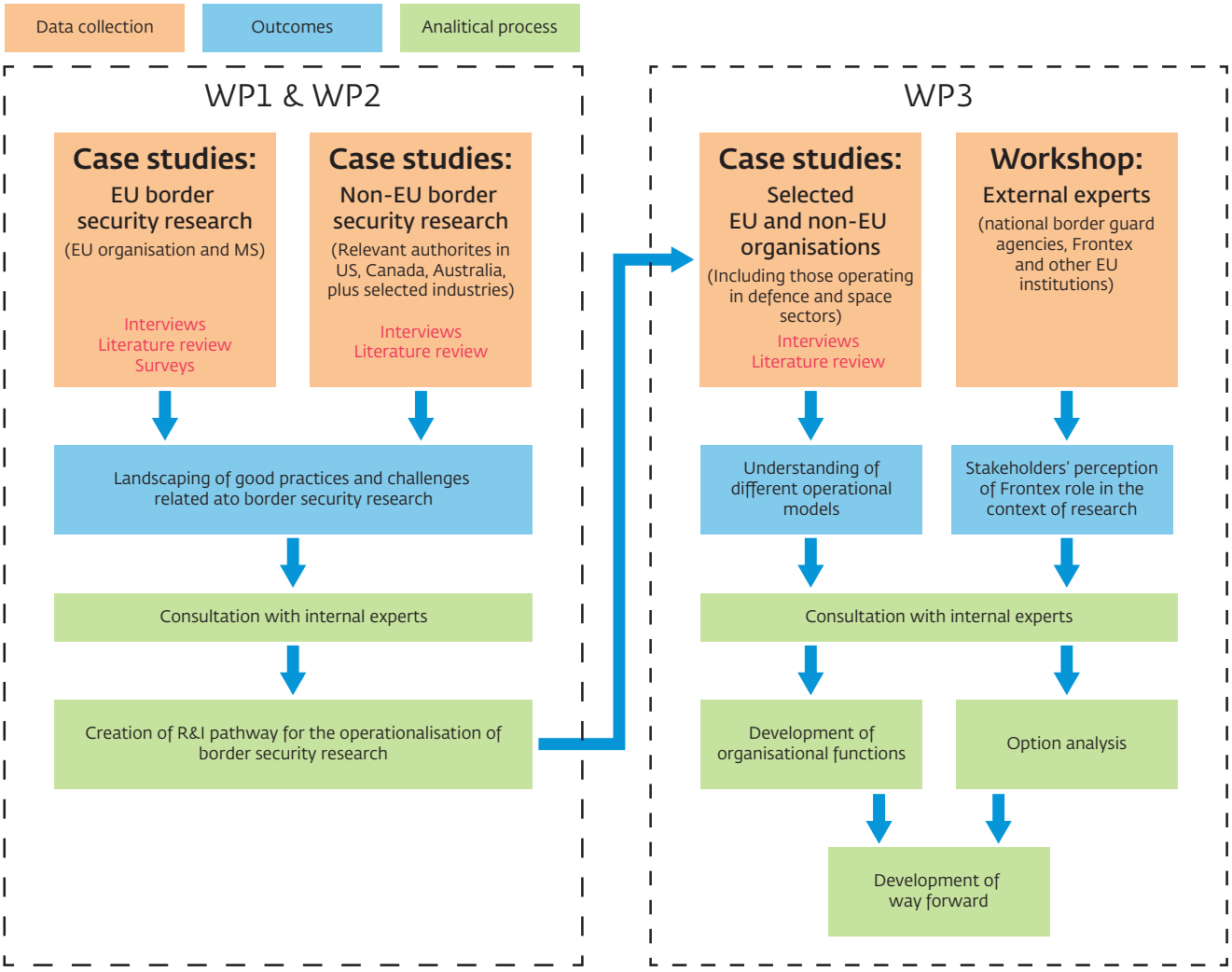
39 At the client's request, the study's analysis focuses on the EU, US, Canada, Australia and – (to a lesser extent) on Turkey and three North African countries: Egypt, Morocco and Tunisia (see Section 1.3).

40 Lawrence Berkeley National Library (n.d.).

41 Lawrence Berkeley National Library (n.d.).

42 At Frontex's request, the EU, US, Canada and Australia cases studies offer a more granular analysis of how research is set up, conducted and implemented in practice, while the Turkey and North Africa cases offer a 'lighter-touch' analysis that provides a high-level description of: (i) the extent to which border security research is already being conducted and operationalised in these countries; and (ii) any existing or intended involvement in the Horizon 2020 programme.

Figure 1.1 **Overview of research approach**



applicable lessons for border security R&I (ESA, EIT and DIUx). Literature availability was also a considered as part of selection in order to ensure that there was sufficient source material to conduct an informed analysis. Detailed descriptions of the WP3 case studies are provided in Chapter 4 of the Technical Annex.

As the following paragraphs describe in more detail, the WP1–3 case studies are based on a combination of literature review and research interviews, with additional WP1 data collected through two surveys.

Literature reviews

Across all WPs, data was collected through structured reviews of peer-reviewed and 'grey' literature.[43] The WP1–2 review focused on literature relating to the institutional setup of border security research across the case study countries and regions, while the WP3 review explored the functional activities of the six case study organisations. Both reviews were conducted through Google and Google Scholar searches and 'snowball' searching.[44] Given the institutional and procedural focus of the study, the study team identified most of the literature reviewed by searching the websites of relevant government agencies and other stakeholders involved in the setup, management and operationalisation of research. The team included literature in the review on the basis of relevance to the research questions and to the scope of the study, and findings were written up in a narrative synthesis.

Research interviews

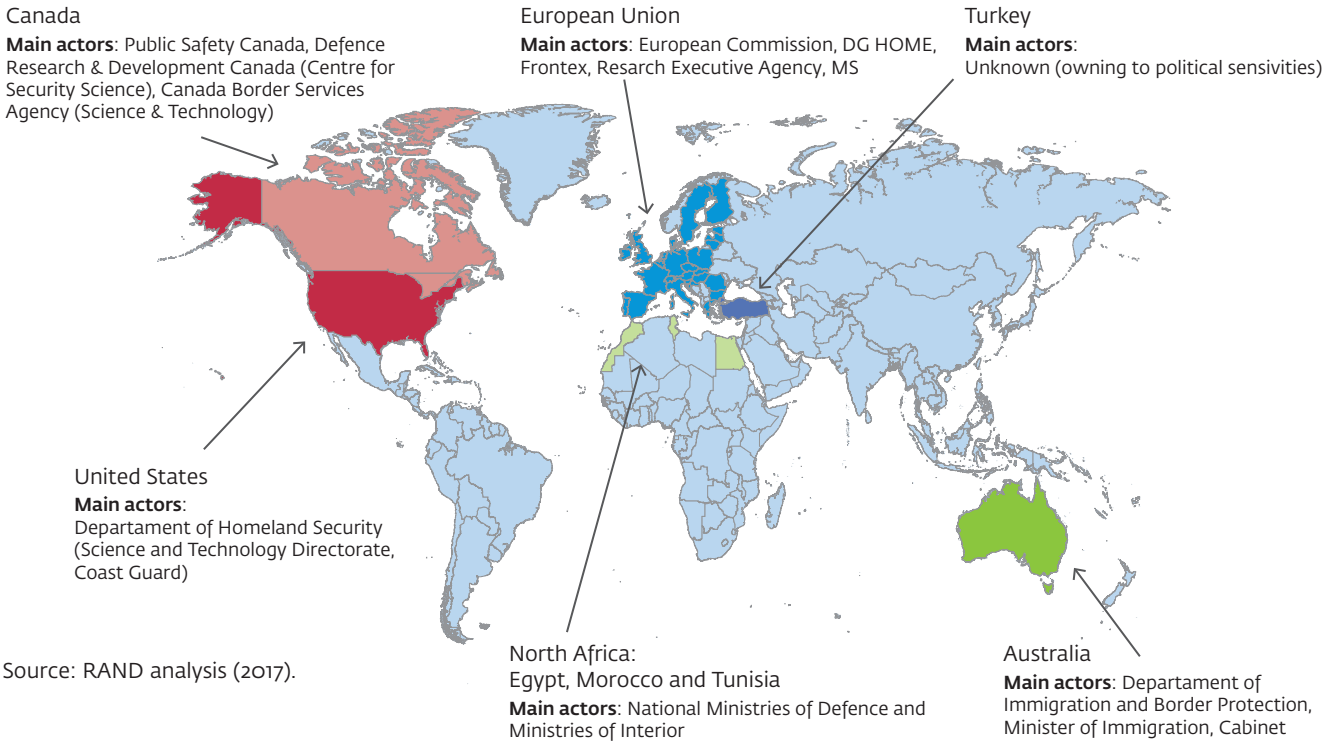
Complementing the literature review, a total of 32 semi-structured[45] telephone in-

43 'Grey literature' is produced by organisations outside of academic or commercial publishing channels. Examples of grey literature include government documents, technical reports, working papers, doctoral theses and conference proceedings.

44 'Snowball searching' involves using a given document's reference list to identify other relevant documents.

45 Semi-structured interviews combine the use of an interview protocol containing specific questions with flexibility to ask unplanned follow-up questions. By contrast, structured interviews follow an interview protocol with all interviewees asked exactly the same questions in the same order, while unstructured interviews consist of a free-flowing conversation on a given topic.

Figure 1.2 **Overviev of WP1 and WP2 case studies**



Source: RAND analysis (2017).

terviews were conducted across all WP. Interviewees were policy officials, border guard practitioners, academic experts and industry representatives with expertise relating to the case studies under analysis.[46] Interviewees were identified by conducting online searches and leveraging RAND's contact networks, and through recommendations from Frontex. An interview protocol was used to conduct these interviews (see Appendix B of the Technical Annex). This guidance document was designed to help interviewers cover all the desired topics while allowing scope for flexibility, and was adjusted for each of the case studies. It was also designed to ensure that all topics of discussion were, as far as possible, covered with all participants.

We conducted 14 interviews focused on EU border security research (WP1), 14 interviews focused on non-EU border security research (WP2), and 4 interviews with representatives from R&I organisations (WP3). The majority of interviews focused on WP1–2, given that the WP3 case studies were intended to be based primarily on a literature review. Table 1.1 presents the distribution of interviewees across countries and regions.

Surveys

To support the WP1 analysis, the study team distributed two electronic surveys. The first survey was circulated to National Frontex Points of Contact (NFPOC) within all 28 EU MS, with a 39 per cent response rate (11 of 28 MS).[47] In order to complement the MS survey data with perspectives from research, academic and industry representatives, Frontex circulated a second survey to 52 of their contacts from industry and academia, with a 10 per cent response rate (5 of 52 contacts). The purpose of these surveys was to expand on and validate the emerging findings of the WP1 literature review and interviews, as well as to provide further details about EU border management processes and the roles of different agencies that were not otherwise captured through the literature review.

Workshops

In addition to the case studies, an external stakeholder workshop was held at Frontex premises in Warsaw, Poland, on 5 September 2017 with the participation of 30 experts from national border guard agencies, Frontex and other EU institutions.[48] The purpose of this external stakeholder workshop was to analyse different types of functional role that Frontex could play in order to support the operationalisation of border security research (see Chapter 5).

To help structure our research approach and synthesise findings, three internal analysis workshops were held with a RAND Experts Group made up of senior researchers and topic experts in research, innovation and border security at RAND Europe. The purpose of the first internal workshop, held at the early stages of the study, was to develop a draft research and innovation pathway to map the possible processes linking border security research and its

46 A full list of interviewees is included in Appendix A of the Technical Annex.

47 7 NFPOC (Surveys A–G) provided completed survey responses: 3 NFPOCs (Surveys H–J) informed the study team that they do not perform activities related to border security research, and 1 NFPOC (Survey K) was unable to complete the survey due to other work commitments.

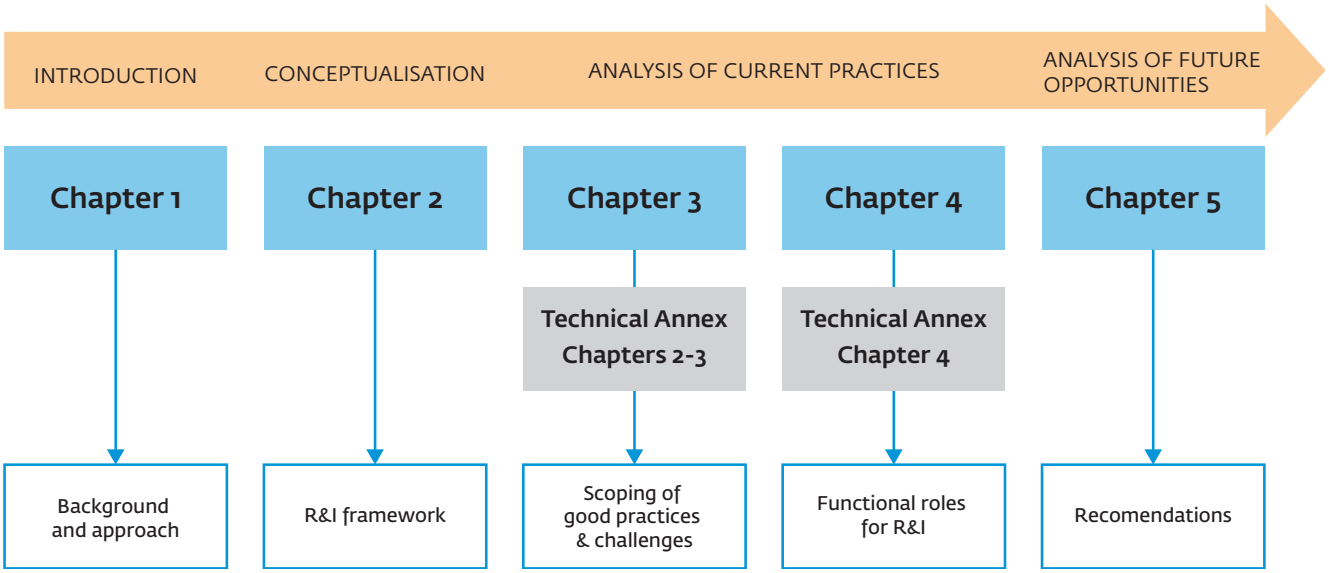
48 For information on supporting materials used at the workshop and on workshop findings, please refer to Appendices D and E of the Technical Annex, respectively.

Table 1.1 **Distribution of interviews across countries and regions (WP1–3)**[49]

	EU	US	Canada	Australia	Turkey	North Africa, *(Tunisia, Morocco, Egypt)*
Interviews conducted	**15** (*WP1: 14, WP3: 1*)	**5** (*WP2: 2, WP3: 3*)	**5** (*All WP2*)	**4** (*All WP2*)	**1** (*WP2*)	**2** (*Both WP2*)

Source: RAND analysis (2017).

Figure 1.3 **Structure of this report**



implementation by border guard authorities. The resulting framework was used to structure the study team's approach to data collection (see Chapter 2). The second internal workshop focused respectively on refining the research and innovation pathway, and the third on validating the case study and external stakeholder workshop findings.

1.4. High-level assumptions

A number of high-level assumptions should be noted in considering the findings presented in this report:

- From a terminology perspective, this report uses the term 'research and innovation' to refer to the entire process that leads to the operationalisation of research and its related impact on policy and operational practices. This process includes, but it is not limited to, the 'research & development' phase (see Chapter 2 for more details).
- Across the WP1–2 case studies, more literature and interview data was available for the EU and the US than for other countries and regions.[50] A relative shortage of data on Canada, Australia, and in particular North Africa and Turkey (in part due to political sensitivities)[51] has implications for the depth of analysis on these focus countries and regions.
- In a number of areas, the nature of the data available to the study team means that the WP1–2 case study findings lack granularity. While specific examples of 'research impact', 'end user involvement' and 'the operationalisation of research' were sought by RAND researchers, in some cases little detail on this could be elicited from the available literature, interviews and survey responses.
- The identification of 'good practices' and 'challenges' in the setup and management of border security research across the case studies is based largely on the views of WP1–3 study interviewees representing policy, practitioner, academic and industry stakeholder communities.
- While the report highlights the main challenges and areas of good practice identified through the WP1–3 interviews and literature review conducted within the study timeframe, the study team recognises that there are likely to be good practices and challenges not captured in this document, and that those listed are not exclusive to the case studies in which they are outlined.
- Relatively low WP1 survey response rates (39 per cent and 10 per cent respectively for the MS and industry

49 Since submission of the Interim Report in June 2017, additional interviews have been conducted with EU stakeholders (n=3) and Australian stakeholders (n=1) to update WP1 and WP2 content. A total of 4 WP3 interviews have also been conducted (n=3 US interviews comprising 1 with SBIR, 1 with HSIP and 1 with an anonymous US organisation; and n=1 EU interview with an anonymous EU organisation).

50 While comparatively few interviews were conducted with US stakeholders (n=2), this limitation was offset by the high availability of US literature.

51 Please refer to Section 2.2.3 of this report and Section 3.4 of the Technical Annex.

surveys) limited the generalisability of the data collected from respondents. However, complementing survey data with data from the research interviews ensured that our analysis was informed by a wide range of stakeholder perspectives.
- Discussions at external workshop were informed mainly by EU border guards and Frontex representatives, given that these stakeholder groups accounted for the majority of attendees.

1.5. Structure of the report

This report outlines the findings of this study and provides a set of recommendations for Frontex. In addition to this introduction, this document contains four substantive chapters:

- **Chapter 2** outlines the concepts of research and innovation, and presents the research and innovation pathway developed as part of this study to guide our analysis.
- **Chapter 3** provides a summary of findings across the WP1–3 case studies in relation to good practices and challenges for operationalising border security research.
- **Chapter 4** explores a range of functional roles that organisations can play along the research and innovation pathway described in Chapter 2.
- **Chapter 5** presents a series of forward-looking recommendations for consideration by Frontex.

This report is accompanied by a Technical Annex, the contents of which are as follows:

- **Chapter 1** provides an overview of the Technical Annex.
- **Chapters 2–4** are the 'core' chapters of the Technical Annex, presenting case study findings relating to EU border security research (WP1), non-EU border security research (WP2), and the functional roles for R&I within different organisations (WP3).
- **Appendix A** lists the study interviewees.
- **Appendices B–D** present supporting research materials: interview questions (Appendix B), survey outlines (Appendix C), and materials for the external workshop (Appendix D).
- **Appendix E** summarises proceedings and findings of the external stakeholder workshop.

Figure 1.3 on the previous page highlights the links between the chapters of this report and the core chapters of the accompanying Technical Annex.

2. Conceptualising research and innovation

This chapter introduces the concepts of research and innovation, explaining how the latter relates to the adoption of research by end users in the border security context. The following sections then draw on established R&I models and theories identified through a literature review to develop a bespoke 'research and innovation pathway', which serves two purposes. First, this pathway offers a way of presenting case study findings related to EU and non-EU border security research (WP1–2) in a structured and consistent way (see Chapters 2 and 3 of the Technical Annex).[52] Second, a number of 'functional roles' for R&I, identified through the case study research (WP1–3), are mapped onto the pathway (see Chapter 4) in order to inform a set of recommendations for Frontex (see Chapter 5).

2.1. Overview of key definitions

Understanding the distinctions between 'research' and 'innovation' is important for enhancing awareness of how new technology or knowledge can be more efficiently and effectively translated into operational practice. As described in Section 1.2, one possible way of defining research is by splitting the concept into two categories:

- **'Basic research'** (also referred to as 'fundamental' or 'pure' research), which is driven by interest in expanding knowledge, rather than a focus on creating or inventing products;[53] and
- **'Applied research'**, which is designed to solve practical problems of the modern world, rather than to acquire knowledge for knowledge's sake.[54]

Whether basic or applied, research is part of innovation (though not all innovation requires research), but it is limited to the creation and investigation of new ideas and solutions – in simple terms, it goes only halfway to solving an identified gap since it does not include all the steps that turn ideas into new products, services and processes.

Translating border security research into operational practice goes beyond the success of any individual project and relies on the existence of two main processes:

- **From an industrial and academic perspective**, it requires a process that is able to transform new ideas into new products, services and processes, also encompassing the process of invention with a focus on ensuring that such new ideas are applied to the benefit of end users. This process is usually known as 'innovation'.[55]
- **From a border security perspective**, the acquisition of a newly available technology is not *per se* a new capability. In most cases, 'capability' comprises a range of different constituent parts (e.g. pieces of equipment, infrastructure and knowledge). For example, the North Atlantic Treaty Organisation (NATO) identifies eight elements that collectively make up a capability: Doctrine, Organisation, Training, Materiel, Leadership and Education, Personnel, Facilities, and Interoperability (DOTMLPFI).[56] Even when thinking only about new equipment or technology, it is not enough simply to procure it for border guards to use; there must also be an effective maintenance and support solution in place, in addition to the wider changes to training, policy and processes set out under the DOTMPLFI framework. While the definition of capability and its constituent parts may vary by sector or country, the principle that it includes more than just new technologies or new knowledge still holds true. The process through which new technologies and new knowledge are integrated fully into operational practice is usually referred to as *capability development*.[57]

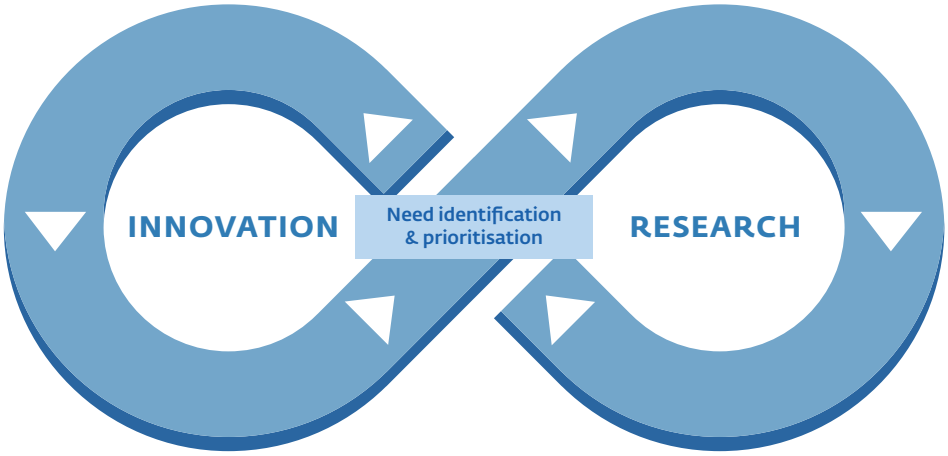
Given that the focus of this study is on research (both basic and applied) and innovation, analysis of the capability-development process is beyond the scope of this report. However, Frontex should remain cognisant of these considerations when approaching R&I if it is to take innovative new products and effectively put them into the field as fully matured, supportable new capabilities.

2.2. The research and innovation pathway

In relation to research and innovation, it is possible to identify a series of sequential steps that connect the generation of an idea, or the identification of a capability gap, to the adoption of a solution by end users and its related impact on operational practices and its wider societal benefits. These steps are often integrated into the concept of a 'pathway' in the literature.[58] Pathways are not linear processes, but are often cyclical, with

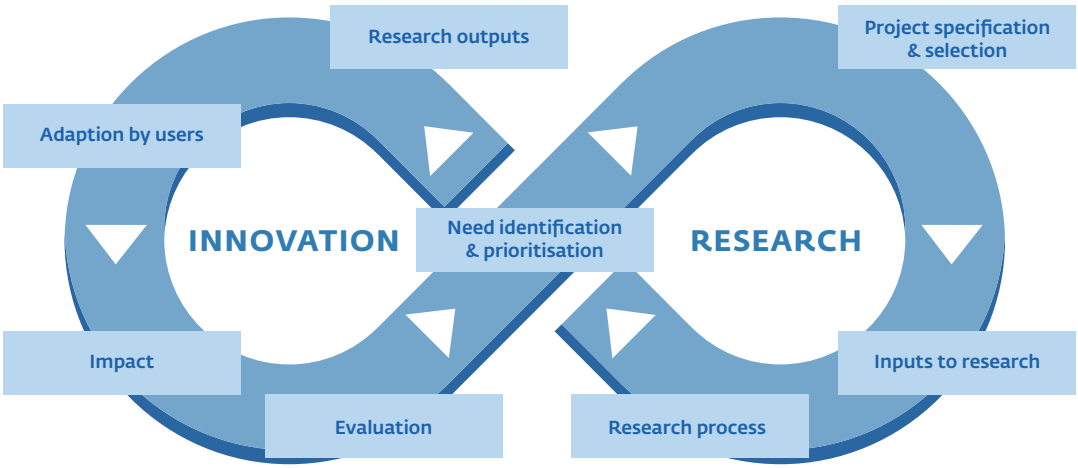
52 See in particular Sections 2.1.4, 3.1.4, 3.2.4 and 3.3.4 of the Technical Annex.
53 Lawrence Berkeley National Library (n.d.).
54 Lawrence Berkeley National Library (n.d.).
55 Freeman et al. (2015).
56 US Army Training and Doctrine Command (TRADOC) (2013).
57 This refers to the development and operationalisation of a capability. Capability is defined as: 'The power to achieve a desired operational effect in a nominated environment within a specified time and to sustain that effect for a designated period' (Australian Government Department of Defence (2014).
58 For an example of a research and innovation pathway model, see Donovan and Hanney (2011).

Figure 2.1 **Research and innovation as connected processes**



Source: RAND Europe analysis.

Figure 2.2 **The eight steps of the research and innovation pathway**



Source: RAND Europe analysis. Please note that the steps of this graphic should be read in the order described on the previous page (i.e. beginning with 'needs identification and prioritisation', moving clockwise to 'project specification and selection', and continuing in the order indicated by the arrows).

continuous feedback loops between each of the steps.

Figure 2.1 illustrates how border security research and innovation are part of a cyclical process originating from the identification of a capability gap (or area requiring improvement). Figures 2.2 and 2.3 elaborate on this pathway, which was refined through a series of internal workshops with RAND Europe border security and innovation experts.

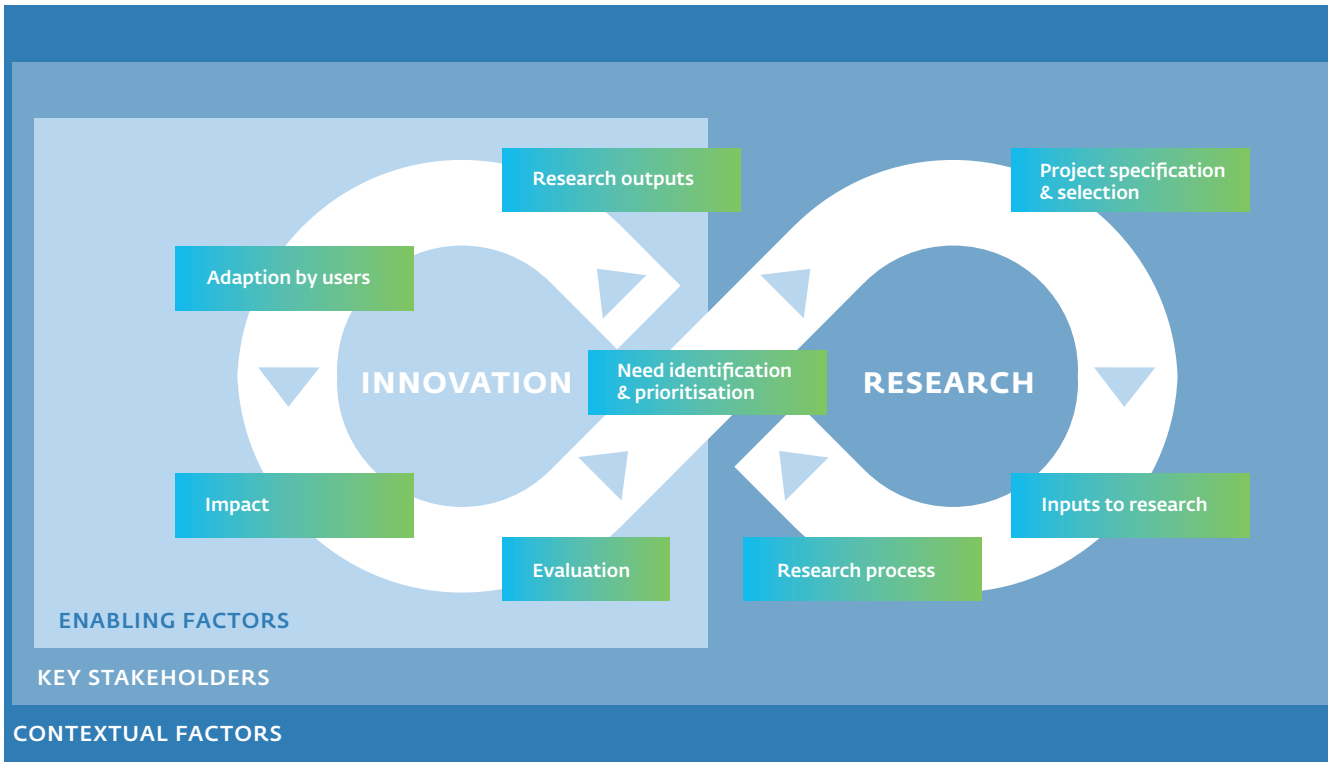
Several steps follow the identification of a need (e.g. a capability gap) to form the research and innovation pathway. These include:[59]

- **Project specification and selection:** This step includes the creation of technical specifications to be addressed by the research project, as well as the overall selection process of suppliers.
- **Inputs to research:** 'Inputs' are the components that provide a basis for the research process to take place (e.g. funding, technical expertise, relationships, project management, personnel).
- **Research process:** This includes all activities related to the delivery of the research against the technical requirements (see definition of 'basic' versus 'applied research' above).
- **Research outputs:** 'Outputs' are the products that result from project activities (e.g. research publications, toolkits, technologies/prototypes).
- **Adoption by end users:** This step, also referred to as 'operationalisation', refers to the integration of research outputs into operational practice.
- **Impact:** While definitions vary, 'impact' can be defined as the extent to which research improves operational practices, contributes to an enhanced understanding of policy issues, and builds capacity through skills development.[60]

59 RAND Europe analysis.

60 ESRC (n.d.).

Figure 2.3 **The research and innovation pathway in context**



Source: RAND Europe analysis.

- **Assessment:** This last step focuses on the ex-post evaluation of the impact generated by the adoption of innovative solutions. As a result of this assessment, new gaps may be identified in the same or different areas, re-starting the cycle described in the steps above.

As described above, the research and innovation pathway is not a linear process, but is characterised by continuous feedback loops as illustrated in Figure 2.2 (on the left).

Research and innovation do not take place in a vacuum, but rather are shaped by a series of overarching aspects that influence each step of the pathway. As Figure 2.3 shows, the first aspect to consider is the wider **contextual factors** of the country or region in which research and innovation are undertaken. This wider context includes political, strategic, cultural, social and technological factors. In the context of border security, the wider context may determine, for example, the perception and prioritisation of threats, which would subsequently trigger the identification of a capability gap.

The second aspect relates to **key stakeholders**. These may vary on a project-by-project basis and differ along the research and innovation pathway. Key stakeholders can include: (i) policy makers, as those setting strategic priorities and with an interest in the overarching impact of research; (ii) actors commissioning, funding and managing research; (iii) research and innovation providers such as industry and academia; (iv) investors; and (v) border security authorities.

The third and final aspect refers more specifically to the innovation part of the pathway and includes a series of **enabling factors** that facilitate and shape innovation. These factors range from the drivers, or motivations, that allow innovation to occur. For example, in the context of border security, possible drivers include the reduction of the number of illegal entries through document fraud at border crossing points, as well as capital, talent and skills, networks, structures and infrastructures.[61]

The research and innovation pathway outlined above has been used to present the core processes in relation to research setup, management and operationalisation within and beyond the EU (WP1-2: see Chapters 2 and 3 of the Technical Annex). The WP3 case studies (Chapter 4 of the Technical Annex) are intended to enhance understanding of how different organisations, operating in the border security sector as well as in other sectors, position themselves along this pathway and what functional roles they play in facilitating research and innovation. These functional roles are mapped onto the pathway in Chapter 4, and used as a basis for the recommendations for Frontex presented in Chapter 5.

61 For more information on the innovation factors, please refer to Freeman et al. (2015).

3. Good practices and challenges for border security R&I

This chapter outlines a summary of findings in relation to good practices and common challenges for operationalising border security research. These findings relate to both the 'research' and 'innovation' parts of the pathway presented in the previous chapter. This summary is not intended to be exhaustive, but to highlight the main lessons identified from analysis of all case study data collected within the timeframe of the project.[62] The accompanying Technical Annex provides more detail on the implementation of these good practices and the occurrence of different challenges at EU and national levels in the US, Canada, Australia, Turkey and North Africa, as well as among selected R&I organisations.

3.1. Good practices in research setup, management and operationalisation

Case study analysis at the EU, non-EU and organisational levels identifies a number of good practices in relation to the end user networks, funding mechanisms and management processes supporting border security research:

- **End user networks** can support the integration of research products into operational practice through close involvement of border guards (Section 3.1.1) and engagement with senior leadership (Section 3.1.2).
- **Flexible funding models** enable research to adapt to changes in operational requirements (Section 3.1.3).
- **Efficient management processes**, such as coordinated research mechanisms, can help identify capability gaps (Section 3.1.4). Collaboration between industry and academia can drive R&I (Section 3.1.5), and regular evaluation of research processes can ensure their continued fitness for purpose (Section 3.1.6).

The following sections explore these examples of good practice in more detail.

3.1.1. End user involvement at all stages of the research and innovation pathway can help ensure that research reflects operational needs

Actively engaging border guards early and repeatedly throughout research processes has a number of recognised benefits.[63] For example, involving end users in research planning can help ensure that priorities are set and funds allocated in a way that takes operational requirements into consideration. This is the case in the US with the Quadrennial Homeland Security Reviews (QHSR), Integrated Product Teams (IPTs), the Science and Technology Resource Allocation Strategy (STRAS), and the US Coast Guard Research, Development, Test and Evaluation (USCG RTD&E) business process.[64] Engaging border guards in this way can also increase their understanding of the advantages of research products, which may then lead to a greater likelihood of their successful uptake in the field. End users can provide support in a number of ways at various stages of the R&I pathway, including need identification and prioritisation, project specification and selection, research delivery and user adoption.

At the need identification stage, various mechanisms can serve to capture end user input, including meetings and an analysis of capability gaps. In Canada, for example, Public Safety Canada meets with the agencies responsible for border management on an annual basis to discuss their operational priorities and needs, in order to inform the development of calls for proposals.[65] Similarly, the US STR facilitates cooperation between S&T stakeholders and end users through quarterly meetings aimed at ensuring that research efforts remain focused on operational requirements. STRAS also records the work of border guards to identify capability gaps and create a strategy for addressing these.

End user participation in working groups and committees can also help ensure that operational requirements are understood and incorporated into research programmes. For example, the USCG S&T Transition and Innovation Center (CG-STIC) coordinates an Innovation Council and a series of working groups to inform its understanding of end user needs. On the basis of this understanding, it then tailors existing technologies to end user requirements in order to improve the delivery of operationally useful solutions. Another example is ESA's active engagement with users of space technologies in order to tailor its programmes to operational needs and the wider environment.[66]

Interviewees and survey respondents identified numerous other examples of effective involvement of border guards in research delivery, as discussed in Chapters 3 and 4 of the Technical

62 For detailed information regarding the WP1 (EU border security research), WP2 (non-EU border security research) and WP3 (functional roles for R&I within different organisations) case studies, please refer to Chapters 2, 3 and 4, respectively, of the Technical Annex.

63 Industry survey respondents (Surveys L, O).

64 Please refer to Section 3.1 of the Technical Annex.

65 Please refer to Section 3.2 of the Technical Annex.

66 Please refer to Section 4.1 of the Technical Annex.

Annex. In the Canadian case, for example, universities and research organisations submitting proposals are required to collaborate with a 'champion' operational partner agency that will then work with them on the proposed project. Similarly, according to one study interviewee, Frontex's involvement on the Advisory Board of various EU-funded projects has helped ensure that research reflects border guard requirements and the wider operational context.[67]

According to one study interviewee, the transition from FP7 to H2020 has increased the visibility of research to border guards and introduced a requirement for end user involvement in H2020 project consortia.[68] While the extent and nature of their participation varies across the EU FP, end users can participate in workshops, demonstrations and research, as well as leading the consortia responsible for delivering projects. These practices not only help ensure that the research is informed by an understanding of operational needs and priorities, but also that proposed projects are designed in a way that has practical utility to border guards.

3.1.2. Engaging with senior leadership can help ensure the continuous profile of border security research

Involving the senior representatives of border guard agencies and government departments in research processes can also help strengthen the profile of border security research, signalling senior-level commitment to research in this field and encouraging buy-in from other stakeholders. The benefits of engaging senior leadership in research are highlighted by the Australian case. Interviewees noted that positive organisational and cultural changes in the Department of Immigration and Border Protection (DIBP) are linked to strong engagement at the senior leadership level in encouraging innovation, research partnerships and secondments with think tanks in order to drive up interest in research among border security staff.[69] The buy-in of senior personnel is important to ensuring that border security research is prioritised and allocated sufficient resources.

3.1.3. Flexible funding models are responsive to the short-term needs of end users and support further development of existing research

The dynamic nature of the threat landscape means that the operational requirements of border guards may change quickly (see Section 1.1). For research programmes to be responsive to these changing requirements, flexible funding models can help ensure that research continues to have practical value for end users. In Australia, for example, DIBP's approach to funding research has become more responsive in recent years, with commissioned research increasingly focusing on studies with a shorter turnaround and those that are more reactive to emerging issues.[70] In the US, the STRAS, QHSR, IPTs, SBIR and USCG processes also exemplify this flexible approach to need identification. These mechanisms ensure that operational needs and emerging priorities are captured in a flexible and dynamic way before the allocation of resources to projects takes place. Further, as these processes are based on different implementation timelines with staggered decision-making points, this facilitates a continuous capturing of R&D needs.[71] Beyond DHS, DIUx maintains flexibility through an open call for research proposals, which it then assesses on a rolling basis (see Section 4.3 of the Technical Annex).

While important for encouraging investment in long-term research, multi-annual funding programmes such as the EU FPs are said to be less adaptable to the short-term needs of border guards. In the EU, for example, there is not yet a rapid funding mechanism that addresses short-term end user requirements.[72] Nonetheless, the EU offers several follow-on funding mechanisms that are reportedly designed to promote the application of research projects in the field, although their effectiveness could not be determined by the RAND study team based on the data available. These include InnovFin, the European Fund for Strategic Investments (EFSI), InvestHorizon and Progress TT, which are part of the 'Industrial Leadership' pillar of H2020. InnovFin and EFSI are both 'risk finance' instruments available to various types of organisation including small and medium-sized enterprises (SMEs), research centres, PPPs and joint ventures.[73] This type of funding can be used to develop, commercialise and deploy new technologies.[74] InnovFin provides direct loans designed to help 'support the smallest to the largest R&I projects in the EU and countries linked to Horizon 2020',[75] and EFSI helps finance 'infrastructure and innovation projects'.[76]

3.1.4. Coordinated research processes can help identify capability gaps and avoid duplication of effort across multiple teams or organisations

When multiple agencies and divisions are responsible for overseeing border security research, this can lead to duplicated efforts if research activities are not coordinated effectively.[77] Having a centralised entity or set of processes aimed at coordinating research efforts can help mitigate these problems, as well as supporting situational awareness of ongoing border security research activities.[78] In the US, for example, interviewees observed that IPTs demonstrate the benefits of coordinating DHS research processes in this way by linking research activities with the work of the DHS Joint Requirements Council to close existing

67 RAND Europe interview with Dragos Voicu, 11 April 2017.

68 H2020 regulations state that there should be at least three end user entities within a project. Source: RAND Europe interview with EU project officer, 26 June 2017.

69 RAND Europe interview with Dr John Coyne, 20 March 2017; RAND Europe interview with Australian representative, 30 March 2017; RAND Europe interview with DIBP representative, 29 March 2017.

70 RAND Europe interview with Australian representative, 30 March 2017.

71 DHS S&T (2015).

72 Technopolis (2015).

73 European Commission (n.d.-f.).

74 European Commission (n.d.-h).

75 European Commission (n.d.-f).

76 European Commission (n.d.-g).

77 Industry survey respondent (Survey O). See Section 2.3 of the Technical Annex.

78 2 respondents (Surveys A, E).

technology capability gaps.[79] Assigning responsibility for research coordination to one set of actors, such as IPTs, can promote a standardised approach to identifying and tracking research efforts, as well as centralising mechanisms for the identification and reporting of capability gaps. The US experience suggests that a more holistic understanding of research activities across agencies or divisions enables awareness of where research is not addressing capability gaps, which can then inform future research work and planning.

3.1.5. Networks of industry specialists and academic experts can drive research and innovation

Effective engagement between industry and academic stakeholders can also promote research and innovation. In the US, for example, the DHS SBIR and COEs have engaged with DoD contractors with technology development expertise in order to design innovative solutions with operational value. Stakeholder networks have also helped enable border security innovation in the EU: for example, through its Knowledge and Innovation Communities (KICs), the EIT has created innovation hubs that focus on thematic topics and involve collaboration between academic and business stakeholders.[80]

3.1.6. Regular evaluation of existing research processes can help ensure their continued fitness for purpose

It is important that existing research processes are monitored and evaluated at regular intervals to ensure that they remain fit for purpose over time. These evaluations should use a rigorous, evidence-based approach focused on delivery of tangible benefit to border security and other organisational goals. This involves ensuring that research providers capture a dashboard of relevant management information and Key Performance Indicators (KPIs) as a basis for monitoring and evaluation (M&E). The potential benefits of M&E in identifying 'what works' are demonstrated by the US case study: in response to the findings of a Government Accountability Office (GAO) evaluation of the performance of its research portfolio, DHS actively worked to address concerns regarding its limited supervision and coordination mechanisms for research activities by launching IPTs.[81] IPTs have reportedly mitigated the duplication of research efforts and 'stove-piping' across the department, providing a centralised platform for the identification and prioritisation of research needs (see Section 3.2.3). The results achieved by IPTs highlight the significant contribution that external evaluations can make to the internal processes, efficiency and accountability of a department or function – something which is particularly important when border security research is being conducted using taxpayer money and when multinational (i.e. EU) research initiatives must demonstrate value to MS.[82]

The importance of effective evaluation of research processes is also a key feature of the EU case study. Regular evaluations of EU Framework Programmes have been undertaken throughout their duration in order to 'steer the implementation of research and innovation programmes, as well as guide future Framework Programmes'.[83] The FP7 and H2020 programmes have both been, or will be, the subject of an interim and an ex-post evaluation. By conducting these evaluations, it is possible to assess whether research programmes remain relevant, continue to meet their objectives, offer added value, and remain efficient in their use of resources.[84] According to one interviewee, sharing lessons learned regarding the research process can be helpful for both the contracting party and the research provider.[85] Importantly, funding bodies must also have the will and the processes in place to act upon the findings of these evaluations and make effective interventions to support, restructure or re-orient research projects that are found to fall short of the required standards of value, good governance and relevance.

3.2. Challenges in translating research into operational practice

While the case studies highlight a number of good practices with regard to research, various challenges can also be identified in relation to end user involvement and decision making:

- **Challenges linked to end user involvement** include poorly defined 'impact' assessment criteria (Section 3.2.1), a disconnect between research providers and border guards' operational activities (Section 3.2.2), a lack of end user interest in research (Section 3.2.3), and issues relating to information sharing (Section 3.2.4).
- **Challenges linked to decision making** include IP constraints (Section 3.2.5) and a lack of available resources (Section 3.2.6), which can create further challenges for integrating research into operational practice.

The following sections explore these issues in more detail.

3.2.1. 'Impact' assessment criteria often lack a clear definition

While achieving impact is a central objective of research programmes across the case study countries, 'impact' is often poorly defined and lacks a clear set of assessment criteria. By focusing on this objective, research funders seek to improve operational practices, contribute to an enhanced understanding of policy issues, and build capacity through skills development.[86] As the EU case demonstrates, 'impact' is a core component of proposal review processes yet is often not measured in a systematic way by research funders (see Chapter 2 of the Technical Annex). Furthermore, the type of 'impact' that a proposed project will have is likely to depend on the whether the research undertaken is 'basic research' driven by interest in expanding knowledge, or 'applied research' designed to address practical problems rather than to acquire knowledge for knowledge's sake.[87]

79 RAND Europe interview with US representatives, May 2017.
80 EIT (n.d.-a).
81 GAO (2013).
82 DHS S&T (2015); GAO (2013).
83 European Commission (n.d.-e).
84 European Commission (n.d.-e).
85 RAND Europe interview with EU project officer, 26 June 2017.
86 Economic and Social Research Council (n.d.).
87 For further information, see also : RAND Europe (n.d.).

While H2020 proposals are required to describe a project's expected impact, the European Commission's interim H2020 evaluation notes that the programme lacks a rigorous, overarching system to assess 'research impacts'.[88] Study interviewees also observed that the 'expected impact' of H2020 research lacks a clear definition and noted a lack of guidance regarding the expected timelines for 'impact', which may vary depending on the focus of research and the specific type of impact sought.[89] At the MS level, various indicators of successful impact are applied, including the efficiency of operations drawing on research outputs,[90] the provision of positive end user feedback concerning research-based solutions,[91] or the financial impact of research-based solutions applied in the field.[92] Similarly, in the Australian case, it is not clear from the information collected by the study team whether 'impact potential' is measured in any formal way.[93]

Furthermore, under existing research processes, there are often limits on the ability of research providers to directly influence operational 'impact' in the field. In Canada, for example, the primary role of the Defence Research and Development Canada Centre for Security Science (DRDC-CSS) programme is reportedly to present decision makers in the Canada Border Service Agency (CBSA), the Royal Canadian Mounted Police (RCMP) and other operational agencies with evidence upon which to base their decisions. While the implementation of research outputs is viewed as a desirable outcome within the DRDC-CSS programme, it is recognised that the decision to deploy a technology, or to implement recommendations from border security research, ultimately rests with the operational agencies.

3.2.2. A disconnect remains between research and operational practice

Despite ongoing efforts to strengthen links between border security research and operational practice, challenges remain in relation to the operationalisation of research in many cases. As outlined in Section 3.2.1, end users have been involved extensively at various stages of the research and innovation pathway in many different organisations. They not only sit on project advisory boards and review deliverables, but also contribute to the prioritisation of research areas, participate in workshops and demonstrations, and lead the consortia responsible for delivering research projects. Regardless of these efforts, not all research products are successfully translated into operational practice, and the practical impact of research is not always tracked after the end of a project.

Several factors are said to contribute to this disconnect between research and operational practice. Several study participants highlighted a lack of communication between research providers and end users.[94] Similarly, one EU report notes that the communication of research results to end users should be improved.[95] At the proposal stage, the border security experts responsible for evaluating proposals are not always sufficiently aware of practitioner needs and the wider operational context.[96] As a result, the resulting research is not always operationally focused or applicable for end users. As highlighted by one study interviewee, challenges can also arise when border security research does not take into account affordability constraints facing border guards or the compatibility of research-based solutions with the technology and legacy systems already in use in the field.[97] In these cases, the results of research tend to remain on paper and fail to make any lasting impact beyond the end of the project.

Problems can also arise when there is a substantial time lag between need identification by operational agencies and the launching of a research programme aimed at addressing these requirements (see Section 3.1.3). This is because a prolonged lag between these two phases could lead to the development of research products that meet operational needs that have since evolved or disappeared.[98] It is important that needs and priorities emerging from sudden changes in the threat landscape can be captured and quickly investigated through research work (see Section 3.1.3).

3.2.3. A lack of end user uptake can hinder innovative operational practices

A lack of interest among border guards in new research products can also impede their operational application. According to one study interviewee, end users are often not interested in research products because they are operationally focused 'generalists' with responsibility for a range of tasks, and therefore tend to focus on using existing tools and processes to conduct their day-to-day activities, rather than engaging with unfamiliar alternatives.[99]

In the EU case study, it was reported that a lack of end user uptake is related to their lack of effective involvement in research.[100] Despite recent improvements in engaging end users in EU-funded research (see Section 3.1.1), factors such as end users' unfamiliarity with H2020 financial rules, intermittent project engagement, and lack of engagement in technical research are said to remain areas for improvement.[101]

In certain countries, such as Turkey, political sensitivities can lead to reluctance among border guards to incorporate new research-based solutions into their operational practice. In the Turkish case, following the attempted coup in July 2016, many police and military officials, civil servants and academics were made redundant, leading to reluctance among these stakeholder groups to discuss border security and related research with

88 European Commission (n.d.-c).
89 European Commission (n.d.-c).
90 1 respondent (Survey E).
91 1 respondent (Survey F).
92 1 respondent (Survey G).
93 RAND Europe interview with Australian representative, 30 March 2017.
94 Industry survey respondent (Survey O); RAND Europe interview with Peter Ryman, 20 September 2017.
95 European Commission (2017b).
96 RAND Europe interview with FP7 project coordinator, 31 March 2017; industry survey respondents (Surveys L, O).
97 RAND Europe interview with Frontex representative, 19 April 2017; RAND Europe interview with EU institution representatives, 24 April 2017.
98 RAND Europe interview with US representatives, May 2017.
99 RAND Europe interview with Phil Lightfoot, 19 April 2017.
100 Industry survey respondent (Survey O); RAND Europe interview with EU project officer, 26 June 2017.
101 RAND Europe interview with EU project officer, 26 June 2017.

end users (see Section 3.4 in the Technical Annex). One way of mitigating this issue and increasing the interest of border guards in research outputs is by involving them more continuously and effectively in research processes (see Section 3.1.1). Other ways include improving communication around H2020 financial rules and procedures, and doing more to share examples of the effective operationalisation of EU-funded research outputs.

3.2.4. Poor information exchange limits awareness of ongoing research activities

A good understanding of the links between research processes, stakeholder networks and project results is important and can be achieved by coordinating research processes (see Section 3.1.3). For end users to implement research-based solutions, it is essential that they are aware of research findings and recommendations. For example, the ESA offers a centralised repository of information on completed research and ongoing research opportunities, with key publications, forums and news items posted on its Industry Web Portal.[102] DHS S&T Centres of Excellence also have a web portal that provides academic institutions with information regarding funding opportunities, COE projects, COE-related events, and project results and achievements. Other means of sharing information include involving end users in the research. For example, the EU H2020 programme requires that at least three members of the proposed consortium represent the end user community. Proactive outreach and engagement can also raise awareness of the outputs of research activities with, for example, SBIR running technology demonstrations with a view to attracting investors.

However, challenges remain in disseminating this information. For example, one EU MS survey respondent reported that national authorities are not always kept up to date with the latest EU border security research developments due to reported shortcomings in interagency cooperation.[103] As a result, MS may in some cases lack a comprehensive situational understanding of research activities undertaken across the EU. More could be done at both the EU and MS levels to facilitate information exchange across MS and organisations involved in border security research.[104]

While Frontex has set up an online platform for sharing research content (Border Tech-Net),[105] one interviewee noted that this website would benefit from further inputs from border guards in order to provide a comprehensive picture of border security research activities undertaken across the EU and its MS.[106] While MS participation in EU-funded research remains high, another EU MS survey respondent reported that MS often lack access to information regarding project results that could help border guards integrate these lessons into operational practice.[107]

3.2.5. IP constraints can create barriers to the continued development of research

A further challenge relates to the treatment of IPR within research programmes in a number of countries. Under the EU system, for example, IPR rules stipulate that project partners retain IPR to the products resulting from their EU-funded research. While the model grant agreement provides a 'general obligation for beneficiaries to exploit and disseminate the project results that they own' and to grant access rights to the project,[108] project IPR still often remain with the developers, meaning that it can be difficult for research products to be applied in practice by border guards. According to industry survey respondents, IPR challenges are also linked to the consortium model for EU-funded research projects, as it can be difficult for the various partners to arrive at a commercial agreement.[109] This can play a role in constraining border guards not directly involved in the research from developing the findings further and applying them in practice.[110] This approach contrasts with the US approach (see Chapter 3.1 of the Technical Annex), whereby all property developed through US-funded research programmes is federally owned and research can be further developed and exploited by border guards.[111]

3.2.6. A lack of available resources can impede implementation of research products

A shortage of funding for the operationalisation of research activities is a constraint affecting several of the case study countries. For example, the evaluation of the FP7 programme found that EU Framework Programmes lack the funding to support the commercialisation and implementation of research findings.[112] Limited funding for research and manpower shortages were also mentioned as key challenges facing MS survey participants.[113] Similarly, in the Canadian case, the majority of border security resources are reportedly allocated to the improvement of cross-border infrastructure and other operational priorities, while far less have been assigned to longer-term border security research projects and their implementation.[114] For available funding to be allocated to border security research, it is important to demonstrate the value of research through, for example, securing the buy-in of senior 'champions' within relevant agencies (see Section 3.1.2).

Table 3.1 on the right provides a comparative overview of the key challenges and areas of good practice discussed in this chapter.

102 Please refer to Section 4.1 of the Technical Annex.
103 MS survey respondent (Survey C). Please refer to Section 2.2 of the Technical Annex.
104 MS survey respondent (Survey C).
105 Border Tech-Net/ Frontex. 2017.
106 RAND Europe correspondence with Dragos Voicu, 27 September 2017.
107 MS survey respondent (Survey B).
108 European IPR Helpdesk (n.d.).
109 Industry survey respondents (Surveys M, N, O).
110 RAND Europe interview with Frontex representative, 19 April 2017; industry survey respondents (Surveys M, N, O).
111 RAND Europe interview with Frontex representative, 19 April 2017; Freeman et al. (2015). The extent to which US-funded research is developed further by border guards is not clear from the interviews conducted as part of this study.
112 Technopolis (2015). However, it should be noted that this is a constraint that does not affect all EU funding programmes: for example, EU MS reportedly only use half of the funding available to them through the Internal Security Fund (ISF) (RAND Europe interview with Frontex representative, 19 April 2017).
113 4 respondents (Surveys B, C, D, E).
114 RAND Europe interview with Canadian representative, 21 April 2017.

Table 3.1 **Summary of lessons identified from case studies**[115]

Selected case study evidence	
Good Practices	
End user involvement (*Section 3.1.1*)	**EU**: Frontex's involvement on the advisory boards of numerous EU-funded projects helps tailor research to border guard requirements and context (see Technical Annex Section 2.1). **Canada**: Annual Public Safety Canada meetings are held with border management agencies to discuss operational priorities, which feed into the development of invitations to tender (see Technical Annex Section 3.2). **ESA**: The ESA engages with users of space technologies in order to ensure that its programmes reflect operational needs and context (see Technical Annex Section 4.1).
Engagement with leadership (*Section 3.1.2*)	**Australia**: Positive organisational changes in the DIBP are reportedly linked to strong engagement at the senior leadership level in encouraging innovation and research partnerships (see Technical Annex Section 3.3).
Flexible funding models (*Section 3.1.3*)	**EU**. The EU offers several follow-on funding mechanisms reportedly designed to support the operationalisation of research, e.g. InnovFin, EFSI and InvestHorizon (see Technical Annex Section 2.1). **Australia**: DIBP's approach to funding research has become more responsive to emerging issues in recent years, with commissioned research increasingly focusing on studies with a shorter turnaround (see Technical Annex Section 3.3). **DIUx**. In the US, DIUx maintains flexibility through an open call for research proposals, which are then assessed on a rolling basis (see Technical Annex Section 4.3).
Coordinated research processes (*Section 3.1.4*)	**US**: IPTs link research activities to the work of the DHS Joint Requirements Council in order to close existing technology capability gaps (see Technical Annex Section 3.1).
Networks of industry and research experts (*Section 3.1.5*)	**SBIR and COE**: SBIR and COEs work with DoD contractors with technology development expertise in order to design innovative solutions (see Technical Annex Sections 4.4 and 4.6). **EIT**: Through its KICs, the EIT has created innovation hubs that involve engagement between academic and business stakeholders (see Technical Annex Section 4.2).
Evaluation of research processes (*Section 3.1.6*)	**EU**: The FP7 and H2020 programmes have both been, or will both be, the subject of an interim and an ex-post evaluation (see Technical Annex Section 2.1). **US**: In response to GAO evaluation findings, DHS has worked to address concerns regarding its limited research supervision mechanisms by launching IPTs (see Technical Annex Section 3.1).
Challenges	
'Impact' criteria poorly defined (*Section3.2.1*)	**EU**: While H2020 proposals are required to describe a project's expected impact, the interim H2020 evaluation notes that there is not an overarching system in place to assess 'research impacts' (see Technical Annex Section 2.1).
Disconnect between research and operational practice (*Section 3.2.2*)	**EU**: According to EU MS survey respondents, there is a gap between research and operational practice due to (among other factors) a lack of communication between research providers and end users (see Technical Annex Section 2.2).
Lack of end user interest in research (*Section 3.2.3*)	**Turkey**: Following the attempted coup in July 2016, political sensitivities in Turkey have led to reluctance among end users to discuss border security and related research (see Technical Annex Section 3.4).
Poor information exchange (*Section 3.2.4*)	**ESA**: To address information-sharing challenges, the ESA's Industry Web Portal offers a centralised repository of information on completed research and ongoing research opportunities (see Technical Annex Section 4.1).
IP constraints (*Section 3.2.5*)	**US**: All property developed through US-funded research programmes is federally owned and research can be further developed and exploited by border guards. This contrasts with the **EU** system (WP1), whereby IPR rules state that project partners retain IPR to research products (see Technical Annex Sections 2.1 and 3.1).
Lack of available resources (*Section 3.2.6*)	**Canada**: Most border security resources are allocated to improving cross-border infrastructure, while far less funding is provided for border security research (see Technical Annex Section 3.2).

115 This table is not intended to be exhaustive: it highlights the main challenges and areas of good practice identified through the literature review, interviews and surveys, with 1–3 examples cited for each area. It is recognised that there are likely to be additional good practices and challenges that are not captured here.

4. Functional roles for R&I organisations

Following the scoping of good practices and challenges outlined in Chapter 3, the study team conducted a more in-depth analysis of functional roles for R&I organisations in order to inform a set of recommendations for Frontex (see Chapter 5). This chapter outlines different functional roles that a range of organisations and institutions have adopted along the research and innovation pathway presented in Chapter 2. Appendix D of the Technical Annex explains these roles in more detail.

4.1. Overview of functional roles for R&I

After developing the research and innovation pathway described in Chapter 2, the project team conducted a series of case studies (WP3). The purpose of these case studies was to understand how different organisations, operating in the border security domain as well as in other sectors, position themselves along this pathway and what roles they play in facilitating research and innovation (see Chapter 4 of the Technical Annex). Case studies include:

- European Space Agency
- European Institute of Innovation & Technology
- US Defense Innovation Unit Experimental
- US Small Business Innovation Research
- US Homeland Security Innovation Programs
- US network of Centers of Excellence.

The analysis of these case studies, combined with findings from other recent RAND Europe research on innovation models,[116] allowed the project team to identify a set of specific functional roles for organisations coordinating research that characterise organisations that are successful in supporting a clear research and innovation pathway for border security research. Although the WP3 case studies were the primary basis for identifying these functional roles, the case studies of research within and beyond the EU (WP1–2) also provided relevant examples, as elaborated below.

The functional roles are presented in the following sections, with more detailed information found in Appendix D of the Technical Annex. These are intended to summarise existing roles undertaken by organisations involved in research and innovation in a range of sectors, including border security. While these roles are grouped by theme (e.g. providing thought leadership, hosting innovation), the WP1-3 case study evidence does not indicate that the roles are mutually exclusive or that it is necessary to undertake them in a particular order. The following paragraphs offer descriptions and examples of these functional roles, and serve as a basis for the recommendations presented in Chapter 5.

4.1.1. Coordinating requirement identification and setting

Role 1.1: Performing horizon scanning[117] to identify security threats and innovation opportunities

- Description: Systematically examining information in order to identify innovation opportunities and potential risks and threats relating to security, the environment and the political climate, which allows for better preparedness and decision making.
- Example: In the US, the DHS Science and Technology directorate (S&T) undertakes a horizon-scanning function and a 'technology-scouting' process to research and evaluate specific technology landscapes.[118]

Role 1.2: Analysing the operational needs of end users

- Description: Engaging end users in research planning in order to help ensure that priorities are set and funds allocated in a way that takes operational requirements into consideration – this input can be captured through various mechanisms, including meetings and an analysis of capability gaps.
- Examples: In the US, DHS S&T has adopted a STRAS to ensure that S&T efforts are aligned with operational requirements. DHS has also launched IPTs in order to mitigate duplication of research effort; and the USCG has implemented an Idea Submission Review (ISR) process that allows project ideas to be submitted from within the USCG.[119] In Canada, annual meetings take place between Public Safety Canada and operational agencies (Canada Border Services Agency, Royal Canadian Mounted Police and Immigration, Refugees and Citizenship Canada) in order to better understand agencies' operational priorities and interests.[120]

4.1.2. Providing thought leadership

Role 2.1: Conducting research in house

- Description: Participating in research and innovation, whether through actively leading research projects or

116 Freeman et al. (2015).

117 'Horizon scanning' is a technique for detecting early signs of potentially important developments through a systematic examination of potential threats and opportunities, with emphasis on new technology and its effects on the issue at hand. See Organisation for Economic Cooperation and Development (OECD) (n.d.).

118 Please refer to Appendix D of the Technical Annex.

119 Please refer to Section 3.1 of the Technical Annex.

120 Please refer to Section 3.2 of the Technical Annex.

contributing to research activities in a more secondary, supportive capacity.
- Examples: In the US, S&T is the primary R&D organisation within DHS, with responsibility for the RD&I programme that involves conducting basic and applied research.[121] In the EU, Frontex contributes to border security R&I activities through, for example, its role on project advisory boards.[122]

Role 2.2: Influencing policy developments
- Description: Providing independent advice and recommendations to key decision makers on innovative means to address future security challenges.
- Examples: The US Defense Innovation Board was introduced in order to provide independent advice on innovative means of addressing future challenges for defence.[123]

4.1.3. Facilitating information provision and knowledge transfer

Role 3.1: Centralising information on R&I opportunities
- Description: Presenting information regarding R&I funding in a consolidated and easily accessible way, for example on a single webpage or on an openly accessible database – this can help raise awareness regarding R&I opportunities among research stakeholders, industry representatives and end users, at both the EU and MS levels.
- Examples: The study research did not identify an organisational example; this was a gap identified by Frontex study interviewees.[124]

Role 3.2: Sharing information on operational impacts of research
- Description: Systematically communicating information on how research results have been integrated into operational practice after the end of each project, for example through press releases, briefings and other communications activities – this is aimed at increasing awareness among end users of the operational benefits of EU-funded research.
- Examples: The study research did not identify an organisational example; this was a gap identified by Frontex study interviewees.[125]

Role 3.3: Facilitating knowledge transfer
- Description: Systematically capturing lessons learned during project implementation and after project completion to build a repository of good practices and inefficiencies, with a view to supporting MS and other relevant authorities in the setup and management of future research and innovation.
- Examples: NATO has set up a Joint Analysis and Lessons Learned Centre aimed at capturing lessons in a systematic way and, among other activities, managing the NATO Lessons Learnt Portal.[126]

Role 3.4: Delivering training and education for end users
- Description: Delivering training for end users on the use of newly developed technologies to support the uptake and operationalisation of tools, technologies and other solutions developed through R&I.
- Examples: In the US, the DHS S&T COE model provides education and training through, for example, the Military Services Academics Program.[127] In the EU, the ESA provides education and training for astronauts through its European Astronaut Centre.[128]

4.1.4. Providing an 'honest broker'[129] function

Role 4.1: Facilitating coordination and cooperation between industry, academia, policy officials and practitioners
- Description: Cultivating relationships between research, industry, policy officials and end users in order to help develop greater cross-sector partnerships – this involves moving away from more contractual customer/supplier relationships to an increased focus on innovation in partnership towards a shared endeavour, which would be encouraged by an 'honest broker' organisation that would also identify opportunities for these partnerships.
- Examples: In the EU, Frontex organises events that bring together end users, research providers and industry.[130] An FP7 project, SOURCE, aims to create a virtual centre of excellence to help with networking, research, information gathering and education.[131] In the US, funding opportunities for COEs are open to US universities and colleges, who are encouraged to partner with industry. One example is the Borders, Trade and Immigration Institute (BTI), which focuses on developing technology-based tools, techniques and educational programmes.[132]

Role 4.2: Supporting coordination and cooperation between industry, academia, nations and investors (e.g. venture capitalists)
- Description: Supporting innovation by coordinating the actions of third parties, rather than by directly funding or performing the work – for example, facilitating regular interactions among the members of the private venture capital community, small innovative companies and end users.
- Examples: In the US, the Defense Venture Catalyst Initiative (DeVenCI) supports R&D by coordinating the actions of third parties, and facilitates regular interactions among stakeholders within the private venture capital community.[133]

121 Please refer to Section 3.1 of the Technical Annex.
122 Please refer to Section 2.1 of the Technical Annex.
123 Mehta (2016).
124 Please refer to Section 2.1 of the Technical Annex.
125 Please refer to Section 2.1 of the Technical Annex.
126 NATO (n.d.).
127 Please refer to Section 4.6 of the Technical Annex.
128 Please refer to Section 4.1 of the Technical Annex.
129 An 'honest broker' is an organisation that actively seeks and encourages partnership-oriented relationships with external actors. See Freeman et al. (2015).
130 Please refer to Section 2.1 of the Technical Annex.
131 SOURCE (n.d.).
132 Please refer to Section 4.6 of the Technical Annex.
133 Webb et al. (2012).

4.1.5. Hosting innovation

Role 5.1: Running technology demonstrations

- Description: Presenting a prototype or incomplete version of a future system, put together as proof of concept with the purpose of showcasing the possible applications, feasibility, performance and method of a new technology. Demonstrations can be run for potential investors, researchers or end users in order to test the technology and convince these stakeholders of the viability of the chosen approach. It also presents an opportunity to gather end user feedback and make adjustments to the prototype or concept to better deliver value to end users and increase the probability of successful commercialisation.
- Examples: In the EU, H2020 projects often involve technology demonstrations that bring together academic, industry and end user stakeholders.[134] In Canada, the Technology Demonstration Programme funds one or more large-scale R&D projects per year.[135]

Role 5.2: Running prize competitions or 'grand challenges'

- Description: Running innovation competitions to encourage industry experts to attempt to solve innovation challenges – by offering financial or other incentives ('prizes'), these initiatives can help entrepreneurs grow their business ideas, connect them to investors and global markets, and strengthen their innovative capabilities for the benefit of industry, end users and wider society.
- Examples: In the US, the Defense Advanced Projects Research Agency (DARPA) Grand Challenges is a cash prize competition for autonomous vehicles.[136] DHS S&T also runs the 'InnoPrize' Programme which focuses on addressing innovation gaps: in 2015, for example, the challenge focused on sensors and communication.[137] The National Institute of Standards and Technology also runs a similar challenge on the topic of 'Virtual Public Safety Test Environment' in order to identify new first responder technologies.[138]

Role 5.3: Launching an innovation incubator

- Description: Hosting an innovation 'incubator' or 'hub' on an organisation's premises, which can strengthen innovative capacity by bringing together key stakeholders from academia, industry and end users, and by offering skills training and key infrastructure (e.g. labs, IT tools). An incubator can also be virtual (i.e. run online).
- Examples: The NATO Cyber Incubator tests ways of strengthening pre-competition cooperation between industry (including SMEs), academia and NATO's technical community.[139]

4.1.6. Facilitating access to funding

Role 6.1: Providing direct R&I funding

- Description: Providing grants, subsidies, subsidised loans and equity financing for R&I, often (although not always) offered on a competitive basis.[140]
- Examples: In the EU, H2020 and Frontex provide funding for research projects.[141] In the US, HSIP provides direct funding for R&I start-ups.[142]

Role 6.2: Facilitating access to available funding instruments

- Description: Raising awareness on how to access funding opportunities. For each funding programme, this involves providing details regarding its purpose, activities, timeframe, budget, eligibility, and application process.
- Examples: The European Defence Agency has a centralised webpage that presents information on EU funding opportunities.[143] In the US, DHS S&T has a grants resource webpage that presents information on available grants.[144]

Role 6.3: Using procurements to 'pull' innovative solutions from the market

- Description: Providing funding for R&I projects designed to address short-term, high-priority end user requirements that need to be addressed quickly.
- Examples: In the US, the Rapid Innovation Fund allows small businesses to provide DoD with innovative technologies that can be rapidly inserted into acquisition programmes that meet specific defence needs.[145]

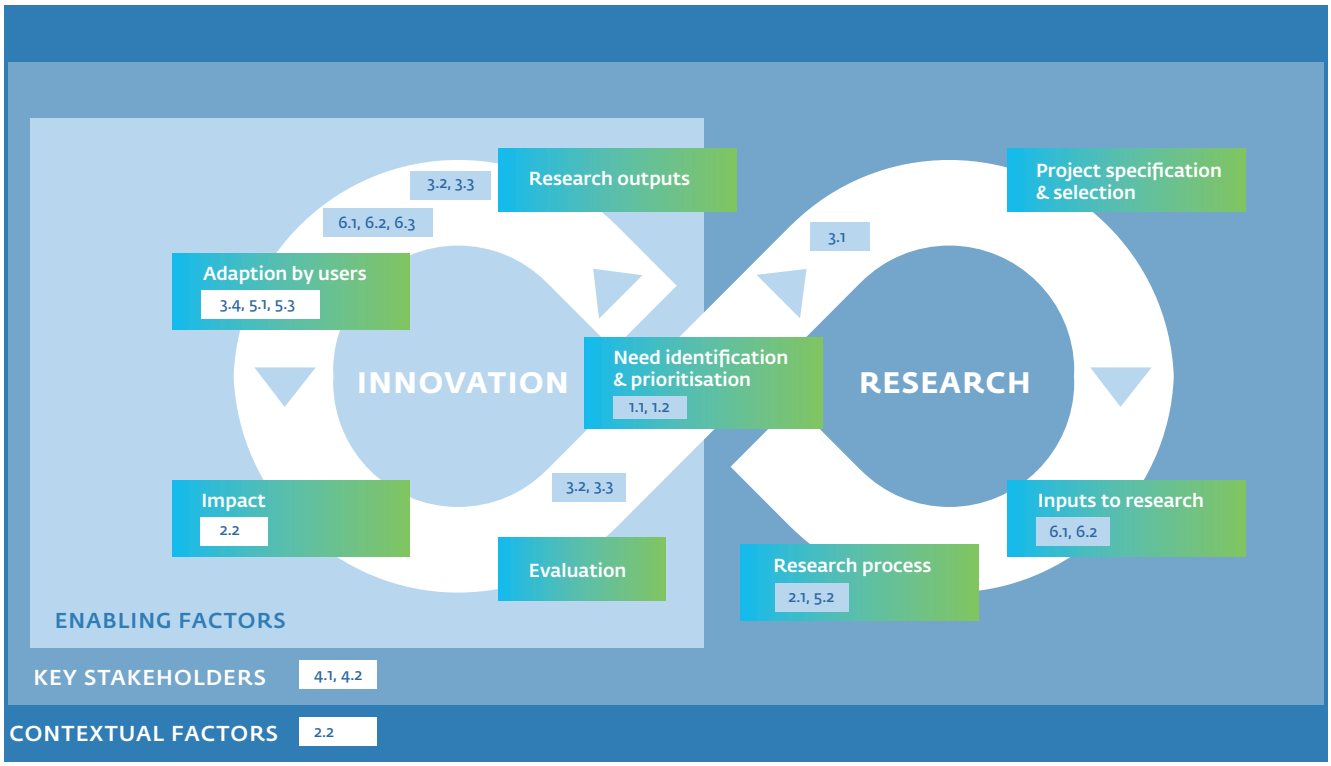
4.2. Mapping roles onto the research and innovation pathway

When considering the placement of the roles described above onto the research and innovation pathway (see Figure 4.1), the majority of roles are shown to be enablers or connectors between the different steps, rather than being an integral part of a specific step. In practice, this means that it is important to ensure that core R&I activities (need identification, research, evaluation, etc.) do not take place in isolation. Rather, these activities should be coherent and mutually supportive in order to sustain the feedback loops within the pathway.

In addition, some of these specific functions can appear in multiple locations. For example, direct funding could be provided to support the research itself or, once the research is completed, support the transition of research outputs into operational practice. This could be achieved by sponsoring capability demonstrations or the advancement

134 Please refer to Section 2.1 of the Technical Annex.
135 Please refer to Section 3.2 of the Technical Annex.
136 DARPA (2014).
137 DHS (n.d.-a); Global Biodefense (2015).
138 Challenge.gov (n.d.).
139 NATO (2015).
140 Non-competitive funding can also be offered through, for example, sole-source mechanisms where the funding is intended for a unique technology or where it has to be allocated within a short timeframe.
141 Please refer to Section 2.1 of the Technical Annex.
142 Please refer to Section 4.6 of the Technical Annex.
143 European Defence Agency (2017).
144 DHS (n.d.-b).
145 Defense Innovation Marketplace (2017).

Figure 4.1 **Functional roles and the research and innovation pathway**



Source: RAND Europe analysis.

of the research output through successive TRLs.[146] In addition, some roles may be linked to broader aspects (e.g. wider context, or key stakeholders) and may therefore have an impact on the entire pathway. Figure 4.1 illustrates how the study team has mapped the functional roles onto the research and innovation pathway, listing each option by number (explained in Table 4.1, on the right).

Table 4.1 **Numbering of functional roles**

Number	Description of functional role
1.1	Performing horizon scanning to identify security threats and innovation opportunities
1.2	Analysing the operational needs of end users
2.1	Conducting research in house
2.2	Influencing policy developments
3.1	Centralising information on R&I opportunities
3.2	Sharing information on operational impacts of research
3.3	Facilitating knowledge transfer
3.4	Delivering training and education for end users
4.1	Facilitating coordination and cooperation between industry, academia, policy officials and practitioners
4.2	Supporting cooperation between industry, academia, nations and investors (e.g. venture capitalists)
5.1	Running technology demonstrations
5.2	Running prize competitions or 'grand challenges'
5.3	Launching an innovation incubator
6.1	Providing direct R&I funding
6.2	Facilitating access to available funding instruments
6.3	Using procurements to 'pull' innovative solutions from the market

146 Please refer to Appendix F of the Technical Annex for a definition of 'TRL' and other key terms.

5. Ways forward for Frontex

This chapter draws on the findings of all case studies conducted as part of this project, as well as the R&I pathway provided in Chapter 2, to identify opportunities for Frontex to improve the status quo by developing new solutions or expanding existing initiatives. The recommendations presented in this chapter build on the outcomes of the external expert workshop held at Frontex's premises in September 2017, at which over 30 representatives of national border agencies, European institutions and Frontex itself were asked to analyse and prioritise the functional roles described in Chapter 4[147]. The findings of the workshop were further analysed at two internal expert workshops, in October and November 2017, to generate the recommendations presented below.

Table 5.1 **Overview of recommended interventions**

Recommendation 1:

Frontex should facilitate access to information, knowledge and networks for relevant national and EU institutions, industry, academia and investors

- *Intervention 1.1:* Frontex should create a centralised repository of information related to existing and prospective research initiatives, funding opportunities and successful implementation of research outputs.
- *Intervention 1.2:* Frontex should create a mechanism for the systematic capturing and sharing of lessons identified to inform the future setup, management and operationalisation of research projects, both within the organisation and within MS.
- *Intervention 1.3:* Frontex should play an active role in brokering connections between stakeholders, including research and innovation providers and recipients.

Recommendation 2:

Frontex should establish mechanisms to ensure that research projects are designed, selected and implemented to be relevant for identified operational needs

- *Intervention 2.1:* Frontex should create a mechanism to systematically collect information on the development of technological solutions with specific applications and potential added value for border security.
- *Intervention 2.2:* Frontex should centralise information on national operational requirements with a view to supporting harmonisation where applicable. In this context, Frontex should also support innovative approaches to 'pull' innovation ideas from end users themselves, in addition to more traditional 'top-down' approaches.
- *Intervention 2.3:* Frontex should adopt a 'research champion' role in order to inform policy and decision making within EU institutions, ensuring that border security research priorities and themes established at the EU level are tailored to the most up-to-date user requirements and technological developments.
- *Intervention 2.4:* Frontex should integrate traditional research selection and implementation processes, which are generally focused on technical requirements, with more innovative approaches focused on problem statements and desired end state, without imposing too many restrictions on solutions.

Recommendation 3:

Frontex should facilitate and support the uptake and operationalisation of research outputs by end users

- *Intervention 3.1:* Frontex should establish mechanisms to maintain the continuous engagement of end users during the research and innovation process.
- *Intervention 3.2:* Frontex should facilitate access to funding that could be used to bridge the gap between the completion of the research project and the commercialisation of the technology. This may include the provision of direct funding, the facilitation of access to available EU funding instruments, and/or the establishment of efficient networks and connections with investors (e.g. venture capitalists).

5.1. Defining Frontex's role in research and innovation for border security

Chapters 3 and 4 identified a series of good practices that could, if implemented, support a more efficient and effective operationalisation of research outputs. Within this general context, a key question is how to define the role that Frontex could play in the research and innovation domain.

In general terms, based on a synthesis of stakeholder and expert views gathered through this study,[148] Frontex's role should be to consolidate and accelerate the delivery of border security outcomes through research and innovation by:

1. Acting as an honest broker between end users, MS, the European Commission, industry, academic experts and other stakeholders;
2. Helping bridge the gap between research outputs and operational implementation by EU MS border agencies; and
3. Evaluating and disseminating research outputs and outcomes, as well as their impact on operational practice.

In order to fulfil this role, the project team identified nine interventions, which were grouped under three high-level recommendations linked directly to the three roles described above. These are listed in Table 5.1 and further analysed in Section 5.2.

In assessing the viability of each recommendation and intervention, Frontex should consider the internal implications and the changes for implementation would require in relation to resources, mandate, staff, and existing processes and procedures.[149]

These recommendations and related interventions are not intended to be cumulative (i.e. they can be implemented individually and in any order) or mutually exclusive. They are, however,

147 See Appendixes D and E in the Technical Annex for further details on the workshop.

148 Stakeholder workshop at Frontex, Warsaw, 5 September 2017; internal expert workshop at RAND Europe, Cambridge, 5 October 2017.

149 This type of feasibility assessment is outside of the scope of this study.

interconnected and mutually reinforcing. The order and extent of Frontex's implementation of these recommendations is dependent on the level of ambition and available resources.

The purpose of this study is not to prioritise or recommend any specific intervention over another, but rather to present, in a structured way, interventions that Frontex may want to consider as it rethinks its role in the context of research and innovation for border security.

5.2. Providing implementation guidelines for Frontex

The following sections provide more detailed information on each recommendation by elaborating on:

- The challenge that each recommendation is designed to address
- Implementation-focused descriptions of specific interventions, including:
  - Key actors involved;
  - Description of benefits;
  - Description of risk (defined as factors impacting the probability of failure to achieve the desired outcomes);
  - Indicative assessment of the timeframe necessary to implement the intervention;
  - Considerations on drivers of costs (specific figures are given only in relation to known examples of good practices); and
  - Examples of good practices.

It is relevant to note that considerations and assessments of time and costs are made assuming that each recommendation is technically feasible (e.g. it is supported by existing regulations and resources). More detailed discussion of this caveat is presented in Section 5.3.

5.2.1. Accessing information, knowledge and networks

SUMMARY OF CHALLENGE
Study participants highlighted a lack of awareness of current research initiatives in Europe among a number of national border security agencies. The evidence also points to limited understanding of the various funding vehicles available, both in terms of funding opportunities for border security research, and in terms of funding available to help operationalise the research outputs. Furthermore, limited engagement with end users adversely affects project uptake.[150]

RECOMMENDATION 1:
Frontex should create means and opportunities that facilitate access to information, knowledge and networks by relevant national and EU institutions, industry, academia and investors.

Intervention 1.1

Frontex should create a mechanism (for example a web platform) to support access by MS, industry and academia to a centralised repository of information related to existing and prospective research initiatives, funding opportunities and successful implementation of research outputs.

This web platform could build on the existing Border Tech-Net (BTN) if appropriate, or it could be developed as part of a new Frontex-owned web platform. This intervention is based on the assumption that enhancing BTN is the most viable and cost-effective solution, but this assumption should be verified as part of a feasibility study (see Section 5.3).

Frontex could build on its BTN web platform in order to centralise access to all European research calls related to border security, whether issued by Frontex or other organisations. Targeting potential research providers (e.g. industry and academia), BTN should also provide guidelines on how to apply for different EU funds (e.g. H2020, Internal Security Fund), with a view to increasing awareness of available funding vehicles (see also Intervention 3.2 for further details). BTN should also be leveraged to provide information on future areas, or technologies, of particular interest for border security, building on the outcomes of a more proactive approach to horizon scanning and needs identification (see Intervention 2.1 for further details).

With respect to MS, BTN should contain a repository of completed research projects related to border security (implemented by Frontex or otherwise, including national and multinational cooperation projects that can be presented in the public domain). BTN should also be used to share analysis briefs prepared by Frontex (using a simple template with a two-page cap) on the prospective benefits and impact that such projects could have on operational practices and identified needs. These analysis briefs should be prepared with a view to providing relevant national border authorities with a concise and user friendly description of the 'so what' related to each project, as well as a clear indication of the next steps required to bring project outputs to fruition. These Frontex-led briefs could be hosted on a restricted-access section of BTN, visible only to MS, should the information contained be considered too sensitive to share openly. Should Frontex consider this activity unsustainable over time, the responsibility for populating these forms could be transferred to research providers.

BTN could also be leveraged to promote more active engagement and information exchange between R&I providers and recipients. This could be achieved through the creation of a discussion forum administered and moderated by Frontex.

Finally, the BTN platform could be used to facilitate access to experts from academia or industry by fully developing the existing 'Key Players' webpage. Experts could be identified by leveraging existing Frontex networks. This centralised contact book of border security R&I experts would facilitate the identification of SMEs for inclusion in future project proposals.

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

150 Please refer to Section 3.2 of this report and Section 2.1 of the Technical Annex.

- **Key actors involved:**
  - Implementing agency: Frontex
  - Other actors/beneficiaries: border guard agencies, industry, academia, investors.
- **Description of benefits:** This platform would offer a 'one-stop shop' for all information regarding border security R&I by centralising information that is already available on different websites. In addition, this platform would facilitate and stimulate dialogue between industry, academic experts and end users.
- **Description of risks:** The main risk associated with this intervention is a potential lack of engagement with the new platform from MS, industry, academic experts or investors. This might be due to a lack of awareness of its existence, or a decrease in interest if the platform is not seen to bring benefits. Should Frontex decide to implement this intervention, it should consider planning an outreach campaign to ensure that maximum visibility is given to the enhanced BTN platform. In addition, it should allocate sufficient resources to ensure that the content is updated regularly. Depending on the uptake of the forum tool, moderating and administrating the portal might become particularly time-intensive.
- **Indicative assessment of timeframe:** Less than 6 months, as the intervention would build on the existing BTN platform.
- **Considerations on costs:** Considering that the BTN platform is already operating, the main cost sources would be limited to the refitting of the website architecture and development of new content. Long-term staff costs are likely to increase as the portal increases its content and traffic, potentially requiring full-time staff allocated to the administration and maintenance of the platform.
- **Examples of good practice:**
  - The ESA has an online web portal (Electronic Mailing Invitation to Tender System – EMITS) that provides interested parties with up-to-date information on existing and prospective research initiatives. The purpose of this portal is to support fair competition and allow access to ESA's procurement for all interested parties, including industry, research institutions, universities and ESA MS delegations. This portal offers a centralised list of Intended Invitations to Tender (IITT) and a list of live Invitations to Tender (ITT).[151]
  - The EDA has a centralised webpage presenting information on EU funding opportunities, which aims to raise awareness across the European Defence Technological and Industrial Base (EDTIB) on how to access this funding. The webpage focuses in particular on European Structural and Investment Funds (ESIF), the new EU COSME (Competitiveness of Enterprises and SMEs) programme and H2020.[152]

Intervention 1.2

Frontex should create a mechanism for the systematic capturing and sharing of lessons identified to inform the future setup, management and operationalisation of research projects, both within the organisation and within MS. These lessons should include the perspective of both the research provider (discussing, for example, technical challenges or management issues caused by Frontex-mandated processes) and Frontex related to, for example, difficulties in integrating research outputs with other work if projects exceed a certain duration.

This should include engagement with individual project teams at the end of each project to reflect on lessons identified during implementation. This could be done in person or through the use of project evaluation forms to be submitted electronically and stored locally on Frontex networks. These lessons should then be discussed within Frontex on a regular basis (e.g. every 6 or 12 months) to identify areas requiring improvements or examples of best practices related to project management, engagement with end users and operational impact. To ensure that lessons identified are used effectively, each internal meeting within Frontex should also review the extent to which previous lessons identified have been taken up in organisational practice.

In addition, Frontex may consider championing a wider 'lessons identified' initiative with other EU institutions that commission border security-related R&I projects, with a view to promoting information sharing on this issue. This initiative could take the form of an annual conference open to other European agencies operating in different sectors (e.g. the EDA and ESA), but with similar emphasis on improving operational practices and outcomes. This conference would provide the opportunity to discuss lessons identified in the last 12 months, including, for example, the presentation of particularly relevant case study projects. The outcomes of this conference should be consolidated in a report shared among EU agencies, MS and, to the extent possible, the public through BTN or other means.

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

- **Key actors involved:**
  - Implementing agency: Frontex
  - Other actors/beneficiaries: Frontex, EC, ESA, EDA, MS and others as appropriate.
- **Description of benefits:** This intervention would allow Frontex to systematically capture over time enough data to adapt project-management processes with a view to maximising the impact of R&I on operational practices. This body of knowledge, ideally built and shared with the support of other EU agencies facing similar challenges, would enable a more consistent and operationally focused approach to R&I management, allowing for the cross-fertilisation of experiences between different projects.
- **Description of risks:** There is a risk that the outcomes of this intervention (i.e. the lessons identified) will not be used in a practical way. Lessons identified are only useful to the extent that they inform changes within processes, practices and procedures (including an informed decision of 'no change'). To mitigate this risk, Frontex, through its leadership, should promote an internal culture of innovation.

151 Please refer to Section 4.1 of the Technical Annex.

152 EDA (2017). See also Table D2 in Appendix D of the Technical Annex.

- **Indicative assessment of timeframe:** Less than 6 months for the initiation of an internal process within Frontex; between 6 and 12 months for the organisation and delivery of the first multi-agency Lessons Identified Conference.
- **Considerations on costs:** The cost of setting up and running an internal process within Frontex would be limited, as the capturing of lessons identified for individual projects could be included as part of the original list of project activities and the periodic internal meetings would not require additional funding. The cost of organising a multi-agency Lessons Identified Conference would depend on location, time and the extent to which external contractors will be involved in its organisation and delivery.
- **Example of good practice:** NATO has a strong culture of using lessons learned activities to promote constant improvement in the military context, through its Joint Analysis and Lessons Learned Centre. This Centre undertakes a number of activities to support the systematic capturing of lessons learned, including hosting an annual Lessons Learned Conference, undertaking joint analysis, offering support to exercises, and managing the NATO Lessons Learned Portal (NLLP). The NLLP is considered to be NATO's primary tool for sharing information on lessons learned. Based on SharePoint technology, the NLLP is a platform for sharing documents and announcing events in this area. While the focus of NATO is on capturing and analysing operational lessons learned, the principles behind this initiative are transferable to other contexts, making this a relevant example for Frontex.[153]

Intervention 1.3

Frontex should play an active role in facilitating and brokering connections between stakeholders, including R&I providers and recipients. This could be achieved through different approaches, depending on the level of ambition and available resources. These include:

- Creating a form of 'industry advisory group';
- Leveraging networks, communities and centres already established by other European agencies; and/or
- Creating a Frontex-led network of Centres of Excellence.

The least time- and resource-intensive option would be to build on the existing agenda of an annual meeting with industry and MS. Frontex could consider creating an industry advisory group composed of high-level industrial representatives selected by each MS and acting as a focal point and spokesperson for national security industries and associations. This group could also include representatives from relevant academic institutions. Such an advisory group would provide a forum for exchanging views on industrial, technical, management and other relevant aspects of R&I based on current operational needs, as well as advice on how to foster industrial cooperation to satisfy border security requirements. Should Frontex decide to pursue this option, the first action would be to establish clearly defined Terms of Reference for the group, including details on group composition, selection of members, frequency of meetings and format of outputs.

Building on the assumption that many technologies are shared by different sectors (which differ in the way they apply these technologies), a second option would be to consider establishing collaboration agreements with other European organisations or agencies such as the ESA and the EIT to leverage the network of specialised centres already established by these organisations (business incubation centres (BICs) and KICs respectively). This option would support Frontex's effort to expand its reach into the R&I supply-base, including investors, and provide an opportunity for developing internal know-how on how to create and manage more effective relationships with all parties involved in R&I.

The more ambitious, resource-intensive and long-term option would be for Frontex to establish its own network of COEs, building on different models currently operating in Europe (e.g. the ESA's BICs and the EIT's KICs) or abroad (e.g. the US DHS S&T COE model) as described in the Sections 4.1, 4.2 and 4.5 of the Technical Annex. The advantages of creating a bespoke network of COEs include the possibility of centralising in these centres several of the functions described in other interventions (e.g. Intervention 3.2).

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

- **Key actors involved:**
  - Implementing agency: Frontex
  - Other actors/beneficiaries: ESA, EIT, MS, industry, academia.
- **Description of benefits:** While different options are based on different levels of sophistication with their own additional benefits, all options described above will contribute to a more structured, goal-oriented approach to engaging with research and innovation suppliers.
- **Description of risks:** Risks associated with this intervention will vary depending on the chosen course of action. In the case of the advisory group, the main risk resides in the selection by MS of the national industry representatives (e.g. profiles chosen more on the basis of national interests than on the added value they would bring to Frontex). Should Frontex decide to engage with other EU agencies to leverage existing networks, careful consideration should be given to tailoring R&I in other sectors to the border security context. Regarding the option of Frontex creating its own network of COEs, notwithstanding the need to conduct a feasibility study to ensure that such network could be established in the first place, risks would include Frontex's ability to mobilise the R&I supply base to generate enough interest and momentum around such new entities.
- **Indicative assessment of timeframe:** The time required to implement this intervention will depend on which option Frontex is willing to pursue. Establishing an industrial advisory group and for creating partnerships with other entities (e.g. the ESA or EIT) to exploit existing networks and communities of innovators would take 6–12 months, whereas the establishment a Frontex-led network of COEs would take 18–24 months

153 NATO (n.d.).

(including the timelines necessary for conducting a feasibility study, but excluding the time required to obtain the necessary approvals).

- **Considerations on costs:** Depending on which option is adopted, establishing an industry advisory group or leveraging the networks of other R&I organisations would be relatively inexpensive compared to the costs associated with setting up one or more COEs.
- **Examples of good practice:**
  - Recognising the need for close involvement with the industry, NATO has established the NATO Industrial Advisory Group (NIAG) to assist in the development of military capability requirements and foster industrial cooperation. The NIAG meets in its plenary form three times a year, while special advisory groups are created as required.[154]
  - The ESA helps facilitate coordination and collaboration between MS, industry, academia and the ESA itself through a variety of initiatives and activities. One such initiative is a network of BICs which aim to support entrepreneurs and work with young start-ups.[155]
  - In the US, DHS S&T funds and manages a programme of academic COE. This programme facilitates cooperation between academia, industry and government stakeholders: for example, calls for the setup of COEs encourage universities and colleges to partner with industry and private sector stakeholders in proposal preparation and project delivery.[156]

154 For more information on the NIAG, please refer to NATO (2017).

155 Please refer to Section 4.1 of the Technical Annex.

156 Please refer to Section 4.5 of the Technical Annex.

5.2.2. Ensuring operational relevance of research

SUMMARY OF CHALLENGE
A disconnect is often evident between end users' needs and the border security research commissioned. This reduces the likelihood of successful translation of research outputs into operational practices, limiting the potential for innovation. In some cases, end users report that they often do not feel engaged in the research, or see its added value.[157]

RECOMMENDATION 2 :
Frontex should establish mechanisms to ensure that research projects are designed, selected and implemented to be relevant for identified operational needs.

Intervention 2.1

Frontex should create a process to systematically collect information on the development of technological solutions with specific application and potential added value for border security. This could be achieved through horizon scanning and technology watch or scouting – processes that are often used in the defence context. The main output of this activity could be a quarterly newsletter (on emerging technologies of interest in border security) that Frontex circulates to its stakeholder networks in industry, academia, EU institutions and border guard agencies.

The main difference between horizon scanning and technology watch resides on the scope of the research. The former prioritises breadth of research with a view to capturing science and technology developments in all areas and then analysing them through the lense of a particular application (e.g. border security). The latter pre-identifies technology areas of particular interest and prioritises depth of analysis in those areas.

Both approaches are based on two main components: a data-collection/scanning function that aims to capture new S&T developments in a structured way, and an assessment method that would support 'detection of signal over noise' (i.e. S&T developments of interest for border security specifically). A further layer of analysis could then be added to compare relevant technologies and their suitability to address identified needs.

Depending on the level of ambition and resource availability, Frontex may wish to:

- Set up an internal horizon-scanning function that adopts a simplified method and produces a basic output, such as a document summarising top trends on a quarterly basis;
- Leverage other EU horizon-scanning activities by partnering with another institution that does this and importing the results, producing a summary document that can be shared with MS;
- Request that MS with experience in horizon scanning share outputs that Frontex can then combine and circulate to its stakeholder community; and/or
- Purchase a continuous horizon-scanning service or commission a horizon-scanning provider to produce a quarterly or biannual analysis which Frontex can then share with its contact networks.

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

- **Key actors involved:**
  - Implementing agency: Frontex (with the potential support of an external provider);
  - Other actors/beneficiaries: industry, academia.
- **Description of benefits:** The goal of adopting this type of approach is threefold: (i) to position Frontex to better anticipate emerging or future threats or opportunities relevant to border security (e.g. new technologies/methods for stand-off visual ID or detection of imbibed illegal substances); (ii) to minimise the risk of 'strategic surprise' or rapid obsolescence of border security capabilities, offsetting as far as possible the comparatively slow pace of procurement by starting the process of acquiring new capabilities as early as possible; and (iii) to more proactively seek out emerging and future requirements.

157 Please refer to Section 3.2 of this report and Section 2.1 of the Technical Annex.

- **Description of risks:** Risks associated with this intervention include the lack of internal resources to perform and sustain a horizon-scanning function, as well as the lack of the required research and analysis methodologies to ensure that the horizon scanning produces information that is useful and tailored to the specific border security context.
- **Indicative assessment of timeframe:** Less than six months to set up a horizon-scanning function.
- **Considerations on costs:** The costs of running a continuous horizon-scanning function would depend on the extent to which processes are conducted in house or outsourced.
- **Example of good practices:** DHS S&T provides analysis and recommendations on technologies, products and services that can advance homeland security capabilities. To do this, DHS draws on horizon-scanning activities and a 'technology scouting' process to research and evaluate specific technologies by sifting through global data on technology and market environments.[158]

Intervention 2.2

Frontex should centralise information on national operational requirements, needs and capability gaps with a view to supporting harmonisation where applicable. For Frontex to do this, MS should first provide information on their national operational requirements. Frontex would then be in a position review the aggregated requirements, needs and capability gaps, before:

- Sharing a list of these requirements (cleared of any sensitive information) with MS to present a picture of common trends, for example through the use of a virtual platform (e.g. a restricted area of BTN) or through periodic consultations with MS;
- Performing high-level market analysis to identify what solutions exist on the market and sharing this information with MS;
- Connecting states with shared requirements so that they can consider joint procurement (in cases where relevant solutions already exist) or collaborative R&I projects (in cases where R&I is needed to develop relevant solutions);
- Identifying ongoing work (within or outside Frontex) that could provide a partial or complete solution to an identified need; and/or
- Generating a set of requirements in areas where there is no ongoing or completed research to address the problem.

In the context of requirement identification, Frontex should also support innovative approaches to 'pull' innovation ideas from end users themselves, in addition to more traditional 'top-down' approaches whereby requirements are set by organisational leadership following political guidance.

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

- **Key actors involved:**
  - Implementing agency: Frontex
  - Other actors/beneficiaries: MS, end users.
- **Description of benefits:** The benefits of this intervention include the possibility of creating research projects that, by design, meet clearly identified operational needs of multiple MS.
- **Description of risks:** The risks associated with this intervention include willingness of MS to share their requirements and, if and when they are shared, the difficulty of harmonising requirements both from a quality perspective (in the absence of clearly identified standards/performance indicators) and from a planning perspective (in terms of aligning timelines and budgets).
- **Indicative assessment of timeframe:** Between 6 and 12 months to create a structured mechanism to centralise information on requirements, including those flagged by end users, and map them against current market opportunities (leveraging the horizon-scanning function, if available) or current research projects.
- **Considerations on costs:** Infrastructure costs related this intervention would be minimal.
- **Example of good practices:** DHS S&T draws on a variety of means to 'pull' innovative ideas from different stakeholders. These include the Science and Technology Resource Allocation Strategy, which is a coordinated framework designed to ensure that S&T efforts are aligned with operational requirements. STRAS records the work of end users in order to identify capability gaps and chart a course of action for filling these gaps. The USCG also deploys an Idea Submission Review process that allows for RTD&E project ideas to be submitted from a variety of USCG members and stakeholders across different operating levels.[159]

Intervention 2.3

Frontex should adopt a 'research champion' role in order to inform policy and decision making within EU institutions, ensuring that border security research priorities and themes established at the EU level are tailored to the most up-to-date users requirements and technological developments. Frontex should use a structured approach to presenting these recommendations, using business cases to document needs, costs and benefits. These recommendations should be informed by other activities conducted as result of other interventions (e.g. horizon scanning, harmonisation of needs, etc.) to build stronger business cases, as well as by information that Frontex has on capability gaps, ongoing research and funding opportunities. By engaging with other EU institutions, Frontex can collect information on research initiatives and funding opportunities in order to feed this back through a regular publication or a centralised webpage (see Intervention 1.1).

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

- **Key actors involved:**
  - Implementing agency: Frontex
  - Other actors/beneficiaries: European Commission and other EU bodies as appropriate, MS.

158 DHS (2016). See also Table D2 in Appendix D of the Technical Annex.

159 Please refer to Section 3.1 of the Technical Annex.

- **Description of benefits:** This intervention would help ensure that priority areas, research requirements and allocation of resources are informed by operational needs and are coherently developed.
- **Description of risks:** The main risk associated with this intervention is that the advice received by Frontex is not fully considered, or is diluted to the point where it loses its value.
- **Indicative assessment of timeframe:** Less than six months to collect and present information on EU research in a regular publication or on a centralised webpage.
- **Considerations on costs:** If presenting information on research on BTN (as one example of a centralised webpage), the main cost would be associated with developing new website content and reframing the website architecture.
- **Example of good practices:** The US Defense Innovation Board was established in order to encourage a culture of innovation in the Pentagon. The mission of the Board is to provide the Secretary of Defense with independent advice and recommendations on innovative means to address future challenges. Proposals put forward include the appointment of a Chief Innovation Officer to serve as a point of contact for innovation efforts across the DoD, and the creation of a COE for Artificial Intelligence and Machine Learning.[160]

Intervention 2.4

Frontex should integrate traditional research selection and implementation processes with more innovative approaches designed to tackle specific operational needs without imposing too many restrictions on solutions.

These approaches may include the use (where appropriate) of open-ended problem statements with associated desired end state, scenarios and user cases, rather than highly prescriptive technical requirements. While these approaches can also be used in the context of more traditional public procurement procedures, Frontex should also consider implementing alternative processes like prizes, grants and challenges in accordance with existing regulations.[161] Depending on the level of ambition and resource availability, Frontex could either (i) host the challenges and communicate the results to MS; or (ii) award grants for projects and carry out the selection, award, monitoring and communication activities.

These instruments would be particularly valuable in attracting new entrants, including young start-ups and SMEs, to the field of border security.

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

- **Key actors involved:**
  - Implementing agency: Frontex
  - Other actors/beneficiaries: industry.
- **Description of benefits:** The main benefit of adopting innovative R&I approaches is to emphasise the link between the technology solution and a clearly identified operational challenge, while at the same time incentivising innovation and attracting a wider pool of suppliers.
- **Description of risks:** Risks associated with this intervention relate to the sub-optimal identification and definition of the problem and desired end-state. This may have also repercussions for industry's interest in participating in challenges or other forms of prize competitions. In this regard, particular attention should be paid to setting the rules of the challenge, as rules can increase or decrease (intentionally and/or unintentionally) the level of technological achievements of the participating teams.[162]
- **Indicative assessment of timeframe:** Key planning times (based on DARPA's lessons learned): 12 months for organisers, 6 months for performers.[163]
- **Considerations on costs:** The costs of running competitions or challenges vary significantly depending on factors such as complexity, targeted industry (e.g. start-ups versus primes), rules of the competition (e.g. winner takes all; prizes for the first, second and third place; or others). Prizes can range from tens of thousands of euros to several million euros.
- **Examples of good practice:**
  - In order to create an environment that supports entrepreneurship and innovation, the EIT organises annual 'EIT Awards' to recognise and reward successful European start-ups, innovative projects and young entrepreneurial talent. Held at the EIT's annual Innovation Forum, prize money ranges from €15 000 to €50 000 and around 600 individuals attend.[164]
  - The US DARPA Grand Challenges is a cash prize competition for autonomous vehicles. Funded by DARPA, the competition is designed to drive innovation and develop solutions more quickly than possible through more traditional funding mechanisms. Other DARPA prize challenges include: Urban Challenge (2007), Network Challenge (2009), Chikungunya Challenge (2014–2015) and Robotics Challenge (2012–2015).[165] Nonetheless, it should be noted that there is some debate on how beneficial these Grand Challenges have been in practice.[166]

160 Office of the Federal Register (2017). See also Table D2 in Appendix D of the Technical Annex.

161 European Commission (2014).

162 DARPA (2014).

163 DARPA (2014).

164 Please refer to Section 4.2 of the Technical Annex.

165 DARPA (2014). See also Table D2 in Appendix D of the Technical Annex.

166 Please refer to Table D2 in Appendix D of the Technical Annex.

5.2.3. Facilitating and supporting operationalisation of research

SUMMARY OF CHALLENGE
In some cases, it is difficult to translate research outputs into innovative operational practices. This can alienate the end user community from research providers, resulting in a loss of trust, interest and willingness to collaborate.[167]

RECOMMENDATION 3 :
Frontex should facilitate and support the uptake and operationalisation of research outputs by end users.

Intervention 3.1

Frontex should establish mechanisms to maintain the continuous engagement of end users during the research and innovation process. This could include, for example, the creation of cross-organisational project teams (e.g. including one manager from Frontex, one from a selected border guard agency, and one from the contractor if appropriate). Frontex should be responsible for the identification of the end user(s), transferring this role to the research supplier as part of the selection procedure if deemed appropriate. This approach would be particularly useful in managing the risk that research projects lasting several months/years lose their operational relevance as they become overtaken by events.

End users should also be involved in technology demonstrations to test and validate the system as part of the research phase, and/or (after the research has been completed) in the organisation of operational/capability demonstrations to showcase the potential added value of research outputs. Additionally, Frontex could sponsor pilot programmes whereby budget is provided for MS to use both old and new solutions in parallel in order to (i) identify areas for revision within old systems; and (ii) help demonstrate the benefits of new solutions.

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

- **Key actors involved:**
  - Implementing agency: Frontex
  - Other actors/beneficiaries: end users.
- **Description of benefits:** Integrating end users' input throughout the life cycle of a project would increase the likelihood of the project successfully reaching the end of the research and innovation pathway. It would do so by increasing the confidence of industry and investors that research outputs could be exploited if brought to the market. Sponsoring pilot programmes as described above would also help demonstrate the benefits of new solutions, thus encouraging uptake among stakeholders.
- **Description of risks:** The main risk associated with this intervention relates to end users' reluctance to engage in these types of activity, either because this has not been mandated by their national authorities, or because of a general lack of interest in research.
- **Indicative assessment of timeframe:** Between 6 and 12 months to create an operating model and framework of reference (e.g. guidelines, roles and responsibilities) for cross-organisational project teams.
- **Considerations on costs:** Costs related to running cross-organisational project teams would be absorbed by existing staff costs. The cost of running demonstrations is dependent on the complexity of the system, and can range from the low tens of thousands to the low hundreds of thousands of euros.
- **Example of good practices:**
  - DHS S&T launched R&D Integrated Product Teams in 2015. IPTs are tasked with identifying and coordinating DHS research efforts in priority mission areas, and linking research activities with the work of the DHS Joint Requirements Council to close existing technology capability gaps.[168]
  - In the US, SBIR involves running technology demonstrations with a view to presenting a product or service prototype to potential investors in order to convince these stakeholders of its relevance and feasibility.[169]
  - In the EU, the H2020 programme actively encourages the involvement of end users in research projects – it is a requirement that at least three members of the proposed consortium are from the end user community. During the lifecycle of H2020 projects, end users are often directly involved in technology demonstrations organised by the research providers. Similarly, Frontex organises demonstrations as part of their internally funded research projects.[170]

Intervention 3.2

Frontex should facilitate access to funding that could be used to bridge the gap between the completion of the research project and the commercialisation of the technology. This may involve:

- Providing direct funding for the commercialisation of technology, including through alternative approaches (e.g. Public Procurement of Innovative Solutions (PPI), Pre-Commercial Procurement (PCP));
- Sharing information on available EU funding instruments (see Intervention 1.1) and on alternative funding approaches;
- At the pre-submission stage, providing a quality-assurance process for business cases and research proposals aimed at further developing R&I solutions; and/or
- Further building connections with investors (e.g. venture capitalists).

In relation to direct funding, Frontex could explore different funding models to 'procure innovation'. These may include, for example, the use of PPI to bring to the market solutions already tested and validated by end users, or, where no near-to-market solutions exist, PCP can be used to compare the advantages and limitations of competing solutions.[171]

167 Please refer to Section 3.2 of this report and Section 2.1 of the Technical Annex.

168 Please refer to section 3.1 of the Technical Annex.

169 Please refer to Section 4.4 of the Technical Annex.

170 Please refer to Section 2.1 of the Technical Annex.

171 Iossa et al. (2016).

Alternatively, or in addition, Frontex could leverage a web platform (e.g. the enhanced BTN portal – see Intervention 1.1) to provide guidance to industry and academia on how to access other European funds such as ESIF, the EU COSME programme, H2020, and the Internal Security Fund.

In addition to providing useful information on available funding instruments,[172] Frontex could establish a mechanism to offer free-of-charge technical assistance to a selection of promising S&T projects proposed by individual MS to maximise their chances of securing EU funding (e.g. ESIF). This could involve 'red-teaming' (providing constructive challenge to) research proposals before submission, as well as assistance in overcoming administrative hurdles that might be particularly challenging for SMEs. A similar procedure has already been implemented successfully by the EDA.[173]

Finally, as discussed in Intervention 1.3, by leveraging existing networks of COEs (or equivalents like BICs and KICs) or by creating a Frontex-led network of COEs, Frontex could proactively connect stakeholders from industry and academia with interested investors (e.g. venture capitalists).

Below we outline the key actors, benefits and risks associated with this intervention, as well as an indicative timeframe, cost considerations and examples of relevant good practices:

- **Key actors involved:**
  - Implementing agency: Frontex
  - Other actors/beneficiaries: industry.
- **Description of benefits:** This intervention is likely to reduce the number of promising projects that remain 'blocked' at the research phase without having the necessary resources to complete the entire research and innovation pathway. By enabling access to innovation funding, this intervention will increase the likelihood of border guards implementing R&I solutions in the field.
- **Description of risks:** One risk associated with this intervention is the cost attached to performing and sustaining a free-of-charge technical assistance function for research proposals over time.
- **Indicative assessment of timeframe:** Less than six months to generate guidelines for industry in relation to EU funding opportunities, which can then be presented on BTN or another web platform (see Intervention 1.1). Between 12 and 18 months to create a mechanism designed to support promising R&I projects in securing EU funding.
- **Considerations on costs:** PPI and PCP costs will vary on a case-by-case basis. Other initiatives under this intervention would not require major infrastructural investments, but would have higher staff costs.
- **Example of good practices:**
  - The US HSIP programme provides direct funding for innovative start-ups. To do this, HSIP streamlines bidding procedures in a way that caters for the needs of start-ups and technology innovators. For example, contracting timelines are significantly shorter (45 days) than those for standard DHS tendering procedures (9–12 months). HSIP holds a number of external events and industry days, and participates in conferences and technology days in order to raise awareness of its funding opportunities.[174]
  - The EIT has supported the successful implementation of research outputs through its KICs, which are COEs around specific topics of importance to Europe and which comprise businesses, academic institutions and research organisations.[175]

5.3. Next steps

The implementation guidelines described above provide Frontex with an initial point of reference for possible future courses of action. They can be used by Frontex to decide which interventions to prioritise, but should not be considered substitutes for a more rigorous implementation plan.

As next steps, we recommend that Frontex (i) identifies which intervention(s) it is willing to pursue; and (ii) for each selected intervention, conducts a feasibility study (either internally or with the support of an external contractor) to assess current capabilities within Frontex (including governance, regulations, infrastructure, skills, staff, budget, and ongoing initiatives). This assessment would support the identification of gaps to be addressed as well as existing capabilities that could be leveraged, enabling a more accurate assessment of time and cost in relation to the chosen intervention(s).

172 See for example EDA (2017).
173 See EDA (2017).
174 Please refer to Section 4.4 of the Technical Annex.
175 Please refer to Section 4.2 of the Technical Annex.

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Challenges and Opportunities for Operationalising Border Security Research

Technical Annex

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Abbreviations

ABC	Automated Border Control
ABC4EU	Automated Border Control Gates for Europe
ABF	Australian Border Force
AEER	Air Entry/Exit Re-engineering programme
ANTSO	Australian Nuclear Science and Technology Organisation
AOI	Area Of Interest
APP	Assessment of Prospective Portfolio
AQ	Al-Qaeda
ARC	Australian Research Council
ARI	Arab Reform Initiative
ARTES	Advanced Research in Telecommunications Systems
ASPI	Australian Strategic Policy Institute
AT&L	Acquisition, Technology and Logistics
Aus$	Australian Dollar
BAA	Broad Agency Agreement
BAP	Business and Activity Proposal
BIC	Business Incubation Centre
BMD	Borders and Maritime Security Division
bn	Billion
BAO	Basic Ordering Agreement
BTI	Borders, Trade and Immigration Institute
Can$	Canadian Dollar
CBI	Cross Border Institute
CBP	Customs and Border Protection
CBRN	Chemical, Biological, Radiological and Nuclear
CBSA	Canada Border Service Agency
CCTV	Closed-Circuit Television
CG-STIC	USCG S&T Transition and Innovation Center
COE	Centre of Excellence
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSO	Commercial Solutions Opening
CSS	Centre for Security Science
CTP	Science Core Technology Programme
DG	Directorate-General
DG CNECT	Directorate-General for Communications Networks, Content and Technology
DG HOME	Directorate-General for Migration and Home Affairs
DHS	Department of Homeland Security
DIBP	Department of Immigration and Border Protection
DIUx	Defense Innovation Unit – Experimental
DNDO	Domestic Nuclear Detection Office
DoD	Department of Defense
DRDC	Defence Research and Development Canada
EAC	European Astronauts Centre
ECI	European Component Initiative
EFSI	European Fund for Strategic Investments
EIT	European Institute of Innovation and Technology
EMITS	Electronic Mailing Invitation to Tender System
ERA	European Research Area
ESA	European Space Agency
ESCC	European Space Component Coordination
ESPAS	European Strategy and Policy Analysis System
EU	European Union
EUI	European University Institute
EWISA	Early Warning For Increased Situational Awareness
FFRDC	Federally Funded Research and Development Centers
FP	Framework Programme
FTE	Full Time Equivalent
FY	Financial Year
GAO	Government Accountability Office
GSP	General Studies Programme
H2020	Horizon 2020
HSARPA	Homeland Security Advanced Research Project Agency
HSE	Homeland Security Enterprise
HSIP	Homeland Security Innovation Program
HSOAC	Homeland Security Operational Analysis Center
HSSEDI	Homeland Security Systems Engineering and Development Institute
IAP	Integrated Applications Promotion
IBM	Integrated Border Management
IITT	Intended Invitation to Tender
IP	Intellectual Property
IPR	Intellectual Property Rights
IPT	Integrated Product Team
IRCC	Immigration, Refugees and Citizenship Canada
IS	Islamic State
ISF	Internal Security Fund
ISR	Idea Submission Review
ITT	Invitation to Tender
JRC	Joint Research Centre
KIC	Knowledge and Innovation Community
km	Kilometre
KPI	Key Performance Indicator
m	Million
M&E	Monitoring and Evaluation
MoD	Ministry of Defence
MoI	Ministry of Interior
MS	Member State
MSC	Maritime Security Center of Excellence
NATO	North Atlantic Treaty Organization
NCBSI	National Center for Border Security and Immigration
NCGP	National Competitive Grants Programme
NFPOC	National Frontex Point of Contact
NSF	National Science Foundation

OTS	Other Transaction Solicitation
OUP	Office of University Programs
PASAG	Protection and Security Advisory Group
PKK	Kurdish Workers Party
pMS	Participating Member State
POE	Ports of Entry
POV	Pre-Operational Validation
PPP	Office of Public and Private Partnerships
PSC	Public Safety Canada
QHSR	Quadrennial Homeland Security Review
R&D	Research and Development
R&I	Research and Innovation
RAP	Resource Allocation Plan
RCMP	Royal Canadian Mounted Police
RD&I	Research, Development And Innovation
RDC	Research and Development Center
RDP	Research and Development Partnerships Group
RDT&E	Research, Development, Test And Evaluation
RDU	Research and Development Unit
REA	Research Executive Agency
RFP	Request for Proposals
RIS	Regional Innovation Scheme
ROM	Rough Order of Magnitude
S&T	Science and Technology
S&T (US)	Science and Technology Directorate
SBIR	Small Business Innovation Research
SIA	Strategic Innovation Agenda
SME	Small to Medium-sized Enterprise
SOW	Statement Of Work
SRC	S&T Research Council
STRAS	Science and Technology Resource Allocation Strategy
SVIP	Silicon Valley Innovation Program
TAB	Technical Advisory Board
TEB	Tender Evaluation Board
TEU	Treaty on European Union
TFEU	Treaty on the Functioning of the European Union
TIA	Telecommunications and Integrated Applications directorate
TNP	Turkish National Police
TOR	Terms of Reference
TRL	Technology Readiness Level
TRP	Technology Research Programme
TTG	Time-to-Grant
TTI	Time-to-Inform
UK	United Kingdom
US	United States
USCG	United States Coast Guard
USDA&S	Undersecretary of Defense for Acquisition and Sustainment
USDR&E	Undersecretary of Defense for Research and Engineering
USST	S&T Under Secretary
WP	Work Package
YOK	Turkish Higher Education Council

1.Overview of Technical Annex

This Technical Annex presents the study findings from Work Package (WP) 1 (EU border security research), WP2 (non-EU border security research) and WP3 (ways forward for Frontex), and acts as a repository of evidence and supporting document to the main report.[1] Figure 1.1 overleaf illustrates the research approach.

In addition to this introduction, this Technical Annex contains the following substantive chapters:

- **Chapter 2:** An overview of EU border security research;
- **Chapter 3:** An overview of non-EU border security research; and
- **Chapter 4:** A summary of six organisational models that focus on operationalising research.

The following chapters focus on the research processes in the European Union (EU) (Chapter 2) and in the US, Canada and Australia, with a secondary focus on Turkey and three North African countries – Egypt, Morocco and Tunisia (Chapter 3). The case studies presented in Chapters 2 and 3 contain the work undertaken during WP1 and WP2 respectively, and set out the research pathway for each country or region before summarising areas of good practice and challenges of the research process.[2]

While the research process is the main focus of WPs 1 and 2, WP3 focuses primarily on research and innovation (R&I).[3] Chapter 4 presents the six case studies undertaken as part of WP3, which focus on functions and roles of organisations that can support the integration of research outputs into operational practice. These case studies are presented in Chapter 4, and focus on the European Space Agency (ESA), the European Institute of Innovation and Technology (EIT), Defense Innovation Unit – Experimental (DIUx), Small Business Innovation Research (SBIR), the Homeland Security Innovation Program (HSIP) and US Centers of Excellence (COE).

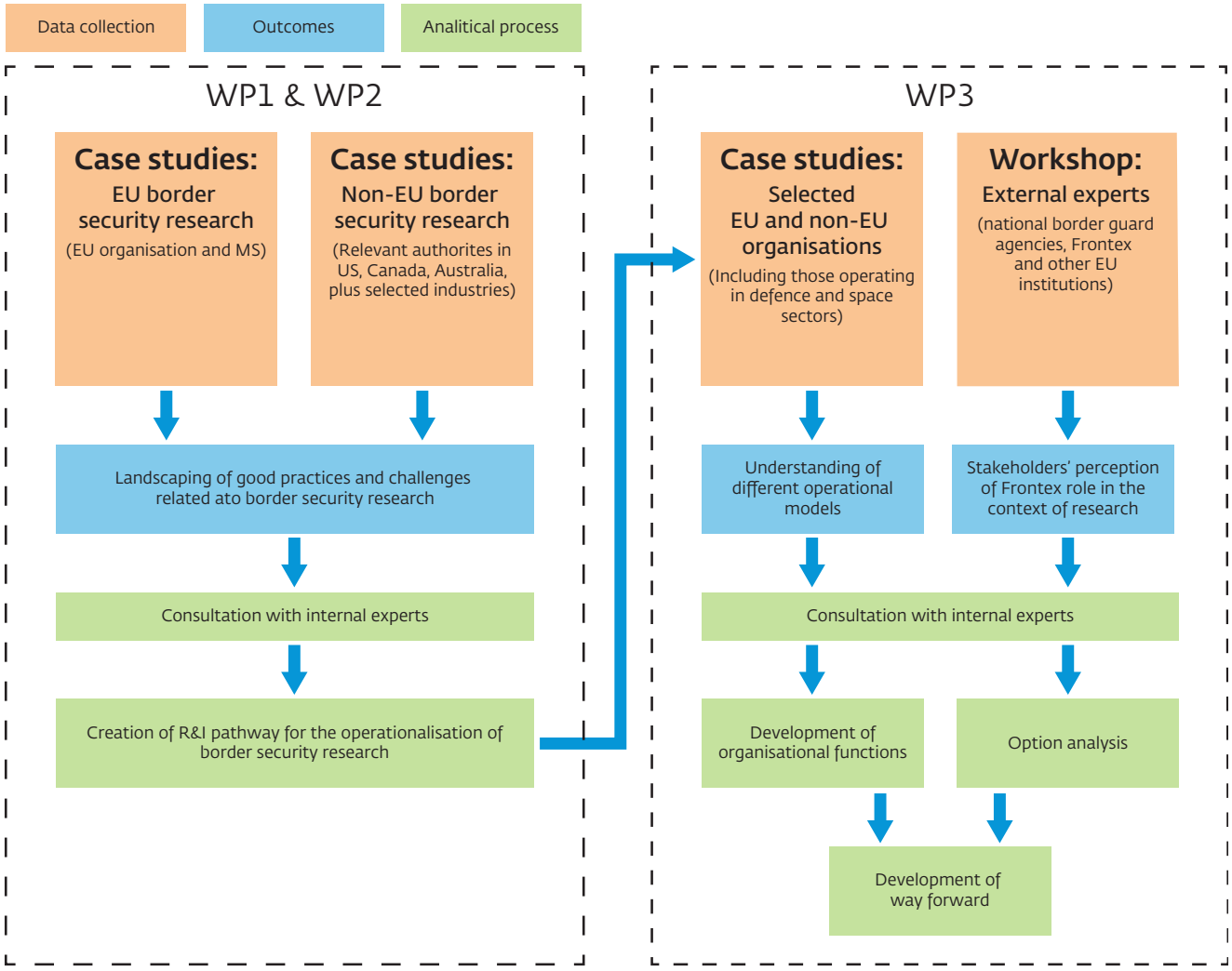
The appendices include the list of study interviewees, the interview questions, the survey outlines and the Frontex workshop material, as well as the workshop summary.

1 See Cox et al. (2017).

2 A combined summary of areas of good practice and challenges for research across all case studies can be found in Chapter 3 of the main report.

3 For a full definition, see Cox et al. (2017).

Figure 1.1 **Overview of research approach**



2. Case studies: EU border security research (WP1)

This chapter provides an overview of how border security research is set up, conducted and operationalised in the EU. The following sections outline research activities undertaken by institutions at the EU level (Section 2.1), as well as offering a more nationally focused analysis of research processes in a selection of Member State (MS) survey participant countries (Section 2.2). Both layers of analysis – the EU-level and the MS-level – are structured in a similar way: the strategic context for EU border security research is presented, followed by a description of the processes linking this research and its integration into operational practice. Finally, a series of lessons are outlined, relating to the main challenges and areas of good practice identified from the literature review, surveys and interviews conducted.

2.1. EU-level border security research

2.1.1. Strategic context

The EU context differs to that of the other case studies presented in Chapter 3 due to it being a supranational union with a focus on cooperation between countries. At the European level, Frontex 'promote[s], coordinate[s] and develop[s] European border management in line with the EU fundamental rights charter and the concept of Integrated Border Management' (IBM),[4] while individual MS are responsible for managing their own borders. With this in mind, border security research at the EU level focuses on wider threats to the EU and collaboration tools available to enhance security.

In the EU, research and technological development are central to the *Treaty on European Union* (TEU) and the *Treaty on the Functioning of the European Union* (TFEU), which are the two core *Treaties of the European Union* setting out the EU's constitutional basis and providing a legal foundation for pre-competitive research.[5] Under TFEU Title XIX ('Research and Technological Development and Space'), the Treaty outlines the EU's objective of 'strengthening its scientific and technological bases by achieving a European research area in which researchers, scientific knowledge and technology circulate freely'. According to the TFEU, this objective should be supported by four key activities at the EU level:

1. Implementation of research, technological development and demonstration programmes, by promoting cooperation with and between research centres and universities;
2. Promotion of cooperation with third countries and international organisations in EU research, technological development and demonstration;
3. Dissemination and optimisation of the results of EU research, technological development and demonstration activities; and
4. Fostering opportunities for training and mobility of researchers in the EU.[6]

Border security forms part of two of the ten strategic priorities presented in the EU's 2014 Political Guidelines, namely those focusing on 'justice and fundamental rights' and 'migration'.[7] As described in the *European Agenda on Security* and the *European Agenda on Migration*,[8] there are multiple threats and pressures affecting EU borders. These include high levels of migration; human trafficking and smuggling;[9] instability in neighbouring European countries;[10] cybercrime; terrorism; and transnational organised crime, including drug and weapons smuggling, money laundering and terrorist financing.[11]

A key objective of the European Commission is to increase external border security, while also protecting individual rights and ensuring that the flow of people and goods is not affected.[12] To this end, the European Commission has called for the development of 'common high standards of border management', emphasising that 'all relevant EU and national actors need to work better together to tackle cross-border threats'.[13] Despite seeking to consolidate border management into a 'Union standard', border management is not currently standardised across EU MS and is based on a 'patchwork of sectorial documents and instruments',[14] which can create challenges for interoperability[15] and wider cooperation.[16] The use of border information systems has also raised issues relating to fundamental rights, data

4 Frontex (n.d.-a).

5 European Union (2012a); European Union (2012b).

6 European Union (2012b).

7 Juncker (2014); European Commission (2016e); European Commission (2015h); European Commission (2015a); RAND Europe interview with Dragos Voicu, 11 April 2017.

8 European Commission (2017b).

9 Frontex (2017).

10 European Commission (2015h); European Commission (2015a).

11 European Commission (2015h).

12 RAND Europe interview with anonymous EU project coordinator, 2 April 2017; European Commission (2017d, 13).

13 European Commission (2015h, 2–6).

14 European Commission (2015a).

15 'Interoperability' refers to the ability of countries to act together coherently, effectively and efficiently to achieve tactical, operational and strategic objectives. In the context of border security, it enables border guard authorities and/or systems to work together to share common procedures and each other's infrastructure, and to be able to communicate (NATO, 2012).

16 European Commission (2015a); RAND Europe interview with anonymous EU project coordinator, 2 April 2017.

protection and privacy due to the personal and biometric nature of the information collected through these systems.[17]

2.1.2. Research pathway

Overview of the EU research landscape

The strategic priorities outlined in the 2014 Political Guidelines[18] inform the EU Framework Programmes (FPs), which are multi-year funding programmes designed to support research and innovation in the European Research Area (ERA).[19] While the European Commission is the main actor responsible for funding research and development at the EU level, Frontex separately awards border security research projects. The main actors involved in undertaking border security research in the EU include academic institutions, research organisations, the private sector and industry, and public bodies.[20]

Table 2.1 presents an overview of the EU Framework Programmes focusing on EU Security Research: Horizon 2020 and FP7.

Table 2.1 **EU Framework Programmes**

Framework Programme	Timeframe	Budget (billions of €)
Horizon 2020	2014–2010	80
FP7	2007–2013	55.9

Source: European Commission (2015e).

European Commission: FP7

Over the course of the most recent Seventh Framework Programme (FP7), over €146.8 million was allocated to border security research projects across five thematic categories: air borders, border checks, border surveillance, land borders and sea borders. The allocation of funding across these different areas is shown in Figure 2.1 on the next page.

'Border checks' is the thematic area allocated the most funding (€75m) under the FP7 programme. Projects in this category have included ABC4EU (Automated Border Control Gates for Europe), FastPass (a harmonised, modular reference system for all European automated border crossing points) and MobilePass (a secure, modular and distributed mobile border control solution for European land border crossing points). On the other hand, 'air borders' received the least funding (€3m). Individual project budgets ranged from just under €1m to over €12m, averaging around €6m across 23 projects.[21] Border security research projects were part of the broader €1.4bn 'Secure Societies' research programme, accounting for around 9.5 per cent of its funding.[22]

European Commission: Horizon 2020

Within Horizon 2020 (H2020) – the eighth and current Framework Programme – border security research falls under 'Secure Societies – Protecting Freedom and Security of Europe and its Citizens' ('Secure Societies'), which is part of the wider 'Societal Challenges' programme. Only two H2020 Work Programmes (2014–2015 and 2016–2017)[23] have been released to date, with preparations for the 2018–2020 Work Programme beginning in 2016 with stakeholder consultations and discussions with MS.[24]

Within the 2014–2015 H2020 Secure Societies Work Programme, the maximum amount of funding available for border security research projects amounted to €73m[25] across five themes: maritime border security, border crossing points, supply chain security, external security and the ethical/societal dimension.[26]

Figure 2.2 on the right shows the breakdown of funding across these thematic areas, which fall under the call 'Border Security and External Security'.[27]

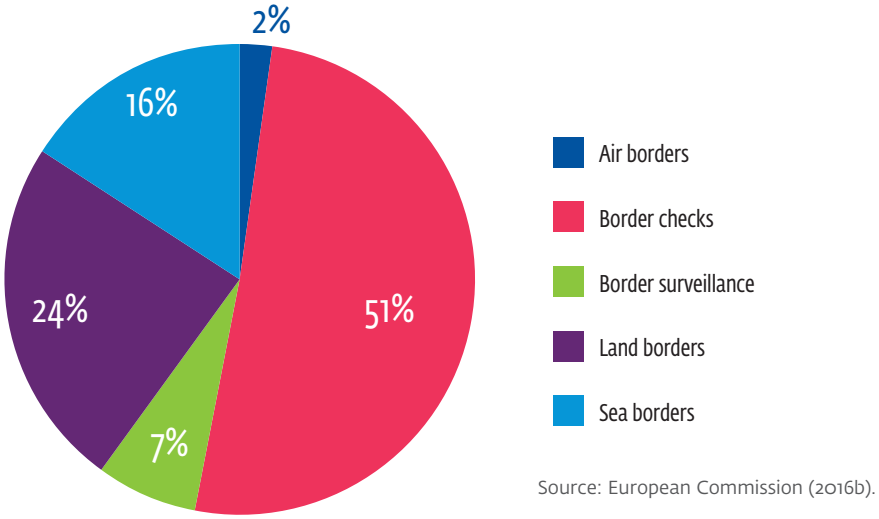
Of the three relevant border security themes included in the 2014–2015 Work Programme, the 'maritime border security' theme has the most projects assigned (four) as well as the largest share of funding (€30m). These projects include work on radar systems and vehicles for coastal and maritime surveillance, as well as aircraft detection. On the other hand, the 'ethical societal dimension' theme had one project and €1m of funding, for a project on human factors in border control. A total of eight border security projects were included in the 2014–2015 Work Programme, with budgets ranging from €2m to €12m.

In 2014–2015, relevant border security projects were allocated approximately 12 per cent of the available funding for the 'Secure Societies' strand of H2020.[28] Technology Readiness Levels (TRLs)[29] were listed for six of the fourteen projects. Of these, four projects were required to progress to TRL 5 ('technology validated in relevant environment'), with one project reaching TRL 7 ('system prototype demonstration in operational environment'), and another reaching prototype level.[30]

The 2016–2017 Work Programme has allocated €55m to 'border security'. A total of eight projects were put forward in this Work Programme, with calls relating to information systems, border

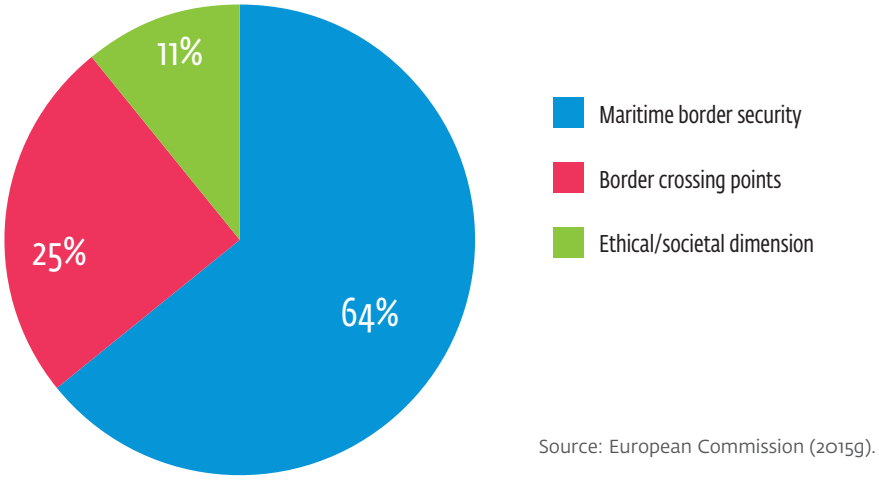
17 Chair of the high-level expert group (2016).
18 Juncker (2014); European Commission (2016e).
19 The ERA is a system of scientific research programmes integrating the scientific resources of the EU. The ERA can be likened to a research and innovation equivalent of the European 'common market' for goods and services. See European Commission (n.d.c).
20 European Commission (2013, 13).
21 European Commission (2016b).
22 European Commission (2016b); CORDIS (2014).
23 Funding opportunities under H2020 are set out in multiannual Work Programmes, which are prepared by the European Commission through a strategic programming process integrating EU policy objectives in priority-setting activities (European Commission, n.d.-d).
24 European Commission (n.d.-d).
25 European Commission (2015g).
26 European Commission (2015g).
27 European Commission (n.d.-n). It should be noted that some of these calls – such as those referring to supply chain security and external security – are not directly relevant for Frontex.
28 European Commission (2015g).
29 TRLs are indicators of the maturity of particular technologies. There are nine TRLs, with TRL 1 being the lowest and TRL 9 being the highest (European Commission, 2017d). See Appendix D for further explanation.
30 European Commission (2015g).

Figure 2.1 **Budget allocation per border research theme in FP7**



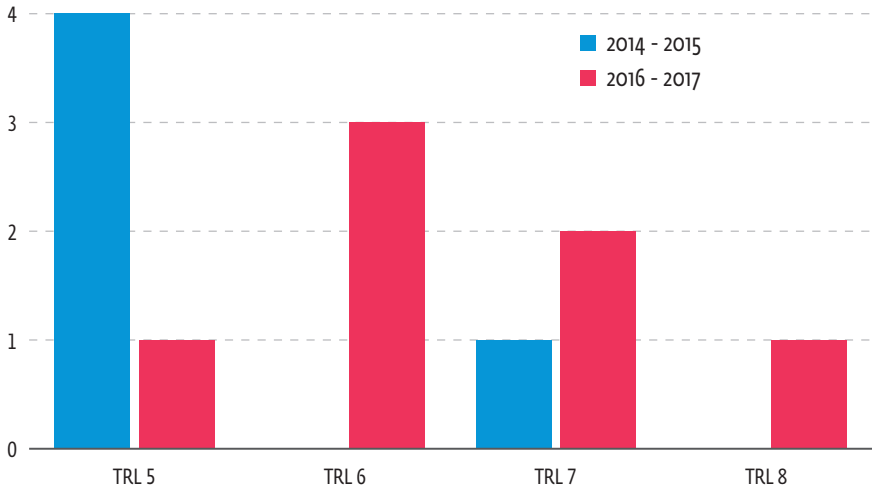
Source: European Commission (2016b).

Figure 2.2 **H2020 2014–15: Budget allocation under 'Border Security & External Security' call**[31]



Source: European Commission (2015g).

Figure 2.3 **Project TRL by Work Programme**



Source: European Commission (2015g; 2016c).

technologies, risk-based screening, detection devices, supply chain security and maritime border security. The TRLs for all but one of the calls were specified in the Work Programme, with the lowest requested being TRL 5 ('technology validated in relevant environment'), the highest being TRL 8 ('system complete and qualified'), and the majority listed as TRL 7 ('system prototype demonstration in operational environment').[32] Figure 2.3 on the left illustrates the variance in project TRL between the different H2020 Work Programmes.

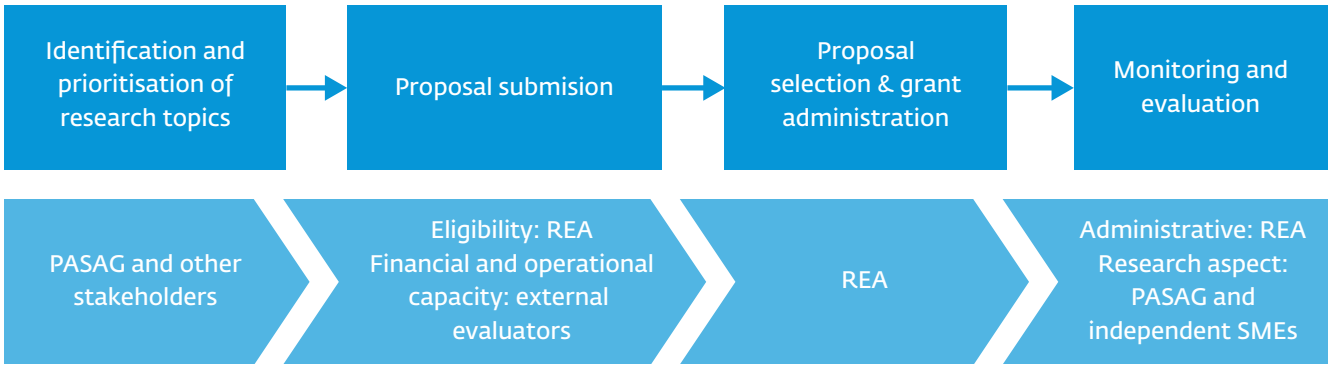
Identification and prioritisation of research topics

Figure 2.4 presents the processes and agencies involved in research prioritisation, proposal submission, grand administration and monitoring and evaluation (M&E) in the EU. The steps discussed in the following sections relate to the setup of H2020 border security research.

In order to identify and prioritise research topics for future H2020 Work Programmes, the European Commission and the H2020 national representatives first consult a wide range of stakeholders before final decisions are taken by the 'Secure Societies' programme committee.[33] This consultation phase tends to take place one to two years before the Work Programme is launched.[34] There are 19 Advisory Groups in total, comprising representatives from industry, research and civil society who contribute to topic identification.[35] Border security research falls under the Protection and Security Advisory Group (PASAG), which is led by the Directorate-General (DG) for Migration and Home Affairs (DG HOME), with DG Communications Networks, Content and Technology (DG CNECT) as the associated DG.[36] PASAG experts are

31 Data relating to calls on supply chain security and external security was not included in this analysis.
32 European Commission (2016c and 2017d).
33 RAND Europe interview with three representatives, European organisation, 3 April 2017.
34 RAND Europe interview with three representatives, European organisation, 3 April 2017.
35 European Commission (n.d.-l); RAND Europe interview with three representatives, European organisation, 3 April 2017.
36 European Commission (2017c).

Figure 2.4 **EU research processes**



Source: RAND analysis (2017).

representatives of industry, civil defence, academia, the civil service, civil contingencies, and industry research and development (R&D) groups.[37]

Other consultation mechanisms used to identify and prioritise research topics include discussions with national representatives from various ministries, public consultations conducted by the European Commission, and engagements with European networks and international bodies.[38] However, the ex-ante evaluation of the FP7 programme has noted that there was little direct consultation with EU citizens when setting the research agenda for the 'Societal Challenges' programme and that this was largely based on a top-down approach.[39]

For example, the consultation process informing the 'Secure Societies' 2018–2020 Work Programme started in 2016 and is expected to be completed by October 2017.[40] According to the European Commission, this process has drawn on the contributions of: PASAG, EU MS administrations, civil society organisations (through the SecurePART FP7 project),[41] security-related networks (e.g. ENLETS, ENFSI, EFRIM, RAN)[42] and associations of research organisations (e.g. EARTO, IGLO[43]) or industries (e.g. ASD, EOS),[44] as well as from the cPPP (Contractual Public-Private Partnership) Strategic Research and Innovation Agenda on Cybersecurity and Digital Privacy and the CONNECT Advisory Forum.[45] The Frontex Research and Development Unit (RDU) has also contributed to this consultation process with a set of research proposals, following discussion with MS and Frontex operational departments.[46] Four draft calls were put forward under the Secure Societies 2018–2020 Work Programme, of which two focus on border security research: 'Boosting the Effectiveness of the Security Union' and 'Fight against Crime and Terrorism, Disaster Resilience, Border and External Security'.[47]

Selection of border security research projects

The EU funds research and development by issuing calls for proposals on the basis of the Work Programmes and then awarding grants to collaborative projects. Within the EU, the Research Executive Agency (REA) has implemented parts of the FP7 and H2020 programmes,[48] and it is currently managing nearly 20 per cent of the H2020 budget, which includes parts of the Societal Challenges programme that focus on border security.[49] The REA operates under the supervision of, and is accountable to, the European Commission. The agency is tasked with implementing the grant management lifecycle, which involves publishing calls, organising proposal evaluations, preparing grant agreements and monitoring implementation of grant agreements.[50]

The REA is responsible for checking the initial eligibility of proposals submitted. Once eligibility has been certified, a minimum of three external 'peer review' evaluators, who are identified from a pool of experts who have expressed their interest in being evaluators, conduct a further evaluation of the 'operational capacity' presented in the proposals – a criterion that is not defined clearly in the available literature.[51] The evaluators who constitute this independent peer review panel are selected on the basis of their expertise in relation to the proposal topic,[52] and scores are assigned to the proposal based on a set of evaluation criteria on financial and operational capacity.[53] The award criteria relate to 'excellence', 'impact', and 'quality and efficiency of the implementation'.[54]

37 European Commission (2017c).
38 RAND Europe interview with three representatives, European organisation, 3 April 2017; RAND Europe interview with anonymous Frontex representative, 19 April 2017.
39 European Commission (2015c).
40 RAND Europe interview with anonymous EU institution, 24 April 2017.
41 SecurePART (2017).
42 European Network of Law Enforcement Technology Services (ENLETS), European Network of Forensic Science Institutes (ENFSI), European First Responder Innovation Managers Meeting (EFRIM), Radicalisation Awareness Network (RAN).
43 European Association of Research and Technology Organisations (EARTO), Informal Group of RTD Liaison Offices (IGLO).
44 AeroSpace and Defence Industries Association of Europe (ASD), European Organisation for Security (EOS).
45 European Commission (n.d.-j).
46 RAND Europe interview with Dragos Voicu, 11 April 2017.
47 European Commission (n.d.-j).
48 REA (2016).
49 REA (2016).
50 REA (2016).
51 REA (2016); RAND Europe interview with anonymous EU project coordinator, 2 April 2017; RAND Europe interview with anonymous EU institution, 24 April 2017.
52 European Commission (2017c); REA (2016).
53 RAND Europe interview with anonymous EU project coordinator, 2 April 2017; RAND Europe interview with anonymous EU institution, 24 April 2017.
54 For an expanded explanation of these award criteria, see European Commission (2016c).

Evaluators first score the proposals individually, before comparing scores and arriving at a consensus for each proposal.[55] Proposals are then discussed at a panel review meeting, where they are benchmarked and ranked by the evaluators.[56] H2020 rules and regulations allow participants to submit a complaint and request a re-evaluation of their proposal. Complaints are handled through a system whereby committee members reconvene to discuss the case and, where appropriate, recommend that the proposal be re-evaluated.[57]

The highest-ranking proposals become eligible for funding, and enter the 'grant finalisation process'.[58] The REA gathers administrative, legal and financial information from the contracting organisation and finalises the funding agreement.[59] According to H2020 guidelines, there should be a maximum of five months between proposal submission and participants being informed of the evaluation results (also known as 'Time-to-Inform' (TTI)). The entire process between H2020 proposal submission and grant signature ('Time-to-Grant' (TTG)) lasts a maximum of eight months (reduced from 12 months under the FP7 programme).[60]

In addition to being assessed on their financial offering, technical proposal and organisational capacity, H2020 proposals also have to pass a number of ethics and security checks. In particular, the REA is responsible for checking that the proposed research meets ethical requirements, that participants (i.e. future beneficiaries of the grant) are not involved in 'serious administrative errors or fraud', and that they are not 'subject to pending legal proceedings for administrative errors or fraud'.[61]

Proposals focusing on information that is EU-classified under the European Commission's internal Rules of Procedure are subject to a 'security scrutiny' review. This process, which applies to most parts of the Secure Societies programme, is coordinated by a Security Scrutiny Working Group comprising experts appointed in close cooperation with the relevant Programme Committee and national security authorities. This working group determines the level of sensitivity of proposals and checks whether all security aspects are being handled appropriately. There are three possible outcomes of this review process: (1) classification is not necessary; (2) classification is necessary; and (3) the proposal is rejected on the grounds that it is too sensitive to be funded.[62]

Monitoring and evaluation

The REA (along with the European Commission, in specific cases such as Pre-Operational Validation (POV) projects in which research services are jointly procured by a number of national authorities in charge of border security)[63] manages:

> *[...] monitoring of the execution of the project activities planned and involves, where appropriate, scientific expert reviewers as well as ex-ante checks on the participants' cost claims.*[64]

Ex-ante controls focus on providing an assessment of a project's progress against its initial objectives, ensuring the validity of the declared project costs and checking compliance with the 'legality and regularity requirements'.[65] [66] During the course of a project, periodic reports are sent to the project officer within the European Commission, and include a technical and financial overview on the project to date.[67] Other subject matter experts are also involved in the ex-ante monitoring of actions.[68]

Part of the REA's role involves collecting information on project results and implementation, and feeding recommendations back to the European Commission in order to inform the development of future work programmes.[69] Despite efforts made during FP7 to reduce the administrative burden, it has been noted that externalising project management to the REA has contributed to increased fragmentation of project implementation.[70]

A new set of key performance indicators (KPIs) were created for H2020 projects. The KPIs in the Societal Challenges theme take into account:

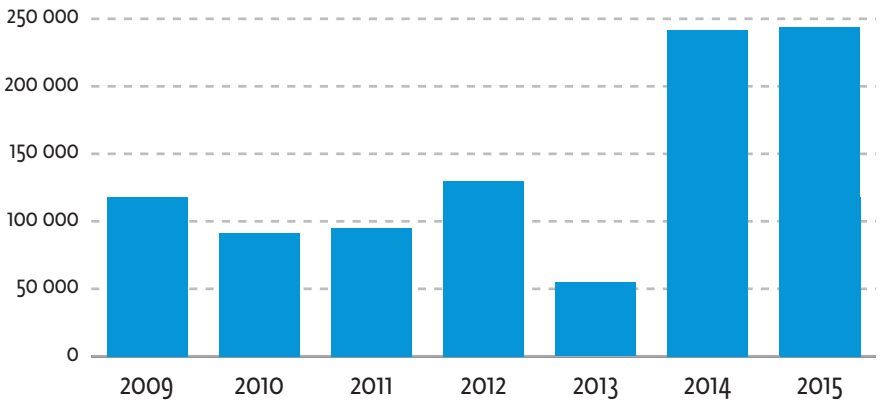
- Number of patent applications and patent awards
- Number of prototypes and testing activities
- Number of joint public-private publications
- New products, processes and methods launched for commercialisation.[71]

Frontex

Frontex also funds border security research, albeit on a lesser scale than the European Commission Framework Programmes and with a different legal basis.[72] The research projects funded through Frontex are not assigned to clear categories, but can be broadly clustered within the themes of 'border checks' and 'border surveillance'.[73] These projects focus mainly on high-tech research.[74] Frontex has funded research projects since 2009, with annual funding increasing between 2009 and 2015, as illustrated in Figure 2.5 overleaf.[75] Project budgets range from €20 000 to €60 000.[76]

55 European Commission (n.d.-f); REA (2016).
56 REA (2016).
57 REA (2016).
58 REA (2016).
59 European Commission (n.d.-d).
60 REA (2016); European Commission (2015g).
61 REA (2016).
62 European Commission (n.d.-o).
63 The European Commission is also responsible for the management of research projects classified as sensitive at the EU level.
64 REA (2016).
65 'Ex-ante' is defined as monitoring undertaken at the beginning or during the course of the project.
66 This includes financial statements, certificates on financial statements and timely submission of project deliverables. Source: REA (2016); RAND Europe interview with Dragos Voicu, 11 April 2017.
67 European Commission (n.d.-i).
68 European Commission (n.d.-f); RAND Europe interview with three representatives of a European organization, 3 April 2017.
69 REA (2016).
70 European Commission (2015c).
71 European Commission (2015f); European Commission (2015c).
72 RAND Europe interview with Dragos Voicu, 11 April 2017.
73 RAND Europe interview with Dragos Voicu, 11 April 2017.
74 RAND Europe interview with Dragos Voicu, 11 April 2017.
75 Amalgamation of data taken from the 2009 – 2016 Governance Documents (Contracts Awarded). Source: Frontex (2017).
76 Amalgamation of data taken from the 2009 – 2016 Governance Documents (Contracts Awarded). Source: Frontex (2017).

Figure 2.5 **Border security project funding (Frontex)**[77]



Source: Frontex (n.d.-b).[78]

Research projects funded by Frontex are mainly outsourced and coordinated by its RDU, which consults with in-house personnel, Frontex Operational Departments and MS border guard experts.[79] The RDU consists of four sections: technology assessment, innovation, technical assistance and harmonisation. These sections are responsible for the management and delivery of internal projects. For example, personnel involved in technology assessment are responsible for organising tests, trials and demonstrations related to border surveillance equipment and technologies.

Project officers within Frontex are tasked with developing Terms of Reference (TORs) and coordinating a consultation process on the TOR that involves Frontex stakeholders and MS representatives.[80] This process is conducted through a series of discussions, consultations, meetings and analysis.[81] Procurement follows EU procurement legislature and timelines.[82] Frontex's assessment criteria for research projects relate to: understanding of context; study objectives and approach; methodology and work plan; quality, relevance and clarity of technical proposal; project team experience; resource allocation; and feasibility of project timeframes.[83] Scoring tends to place more importance on technical quality than on price, with 65 per cent typically allocated to the former and 35 per cent to the latter.[84] Contracts awarded by Frontex typically last between six and nine months.[85] Article 37 ('Research and Innovation') of the Frontex Regulation requires that research findings are disseminated to relevant stakeholders, including the European Parliament, the European Commission and MS.[86]

2.1.3. Pathways to impact

The official description of H2020 places emphasis on active end user involvement in research projects, with end users contributing to activities ranging from the identification of research topics to the coordination of research projects in order to ensure that research outputs are tailored to the operational needs of border security authorities. For example, under the 2016–2017 H2020 Work Programme, the participation of border guard authorities is a mandatory eligibility criterion for research proposals under 7 of the 8 calls relating to border security.[87] While 'end user engagement' is not an explicit part of the H2020 definition of 'impact' (see Box 2.1), the European Commission is placing increasing emphasis on the importance of involving end users in research as a means of achieving impact. Impact is an important component of the H2020 proposal review stage, with H2020 proposals being required to describe projects' 'expected impact'.[88]

Box 2.1 **Definition of 'impact' in H2020 proposal guidance**

In its guidance to H2020 proposal evaluators, the European Commission defines 'impact' as:

[...] the extent to which project outputs should contribute to the expected impacts described for the topic, to enhancing innovation capacity and integration of new knowledge, to strengthening the competitiveness and growth of companies by developing and delivering innovations meeting market needs, and to other environmental or social impacts, as well as the effectiveness of the exploitation measures.[89]

This definition of 'impact' applies to the whole H2020 programme and is not specific to the Secure Societies programme, which includes research aimed at 'strengthening security through border management'. The first interim evaluation of H2020 is due by December 2017 and preliminary feedback from stakeholder position papers has highlighted concern regarding the lack of clarity around how 'expected impact' is defined, with stakeholders stating that 'H2020 lacks a systematic, comprehensive and overarching system to assess research impacts.'[90] Several respondents have also raised concerns regarding the lack of clarity around the definition of 'impact' and the expected timeline for impact, which could differ depending

77 Projects included in this analysis are based on an independent analysis by the authors of research commissioned by Frontex between 2009 and 2015. Contracts awarded for services and goods were not included for the purpose of this analysis.
78 Projects are included in this analysis based on an independent analysis by the authors of research commissioned by Frontex between 2009 and 2015.
79 RAND Europe interview with Dragos Voicu, 11 April 2017.
80 RAND Europe interview with Dragos Voicu, 11 April 2017.
81 RAND Europe interview with Dragos Voicu, 11 April 2017.
82 See European Union (n.d.).
83 RAND Europe interview with Dragos Voicu, 11 April 2017.
84 RAND Europe interview with Dragos Voicu, 11 April 2017.
85 RAND Europe interview with Dragos Voicu, 11 April 2017.
86 RAND Europe interview with Dragos Voicu, 11 April 2017; European Parliament (2016).
87 European Commission (2016c).
88 European Commission (n.d.-j); European Commission (n.d.-k); RAND Europe interview with anonymous EU project coordinator, 2 April 2017.
89 European Commission (2014).
90 European Commission (n.d.-h), with material analysed based on the overviews on position papers (ETH Zurich, IMPACT EV consortium, 8 Danish universities).

on the theme of the research.[91] However, given that the H2020 programme and its evaluation are ongoing, it is too early to assess how effectively H2020 projects have been implemented.

Many of the later FP7 projects have yet to be completed (the typical duration of a project being four years). However, an ex-post evaluation of the FP7 programme has already been conducted and additional information regarding ongoing FP7 projects will be included in the upcoming interim evaluation of H2020.[92] The FP7 evaluation noted that efforts have been made under FP7 to enhance innovation and to bring research results closer to market uptake[93] through an increased focus on prototypes, tests and demonstrations.[94] Lessons learned from FP7 and applied to H2020 also relate to making research publications more openly accessible and carrying out M&E of EU-funded research projects in a more systematic way.[95]

Study interviewees have noted that despite these efforts, several demonstration projects have fallen short of effective implementation in the market due to a lack of dissemination and support for implementation.[96] While a demonstration of research products often takes places at the end of FP7 projects, there is often little practical follow-up. One interviewee said that this is partly because the European Commission lacks the mandate and the funding for monitoring and further developing research results after the completion of EU-funded studies.[97]

The final evaluation of the 'Security' research strand of the Framework Programme found that while FP7 aimed to involve end users in research projects to help promote research uptake, it has not been entirely successful in achieving this goal.[98] Evaluators noted that end user uptake could have been improved by researching solutions with greater operational applicability and involving end users more effectively.[99] It was noted that end user engagement in FP7 projects was generally achieved by involving them on project advisory boards and at dissemination events.[100] The evaluation found that the extent and nature of end user involvement in FP7 research varied across projects.

In response to these findings, H2020 has emphasised the importance of involving end users in research projects. One of the eligibility criteria for projects is the inclusion of at least three end user entities in the project team.[101] The process for 'validating' end users has also been simplified to incentivise end user participation in H2020 research.[102] Despite these steps to simplify the process, one interview said that end users still lack familiarity with the FP7 and H2020 programmes, particularly the financial rules, which can create barriers for end user participation.[103]

Two ongoing projects, the FP7 project ABC4EU and the H2020 project BODEGA,[104] have both involved end users throughout the research process in a variety of ways. ABC4EU, which aims to harmonise Automated Border Control (ABC) gates at the EU level,[105] involves end users in its end user integration groups and an end user community.[106] BODEGA, on the other hand, is not driven by the creation of a technology; rather, it explores the human factors in border checks.[107] In this case, results are drawn from end user involvement in data collection exercises such as surveys.[108]

Boxes 2.2 and 2.3 present PERSEUS and SeaBILLA as examples of completed projects in which end users were closely involved.

Box 2.2 **End user project involvement: PERSEUS**

PERSEUS (Protection of European seas and borders through the intelligent use of surveillance) was an FP7 project that ran from 2011 to 2015.[109] The aim of the project was to create an 'integrated European system for maritime border control'[110] in order to support the monitoring of illegal migration activities, transnational crime and goods smuggling.[111] The project resulted in the creation of a common situational picture, enhanced vessel detection, improved detection and identification of small aircraft and boats, and increased information sharing between actors including Frontex, National Contact Centres and the European Maritime Safety Agency.[112]

PERSEUS involved a number of end users including the Spanish Guardia Civil, the Greek Ministry of National Defence and the Portuguese Ministry of Internal Administration,[113] as well as other international participants such as the North Atlantic Treaty Organization (NATO) Science and Technology (S&T) Organisation. As part of the project, demonstrations were conducted through five exercises which required the approval and participation of these national authorities responsible for border surveillance at sea. These demonstrations also involved industry representatives from companies including Saab and Airbus. Over 40 different technologies were tested at the demonstrations, many of which had a TRL between 7 and 9.[114] Some of the solutions developed have now been put into practice, expanding beyond the maritime surveillance domain.[115]

91 European Commission (N.d.-h), with material analysed based on the overviews on position papers (ETH Zurich, IMPACT EV consortium, 8 Danish universities).
92 European Commission (2016d); European Commission (2015c).
93 European Commission (2015c).
94 European Commission (2015c).
95 European Commission (2015c).
96 RAND Europe interview with three representatives of an European organisation, 3 April 2017.
97 RAND Europe interview with EU policy official, 21 March 2017.
98 RAND Europe interview with Triantafyllos Karatrandos, 20 April 2017; Technopolis (2015).
99 Technopolis (2015).
100 Technopolis (2015).
101 RAND Europe interview with anonymous EU project officer, 26 June 2017.
102 RAND Europe interview with anonymous EU project officer, 26 June 2017.
103 RAND Europe interview with anonymous EU project officer, 26 June 2017.
104 'BOrdDErGuArd – Proactive Enhancement of Human Performance in Border Control'.
105 RAND Europe interview with anonymous EU policy official, 21 March 2017.
106 CORDIS (2016a).
107 RAND Europe interview with anonymous EU project officer, 26 June 2017; BODEGA (n.d.-a).
108 RAND Europe interview with anonymous EU project officer, 26 June 2017.
109 CORDIS (2017); CORDIS (n.d.).
110 Copernicus. (n.d.-b).
111 CORDIS (2017).
112 CORDIS (2017).
113 RAND Europe interview with anonymous EU policy official, 21 March 2017.
114 RAND Europe interview with anonymous EU policy official, 21 March 2017.
115 RAND Europe interview with anonymous EU policy official, 21 March 2017.

Box 2.3 **End user project involvement: SeaBILLA**

The FP7 Sea Border Surveillance (SeaBILLA) project was established to enhance sea border surveillance capabilities through close engagement with end users.[116] The aims of the project were to create an 'architecture for cost-effective sea border surveillance systems at the European level', to improve interoperability across MS, and to reduce the information gap arising from heterogeneous surveillance systems, legislation and modes of operation across Europe.[117] End users including participants from the Maritime Analysis and Operations Centre – Narcotics (MAOC-N) and selected sea border authorities from MS (including Italy, France, Spain, the Netherlands and the United Kingdom (UK)) were involved from the inception of the project in developing sea border surveillance mechanisms.[118] The project reported that end users contributed to SeaBILLA in various ways, including through participation in workshops and live demonstrations.[119]

Project results were disseminated through project meetings, demonstrations and workshops. The successful uptake of results is partly attributable to the close involvement of end users in this project, as well as to the fact that the technology was developed to be compatible with current systems.[120] Moreover, the Intellectual Property Rights (IPR) defined prior to the project allowed for open collaboration between partners in order to 'maximise the potential for collaboration on the exploitation of results' (see Sections 2.1.5 and 4.3.5 for further discussion of IPR).[121] SeaBILLA results have been operationalised, enhancing interoperability and information sharing among European Commission agencies and national authorities tasked with border surveillance.[122]

Box 2.4 **End user project involvement: EWISA[123]**

The FP7 project Early Warning For Increased Situational Awareness (EWISA) is a pre-operational validation project related to security of land borders, for which the public tender has been finalised. The end users include the Romanian border police, Finnish border guards and the Spanish Guardia Civil. The aim of this project is to provide a common concept on how surveillance of land borders should be undertaken. The project emphasises the importance of a common approach and perspective.

A public tender on research and the development of solutions was initiated, and has since been finalised. Once it has been developed, the solution will be implemented, tested and evaluated in four locations for six months. Industry is involved in the process as they will train the border guards with a common training programme. The border guards will be able to use the solutions for six months, after which these will be evaluated and a cost analysis will be performed. The results of the evaluation will then be presented to Frontex and other EU institutions.

To promote the operationalisation of research results, the FP7 evaluation recommended improving 'programme-level support for dissemination' of research findings and creating 'mechanisms to support the application of project results'.[124] The evaluation also found that research projects should have a clearer implementation and exploitation plan, and that project results should be linked to commercialisation.[125] For example, where projects have a coordinator with good market knowledge, this is said to improve the operationalisation of research results.[126] FastPass is an example of such a project (see Box 2.5).

According to one study interviewee, another key factor that can help bring project results to the operationalisation stage is a high level of end user engagement.[127] End users' buy-in during project demonstrations and workshops is said to be important for benchmarking project outcomes against other tools used by border guards.[128]

In this regard, the POV CLOSEYE project has been identified as a 'game changer'. CLOSEYE is the first example of a research project paving the way to an MS initiative supported by the Internal Security Fund (ISF) borders fund.[129] As Box 2.4 shows, CLOSEYE is an example of a project that interviewees considered to have had a tangible impact on border security operations. CLOSEYE led to the award of a follow-up project (ESPIAS) in December 2016, which focuses on helping improve border surveillance by strengthening cooperation between MS under the EUROSUR framework.[130] This project was awarded through ISF funding under the call 'HOME/2015/ISFB/AG/ESUR'.

116 CORDIS (2015).
117 SeaBILLA (n.d.); Technopolis (2015).
118 SeaBILLA (n.d.); Technopolis (2015).
119 SeaBILLA (n.d.).
120 CORDIS (2015).
121 CORDIS (2015).
122 CORDIS (2015).
123 RAND Europe interview with Pantelis Michalis and George Leventakis, 30 August 2017.
124 Technopolis (2015, 86).
125 Technopolis (2015).
126 RAND Europe interview with anonymous EU policy official, 21 March 2017.
127 RAND Europe interview with anonymous EU policy official, 21 March 2017.
128 RAND Europe interview with anonymous EU policy official, 21 March 2017.
129 CLOSEYE (n.d.).
130 European Commission (n.d.-m).

Frontex

Frontex seeks to achieve impact by organising information exchange sessions and workshops with end users, industry, academia and other stakeholders involved in the delivery of research projects.[131] Frontex sits on the advisory board of some EU-funded projects to help ensure that the research conducted reflects border guards' requirements and the wider operational context.[132]

Box 2.5 **Project with a tangible impact: CLOSEYE[133]**

CLOSEYE (Collaborative evaLuation Of border Surveillance technologies in maritime Environment bY pre-operational validation of innovativE solutions) is an FP7 project that aimed to provide:

> *[...] the EU with an operational and technical framework that increases situational awareness and improves the reaction capability of authorities surveying the external borders of the EU.*[134]

End users were closely involved in the setup and management of this project. These stakeholders were consulted, provided project advice, acted as project partners and helped define the specifications for joint development.[135] According to interviewees, the project has demonstrated how novel solutions can be used in the operational context.[136] However, detailed information regarding the project's impact on operational practice was not forthcoming from the interviews conducted to date. The project closed in February 2017 and the research results are 'on the way to being operationalised'.[137]

Box 2.6 **Project with a tangible impact: FastPass**

FastPass is an FP7 project that ran from 2013 to 2017 and focused on creating a harmonised, modular approach for system for all European automated border crossing points.[138] The aim of FastPass is to enhance efficiency of border controls while maintaining security. In order to do so, FastPass gathered a large network of stakeholders that are part of the ABC value chain to develop a harmonised approach to ABC gates, including 'system and component producers, research institutions, governmental authorities, infrastructure operators, and end users'.[139] FastPass also drew on continuous end user inputs, for example taking into account border guards' and travellers' requirements and evaluations when developing and testing technologies.

Various technologies were operationalised through this project, including next-generation sensors, software and algorithms for biometric identification, innovative scenarios for different types of border crossing which rely on a common harmonised architecture, and a holistic risk methodology for threat assessment.[140] The technologies developed through FastPass have reportedly been 'quite successful'[141] in terms of their exploitation, having been put into use at Vienna Airport, Piraeus Port and the Moravita land border crossing point.[142] Additionally, the results from FastPass were reportedly instrumental in informing the design and delivery of the H2020 project BODEGA, which is underway at the time of writing.

131 RAND Europe interview with Dragos Voicu, 11 April 2017.
132 RAND Europe interview with Dragos Voicu, 11 April 2017.
133 RAND Europe interview with anonymous EU institution, 24 April 2017; RAND Europe interview with anonymous EU policy official, 21 March 2017.
134 CLOSEYE (n.d.).
135 RAND Europe interview with anonymous EU institution, 24 April 2017.
136 RAND Europe interview with anonymous EU policy official, 21 March 2017.
137 RAND Europe interview with anonymous EU institution, 24 April 2017.
138 CORDIS (2016b).
139 FastPass (n.d.-b).
140 FastPass (n.d.-b).
141 RAND Europe interview with anonymous EU project officer, 26 June 2017.; FastPass (n.d.-b).
142 RAND Europe interview with anonymous EU project officer, 26 June 2017.; FastPass (n.d.-b).

2.1.4. Summary

Figure 2.6 overleaf provides a visual summary of the EU R&I pathway, including the various associated factors, stakeholders and inputs.

2.1.5. Lessons identified

A number of areas of good practice and enduring challenges can be identified from the EU case study analysis. These are presented below.

Good practices

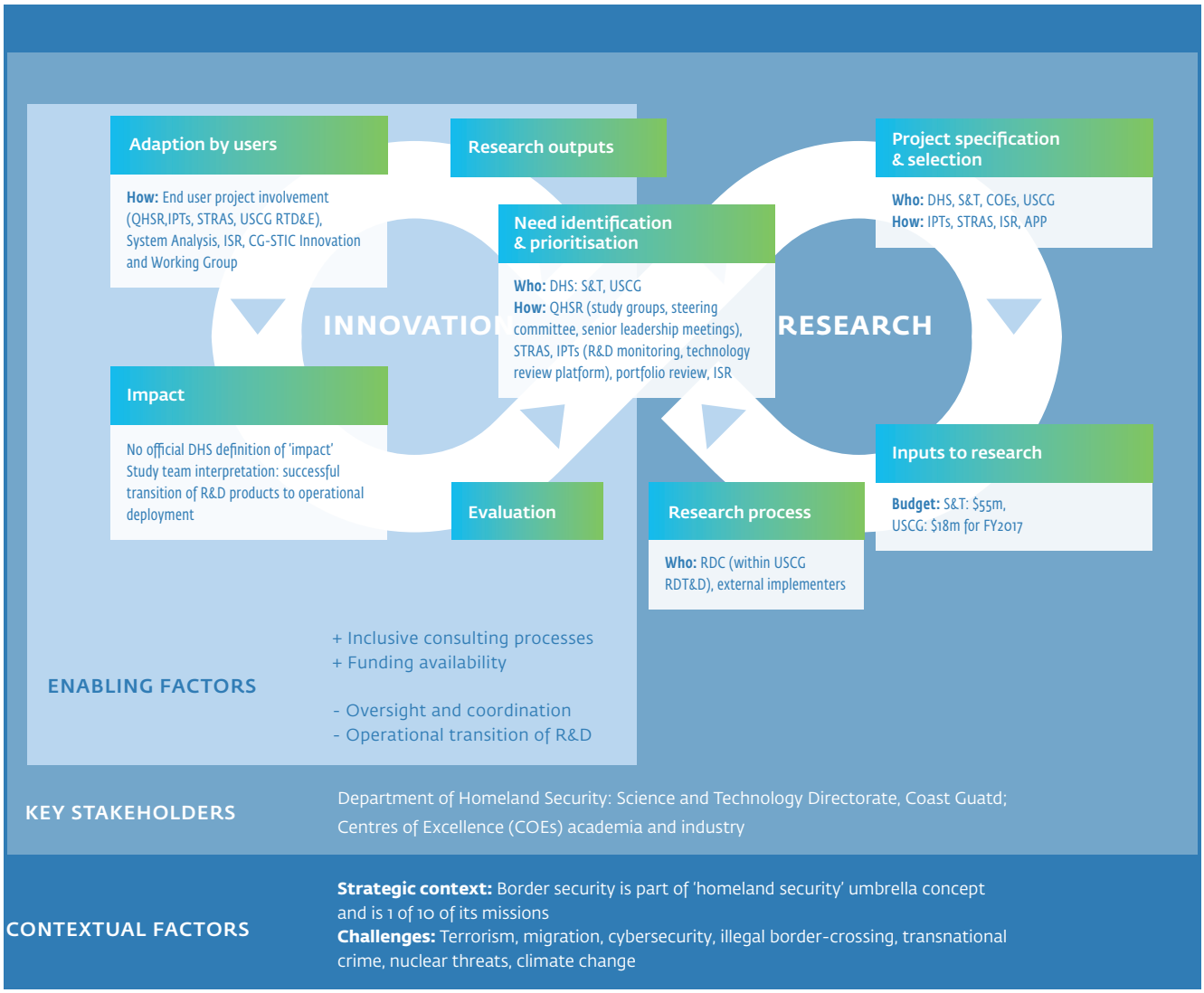
Interviewees reported increased involvement of end users in the H2020 research process compared to the FP7 process. End users were said to be more closely involved in coordinating research projects and in defining the Work Programmes, while their role in previous Framework Programmes was often limited to that of observers or meeting participants.[143] Study interviewees noted that increased end user involvement has enhanced market visibility,[144] improving the relationship between the supply and demand sides and increasing engagement between research providers and end users. However, there is scope for continued improvement. While end users have been more involved in security research, the FP7 Security programme evaluation notes that their role should be better established as a requirement throughout the whole Work Programme cycle, including the topic selection, proposal, project and dissemination stages.[145] To support this objective, the FP7 evaluation recommends improving processes for supporting engagement and articulation of research needs.[146]

Challenges

Despite increased efforts under FP7 and H2020 to strengthen links between border security research and operational practice, challenges remain in relation to the operationalisation of research

143 RAND Europe interview with anonymous EU institution, 24 April 2017; Technopolis (2015).
144 RAND Europe interview with anonymous EU institution, 24 April 2017.
145 Technopolis (2015).
146 Technopolis (2015).

Figure 2.6 **EU research and innovation pathway**



findings.[147] Several interviewees stated that the links between project findings and uptake in the European market were unclear and that too often research did not lead to tangible change in operational measures.[148]

Several factors are said to contribute to this **disconnect between research and operational practice**. At the proposal stage, for example, the border security experts responsible for evaluating proposals are not always sufficiently aware of practitioner needs and the wider operational context.[149] As a result, the type of research conducted is not always operationally focused or immediately applicable for end users. According to one study interviewee, high-TRL research is most useful for border guards in the context of their day-to-day work.[150] However, as outlined in Section 2.1.2, few H2020 Work Programmes to date have included projects with a high TRL, with most being set at TRL 5. To have applicability for end users, it is important for border security research to take into account not only end user requirements, but also a number of considerations including efficiency, affordability and the compatibility of research-based solutions with the field and technology already in use.[151] To ensure applicability of the research outputs for end users, it is important to ensure end users' continuous involvement throughout the research pathway so that they can identify any potential issues with research products and systems from a practitioner perspective before they are too far developed.[152]

147 Technopolis (2015); RAND Europe interview with Dragos Voicu, 11 April 2017; RAND Europe interview with anonymous FP7 project coordinator, 31 March 2017; RAND Europe interview with Triantafyllos Karatrandos, 20 April 2017.

148 RAND Europe interview with Dragos Voicu, 11 April 2017; RAND Europe interview with anonymous FP7 project coordinator, 31 March 2017; RAND Europe interview with Triantafyllos Karatrandos, 20 April 2017.

149 RAND Europe interview with anonymous FP7 project coordinator, 31 March 2017.

150 RAND Europe interview with anonymous Frontex representative, 19 April 2017; RAND Europe interview with Pantelis Michalis & George Leventakis, 30 August 2017.

151 RAND Europe interview with anonymous Frontex representative, 19 April 2017; RAND Europe interview with anonymous EU institution, 24 April 2017; RAND Europe interview with Peter Ryman, 20 September 2017.

152 RAND Europe interview with Peter Ryman, 20 September 2017.

Another issue relates to the **inflexibility of EU funding models**, which are set within the wider European Commission legal framework. According to one interview, current funding opportunities for research projects often lack the flexibility to meet the different needs of end users.[153] While EU-funded research tends to span multiple years, there is not yet a rapid funding mechanism that addresses the emergent 'short-term needs of end users'.[154] Nonetheless, there are several follow-on funding mechanisms that are reportedly designed to take research projects towards application in the field, although their effectiveness could not be determined by the RAND study team based on the data available. These mechanisms include InnovFin, The European Fund for Strategic Investments (EFSI), regional and national funds, InvestHorizon and Progress TT, which are part of the 'Industrial Leadership' pillar of H2020.[155]

The EU Framework Programmes lack funding to directly support the commercialisation and implementation of research findings.[156] To address this **lack of funding for commercialisation**, one study interviewee suggested that the Framework Programmes could be more closely linked to other funding mechanisms relating to border security, such as the ISF, which is a €3.8bn fund for 2014–2020 designed to promote the implementation of the Internal Security Strategy and external border management.[157] Budgetary issues also relate to a perceived **lack of coordination of funding mechanisms** across the EU. At present, there appears to be no centralised overview of the funding mechanisms offered both at the EU and MS levels.[158] However, it should be noted that this observation was made by one interviewee; further research would be required to validate this statement.

A further barrier to the development of EU-funded border security research relates to the Framework Programme **intellectual property (IP) laws**, under which researchers retain IPR to the research products, which can constrain border guards from developing the research further and applying it in practice in cases where they have not been directly involved in the research itself. This approach contrasts with the US approach (see Section 3.1), whereby all property developed through US-funded programmes is federally owned.[159]

2.2. EU Member State survey findings

An electronic survey was distributed to National Frontex Points of Contact (NFPOC) in all 28 EU MS by Frontex (see Appendix C). This survey focused primarily on border security research funded at the national level (see Sections 2.2.1 to 2.2.3) and also examined respondent countries' involvement in EU-funded research (see Section 2.2.4). With a 39 per cent response rate (11 of 28 MS),[160] the findings presented in this section are not representative of the state of play of border security research across all EU MS; rather, they are intended to provide a snapshot of approaches adopted by the participating nations.

2.2.1. Strategic context

Almost all MS respondents stated that border security was of high strategic importance in their countries,[161] while one respondent[162] rated it as being of medium importance.[163] Respondents highlighted similar challenges to their borders, namely illegal migration, illegal border-crossing[164] and forms of cross-border crime including stolen vehicle trafficking, goods smuggling, drug smuggling[165] and human trafficking.[166]

National border guard agencies were identified as the main type of actor responsible for funding border security research across respondent countries.[167] Other actors mentioned include academia,[168] industry, and small and medium-sized enterprises (SMEs).[169] 'Wider government'[170] and 'private institutions'[171] were also noted. In one case, cooperation with partners from academia and industry is reportedly an important factor for ensuring that research is relevant and that customised solutions can be developed rapidly.[172] Other countries rely on funding from their Ministry of Interior (MoI), Ministry of Defence (MoD) and other government departments.[173]

2.2.2. Research pathway

Overview of the EU MS research landscape

In three respondent countries,[174] border security research is reportedly characterised by an even distribution of high- and low-technology projects.[175] In one of these countries, independent research funded by the national border guard tends to draw mainly on social science approaches, while high-tech research is most common in 'development

153 Technopolis (2015).
154 Technopolis (2015).
155 European Commission (n.d.-a).
156 Technopolis (2015); RAND Europe interview with three representatives of a European organisation, 3 April 2017; RAND Europe interview with anonymous EU institution, 24 April 2017. It should be noted that this is a constraint that does not affect all EU funding programmes. For example, EU MS reportedly only use half of the ISF funding available to them (RAND Europe interview with Frontex representative, 19 April 2017).
157 RAND Europe interview with Triantafyllos Karatrandos, 20 April 2017.
158 RAND Europe interview with Triantafyllos Karatrandos, 20 April 2017.
159 RAND Europe interview with anonymous Frontex representative, 19 April 2017.
160 7 NFPOC provided completed survey responses (Surveys A-G); 3 NFPOC (Surveys H-J) informed the study team that they do not perform activities related to border security research; and 1 NFPOC (Survey K) was unable to complete the survey due to other work commitments.
161 6 respondents (Surveys B, C, D, E, F, G).
162 1 respondent (Survey A).
163 Participants were presented with three options for this question: 'high importance', 'medium importance' and 'low importance' (see Appendix C).
164 6 respondents (Surveys B, C, D, E, F, G).
165 5 respondents (B, C, E, F, G).
166 1 respondent (Survey E).
167 6 respondents (Surveys B, C, D, E, F, G).
168 4 respondents (Surveys B, C, E, F).
169 2 respondents (Surveys B, F).
170 2 respondents (Surveys E, F).
171 1 respondent (Survey E).
172 1 respondent (Survey B).
173 2 respondents (Surveys D, G).
174 3 respondents (Surveys B, C, D).
175 'High-technology research' refers to complex technology applied and demonstrated in its final form, while 'low-technology research' refers to low complexity technology where scientific research begins to be translated into applied research and development (see Appendix D).

projects' – a type of research not defined by the MS survey respondent but which the RAND study team understands to refer to more applied research with an operational focus.[176] By contrast, three of the other respondent countries mainly undertake high-tech projects in the field of border security research.[177]

Identification and prioritisation of research topics

In most respondent countries, research topics are identified by the national border guard agency.[178] However, the prioritisation of research topics tends to draw on wider government participation, involving the Ministry of Interior[179] as well as the Ministries of Defence, Security and Justice.[180]

The types of research topics selected depend on the security situation, the operating environment and an assessment of future needs.[181] Respondents C and F specified that they have a *Research Strategy* and an *Integrated Border Management Strategy*, respectively, and that their research projects are based on these strategies.

With one exception,[182] all respondents stated that they always consider the 'impact potential' of border security research projects when identifying and prioritising research topics. However, 'impact potential' is measured in different ways across MS. In one case, 'impact' is measured prior to the project through an assessment of the quality of the proposal,[183] while in all other cases impact is measured upon completion of the project. Indicators of successful impact include more efficient operations following operationalisation of research findings,[184] the provision of positive end user feedback concerning the new devices or technologies produced,[185] and the financial impact of research-based solutions applied in the field.[186]

Selection of border security research projects

While some national processes for awarding border security research contracts are internal to the border guard agencies,[187] other countries hold 'public auctions'[188] or do not have a different process to that used for other tendering work.[189]

Criteria used to evaluate proposals include relevance of the research,[190] cost effectiveness,[191] applicability and usability,[192] impact potential,[193] maintenance costs,[194] quality of the consortium,[195] project risks,[196] type of research (fundamental/applied)[197] and research quality (academic standards).[198] When asked about how much weight was assigned to 'impact potential' when evaluating proposals, it was reported that this was not the most important criterion for some respondents,[199] while others considered it highly important.[200] While two respondents noted that the relative weighting of technical and financial scoring is dependent on the research project,[201] another respondent specified that technical components are weighted at 60 per cent compared to 40 per cent for financial components.[202]

Monitoring and evaluation

Across the respondent MS, research projects are monitored both on a continuous[203] and an annual basis.[204] In two cases,[205] a progress report maps the activities outlined in the proposal to the achievement of project goals. Indicators used to evaluate research projects include:

- Initial impact evaluation[206]
- Operational impact[207]
- Publications[208]
- Technological, operative or educational innovation[209]
- Research conclusions.[210]

2.2.3. Pathways to impact

The main stakeholders involved in the practical implementation of border security research differ by country, but these actors tend to include the Ministry of Interior and national border guard agencies. Respondent MS have various processes and practices in place to improve the operationalisation of research findings, including active communication between researchers and end users (border guards),[211] active participation of end users in research projects,[212] and systematic integration of research results into operational practice.[213]

Most respondents viewed their national border security research processes as 'effective' in terms of the integration of findings into operational practice,[214] while one respondent assessed its processes as being 'very effective'.[215] While these responses are based on a self-evaluation, various explanations were provided for these positive assessments. In one respondent country, research processes were said to be effective given the small size of the country and research system, which was said to facilitate collaboration between researchers and end users.[216] Other systems focus on enhancing the knowledge of end users such as border police officers and on ensuring that they use state-of-the-art technologies.[217] However, a number of shortcomings of existing processes were also identified, particularly in relation to the gap between research and operationalisation.[218] One respondent country noted a time lag between the

176 1 respondent (Survey C).
177 3 respondents (Surveys E, F, G).
178 4 respondents (Surveys B, C, E, G).
179 3 respondents (Surveys B, C, D).
180 1 respondent (Survey E).
181 4 respondents (Surveys A, B, F, G).
182 1 respondent (Survey B).
183 1 respondent (Survey C).
184 1 respondent (Survey E).
185 1 respondent (Survey F).
186 1 respondent (Survey G).
187 2 respondents (Surveys B, C).
188 1 respondent (Survey D).
189 1 respondent (Survey G).
190 3 respondents (Surveys A, B, D).
191 3 respondents (Surveys A, E, G).
192 4 respondents (Surveys B, C, E, F).
193 1 respondent (Survey B).
194 1 respondent (Survey B).
195 2 respondents (Survey C, E).
196 1 respondent (Survey E).
197 2 respondents (Surveys E, G).
198 1 respondent (Survey E).
199 3 respondents (Surveys B, C, G).
200 2 respondents (Surveys D, E).
201 2 respondents (Surveys B, G).
202 1 respondent (Survey D).
203 2 respondents (Surveys B, G).
204 1 respondent (Survey C).
205 2 respondents (Surveys D, E).
206 1 respondent (Survey B).
207 1 respondent (Survey B).
208 1 respondent (Survey C).
209 1 respondent (Survey C).
210 1 respondent (Survey G).
211 1 respondent (Survey B).
212 2 respondents (Surveys B, C).
213 1 respondent (Survey G).
214 5 respondents (Surveys B, C, E, F, G).
215 1 respondent (Survey D).
216 1 respondent (Survey B).
217 1 respondent (Survey F).
218 1 respondent (Survey E).

conception of an idea and the end of a research project, stating that end users need implementable results and commercialisable findings to be produced much more quickly.[219] While most respondents viewed their processes as 'effective', one respondent assessed their border security research management as 'not very effective' as research results often remain on paper because border guards are not obligated to implement recommendations.[220]

2.2.4. Involvement in EU-funded research

Involvement in H2020, FP7 and other EU-funded research is not uniform across MS respondents. While three of the respondent countries[221] do not participate in H2020 or FP7 projects on border security, two are active participants.[222]

The national border guard of one respondent country has participated in H2020 proposals in 2015 and 2016, and is currently involved in a H2020 project on border management technologies as part of a national expert network.[223] While this border guard authority monitors the results of H2020 projects, it has not yet implemented any of those results. Another national border guard has been an active member of consortia for EWISA,[224] EUCISE2020 (a project relating to 'pre-operational Information Sharing between the maritime authorities of the European States'),[225] BODEGA,[226] and FastPass.[227] The latter project was evaluated through on-site demonstrations, with the next generation of ABC gates under development. The respondent country highlighted how these evaluations and further research serve to 'embed the most important social and technological innovations of the project in our development work'.

Another EU MS border police force has also participated in EU-funded research, including the aforementioned FastPass; ABC-Gates, which also focuses on harmonising border control gates;[228] and MobilePass, which has developed mobile land border crossing point equipment.[229] This border police force has undertaken on-site testing for MobilePass equipment, stating that this type of new technology allows them to process travellers more quickly and securely, increasing border agencies' ability to focus on 'intelligence-oriented border control'.

Despite wide-ranging involvement in EU-funded projects, one respondent noted that information on project results could be disseminated more effectively.[230] On the operationalisation side, one respondent stated that research-based solutions are not developed on an industrial scale, and that project results need further testing to ensure their successful integration at borders.[231] Improving these two aspects could help countries integrate H2020 and FP7 research findings into operational practice.

2.2.5. Lessons identified

Good practices

A number of good practices were noted by respondents. Two respondent countries highlighted the importance of having strong stakeholder networks in place between end users, industry, researchers and government.[232] Having one main agency in charge of the research processes was highlighted as a useful way of establishing a single, clearly defined vision, set of objectives and decision-making process,[233] as well a good situational awareness of border security research being undertaken across the country.[234] Respondents also noted the value of efficient internal research,[235] with characteristics such as short timeframes between contract award and project start-up.[236]

Challenges

A lack of resources was the most frequently mentioned challenge facing the respondent MS.[237] MS mentioned limited funding available for research,[238] as well as a lack of financial incentives for border guard recruitment[239] and wider manpower shortages.[240] Another key area for improvement mentioned by several respondents relates to the need for research objectives to be more clearly defined.[241]

It can also be difficult to balance research approaches with operational priorities,[242] particularly when there is a time lag between the approval of a research project and its eventual operationalisation. Furthermore, it was pointed out that a lack of interagency cooperation means that national authorities are not always kept up to date with changes at the EU level.[243] As a result, there is not always a good understanding at the MS level of wider border security research activities taking place across the EU.

While respondents acknowledged some good practices at the EU level, such as Frontex's Master's Degree in Strategic Border Management, they also said that more could be done by Frontex and the EU more broadly to facilitate information exchange.[244] Suggestions for improvement in this area included having a website or database featuring all border research projects being conducted in the EU and setting up a Frontex-coordinated network of MS agencies involved in border security research.[245] This has already been done in the area of key trends and challenges in the wider policy context, through the European Strategy and Policy Analysis System (ESPAS).[246] One respondent country also noted that bilateral or multilateral exchanges between border guards are helpful knowledge-sharing mechanisms.[247] At the national level, respondents noted that a reduction of the administrative burden

219 1 respondent (Survey C).
220 1 respondent (Survey G).
221 3 respondents (Surveys A, D, G).
222 2 respondents (Surveys B, C). 'Respondent E' did not provide a reply to this set of questions.
223 1 respondent (Survey B).
224 CORDIS (2014).
225 European Common Information Sharing Environment for Maritime Suveillance in Europe (EUCISE) (n.d.).
226 BODEGA (n.d.-b).
227 See FastPass (n.d.)
228 ABC4EU (n.d.).
229 See MobilePass (n.d.).
230 1 respondent (Survey B).
231 1 respondent (Survey F).
232 2 respondents (Surveys B, C).
233 2 respondents (Surveys A, E).
234 2 respondents (Surveys B, C).
235 2 respondents (Surveys C, D).
236 1 respondent (Survey B).
237 1 respondent (Survey B).
238 4 surveys (Surveys B, C, D, E).
239 1 respondent (Survey F).
240 1 respondent (Survey B).
241 3 respondents (Surveys D, E, G).
242 2 respondents (Surveys E, G).
243 1 respondent (Survey C).
244 1 respondent (Survey C).
245 1 respondent (Survey C).
246 European Strategy and Policy Analysis System (n.d.).
247 1 respondent (Survey A).

would facilitate management of border research, and that ongoing evaluation of end users' needs would help improve the operationalisation of border security research.[248]

2.3. EU industry and academia survey findings

In order to complement the findings from the EU MS survey, an additional survey was sent out to industry and academia (see Appendix C). The survey focused primarily on border security research funded at the EU level, looking at the research pathway, impact and operationalisation of research, as well as lessons learned. Frontex circulated this survey to 52 of their contacts from industry and academia, with a 10 per cent response rate (5 of 52 contacts). Due to the low level of response, the survey findings are not representative of the experiences of all industry and academic partners in EU-funded border security research. Instead, these responses are treated as additional expert stakeholder input on the research pathway.

2.3.1. Research pathway

Identification and prioritisation of research topics

Overall, even among the limited number of survey respondents, there was a degree of variation in levels of knowledge of processes for identification and prioritisation of research topics. In particular, respondents seemed to be more aware of how research topics are identified than how they are prioritised.[249] Nonetheless, industry respondents stated that industry is generally consulted regarding research topics.[250] Respondents stated that while stakeholder groups are consulted, there is still scope for more dialogue between the various parties.[251] One of the respondents stated that several working groups in the area of research and technology seek to promote this kind of stakeholder involvement. These include the informal Integrated Mission Group for Security, a grouping of various organisations involved in security matters.[252]

In terms of the research topics themselves, respondents stated that these should be more dynamic in order to enable quick response to evolving threats.[253] Suggestions for improving the identification of research topics included mapping and identifying the needs of end users, reviewing best practices used abroad and new developments by industry, and requesting feedback from travellers.[254]

Selection of border security research projects

Respondents generally had a good understanding as to who selects border security research projects (the European Commission, based on scores provided by external experts). However, one pointed out that the experts' evaluation of proposals can sometimes be seen as subjective, as there may only be a small pool of experts on a given border security research topic and this can increase the chance of conflicts of interest.[255] In terms of the assessment criteria used to select the projects, most respondents were aware of the European Commission's focus on assessing impact, methodology and the implementation approach.[256] Respondents also stated that the financial elements were generally not as prominent as the technical elements – especially where proposals do not exceed the budget threshold provided in the call.[257] One respondent, however, felt that the financial aspect of calls is not sufficiently prioritised in the assessment, and that this implies that when scoring proposals, the exploitation plan of the results is not a priority.[258]

Monitoring and evaluation

All respondents had different answers as to who they thought was responsible for M&E, highlighting a lack of clarity on that aspect of the research pathway. Responses varied as to whether the research provider has sole responsibility for M&E,[259] or whether it is a combination of the sponsor organisation, the research provider or an independent assessor.[260]

Continuous project M&E by the user community and end users was seen as important, as was the involvement of external experts (for example through an advisory board) who can provide advice and recommendations.[261] Respondents agreed that M&E is expected to guarantee the usability of the solution, the high quality of the work, and the fulfilment of the relevant professional and scientific requisites.[262]

2.3.2. Pathways to impact

In response to the question on how research findings are operationalised, respondents provided a variety of answers. They highlighted the use of prototypes, the participation of end users in demonstration and validation, and interoperable tools and systems that enable the products of all the partners to be operated together.[263]

Respondents also highlighted several areas that could prevent or slow down the operationalisation of research outputs. These revolve around:

- A lack of effective planning at the start of the proposal or project, including for projects that have a low TRL;[264]
- A lack of requirements to operationalise the output, which undermines the shared interest within the consortium in operationalising project outputs;[265] and
- A lack of foresight as regards the costs of adopting and maintaining the new systems or products.[266]

Additionally, operationalisation of a product may require another tender process,[267] and may lead to a lack of willingness on the part of authorities and

248 1 respondent (Survey D).
249 3 respondents (Surveys L, M, O).
250 4 respondents (Surveys L, M, N, O).
251 1 respondent (Survey L).
252 1 respondent (Survey N).
253 2 respondents (Surveys L, O).
254 1 respondent (Survey M).
255 1 respondent (Survey M).
256 3 respondents (Surveys L, M, N).
257 3 respondents (Surveys L, M, N).
258 1 respondent (Survey M).
259 1 respondent (Survey O).
260 3 respondents (Surveys L, M, N).
261 1 respondent (Survey N).
262 2 respondents (Surveys L, M).
263 2 respondents (Surveys M, N).
264 1 respondent (Survey O).
265 1 respondent (Survey N).
266 1 respondent (Survey M).
267 1 respondent (Survey M).

Table 2.2 **Summary of findings for EU case study**

	Border security context	Key stakeholders	Needs identification and prioritisation	Project specification and selection	Inputs to research	Research process	Pathways to impact
EU (Sections 2.1–2.3)	**Strategic context:** Border security is part of 2 of 10 strategic priorities in *Political Guidelines*. **Challenges:** Migration, instability, terrorism, organised crime, cybercrime.	European Commission: ■ DG HOME ■ Frontex ■ REA. Academia and industry.	**Who:** Secure Societies programme committee, PASAG, Joint Research Centre (JRC), EU MS, research, industry. **How:** Stakeholder consultation; 'top-down' approach.	**Who:** Secure Societies programme committee, REA. **How:** Proposal eligibility checks, external evaluation, proposal scoring, panel meeting, grant finalisation process, ethics and security checks. **What:** Clustered by TRL and thematic area. Higher TRL research requested under H2020 (most calls set at TRL 7 under H2020 2016–17).	**Budget:** FP7 – €146.8m (total); H2020 2014–15 – €73m; H2020 2016–17 – €55m.	**Who:** Academia, industry, REA, DG HOME, public sector organisations.	**How:** End user project involvement (e.g. consortium leads, project advisors); increased focus on prototypes, tests and demonstrations. **Challenges:** Lack of clarity around 'impact' criteria; lack of uptake; lack of funding; IPR.

end users to adopt the new systems or products.[268]

2.3.3. Lessons identified

Good practices

Respondents noted a number of good practices in the following areas:

- **The setup of H2020 projects:** For example, projects provide a space for a dialogue between the research provider and the end users, which helps projects respond to the needs of the end users.[269]
- **The collaborative aspect of H2020**: This helps improve interaction between the various stakeholders (industry, academia, end users, the European Commission) that hold a variety of skills, which in turn leads to the creation of novel ideas.[270]
- Other good practices in EU-funded research include a thorough development of **risk mitigation techniques** through proposals,[271] and a thorough **identification and prioritisation of research topics** through consultation with a range of stakeholders.[272]

Challenges

Respondents also raised a number of challenges in the following areas:

- **Lack of strategic foresight around border security research**: Respondents noted duplication of research calls within FP7 or H2020 on certain products or technologies, as well as a lack of consistency between calls.[273] This is tied to the perception that there is a lack of strategic vision as to the types of research conducted and the prioritisation of research.[274]
- **The consortium model**: Large consortia, despite the complementarity of talent they bring, can potentially slow down the transition from research to operationalisation due to the complexity of managing so many partners.[275]
- **IPR**: IPR issues can affect the adoption of the results. This issue is also closely tied to the consortium model above, as large consortia can make it difficult to reach a commercial agreement with regard to proprietary rights between the various parties, thus restricting the operationalisation of certain results.[276]
- **End users**: There is a lack of clarity around end users' needs, as well as a lack of participation of end users during the course of projects.[277]

Respondents suggested the following as means of addressing these challenges:

- **Strategic foresight**: Have faster turnaround projects, which allow for greater responsiveness to current events, with clearer and more tangible outcomes. Look to exploit or continue developing high-technology solutions used in other domains that could be applicable to border security.[278] Interoperability and standardisation between and within projects should also be encouraged.[279]
- **Consortium model and IPR**: Place additional emphasis on a proposal's exploitation plan in the assessment phase, focusing for example on the willingness of the research provider to make the research results available.[280]
- **End users**: Improve the dialogue between the research provider and the end user at various junctures during the research process (for example when identifying and prioritising research topics) during both the creation of the call specifications and the course of the project.[281] Provide longer demonstrations, carried out by the end users themselves, rather than small pilot applications.[282]

Table 2.2 provides a summary of the findings presented above.

268 3 respondent (Surveys M, N, O).
269 1 respondent (Survey L).
270 2 respondents (Surveys M, N).
271 1 respondent (Survey L).
272 1 respondent (Survey N).
273 1 respondent (Survey O).
274 1 respondent (Survey O).
275 1 respondent (Survey O).
276 3 respondents (Surveys M, N, O).
277 2 respondents (Surveys L, O).
278 1 respondent (Survey O).
279 1 respondent (Survey N).
280 1 respondent (Survey M).
281 1 respondent (Surveys L, O).
282 1 respondent (Survey O).

3. Case studies: Non-EU border security research (WP2)

3.1. US border security research

3.1.1. Strategic context

In the United States (US), border security and related efforts fall under the umbrella term 'homeland security'. Different definitions have been produced over the years, but homeland security is generally understood to refer to national efforts to ensure a homeland that is safe, secure, and resilient against evolving threats and hazards.[283] The concept was introduced after the 11 September 2001 terrorist attacks, and led to the reorganisation of federal border security agencies under a new entity, the Department of Homeland Security (DHS), which is responsible for securing borders and expediting lawful trade and travel.[284]

Since 2010, DHS has been mandated by Congress to produce a series of *Quadrennial Homeland Security Reviews* (QHSRs). These documents provide an overview of the US homeland security strategy over the short and long term, offering guidance on US strategic priorities, policies, programmes, assets, capabilities and budgetary requirements.[285] The 2010 QHSR identifies three key concepts that form the foundation of US homeland security: security, resilience, and customs and exchange.[286] These concepts in turn shape five core missions that all actors involved in homeland security are tasked with supporting: (i) preventing terrorism and enhancing security; (ii) securing and managing borders; (iii) enforcing and administering immigration laws; (iv) safeguarding and securing cyberspace; and (v) ensuring resilience to disaster.

The latest QHSR from 2014 confirms these missions and articulates a series of related goals and activities.[287] With regard to securing and managing borders, these include:[288]

- Securing US air, land and sea borders and approaches, and preventing illegal import, entry, export and exit;
- Safeguarding and expediting lawful trade and travel by safeguarding key nodes, conveyances and pathways, managing the risk of people and goods in transit, maximising compliance with US trade laws, and promoting US economic security and competitiveness;
- Disrupting and dismantling transnational criminal organisations and other illicit actors by identifying, investigating, disrupting and dismantling transnational criminal organisations, and by disrupting illicit actors, activities and pathways.

Border security also forms an important part of other homeland security missions such as those for the prevention of terrorist attacks, the strengthening and effective administration of the immigration system and the prevention of unlawful immigration, and the safeguarding and securing of cyberspace.[289]

The 2014 QHSR further highlights the importance of border security by identifying drivers of change affecting the strategic environment. One such driver is the increasing flow of people and goods across US borders. Lawful US exports and imports increased by 72 per cent and 36 per cent, respectively, between 2005 and 2012. Similarly, lawful travel to the US grew by 36 per cent over the same period, and is forecast to grow by a further 25 per cent between 2012 and 2018.[290] These drivers can create opportunities for increased movement of unauthorised migrants and illegal goods.

Among the drivers identified as having an impact on homeland security in general and on border security in particular, the 2014 QHSR also highlights some that have only recently emerged or are currently emerging. These drivers include: (i) the diffusion of information and communications technology; (ii) natural disasters, pandemics and climate change; (iii) the interdependence and aging of critical infrastructure systems and networks; and (iv) threats connected to terrorism, the cyber domain, biological concerns, nuclear concerns and transnational crime.[291]

3.1.2. Research pathway

Overview of the US research landscape

The transition from the pre-2002 piecemeal approach to homeland security management to the current DHS-centred system entailed a rationalisation and centralisation of border security tasks and functions. This process involved breaking down longstanding 'stovepipes' of activity, including in research work.[292]

Within DHS, three bodies have responsibility for conducting border and maritime security related research:

1. Science and Technology Directorate (S&T)
2. US Coast Guard (USCG)
3. Domestic Nuclear Detection Office (DNDO).[293]

283 Reese (2013).
284 Haddal (2010); US DHS (2010) (hereafter 'DHS').
285 Kahan (2015); DHS (2010; 2014).
286 DHS (2010).
287 DHS (2014).
288 DHS (2014).
289 DHS (2014).
290 DHS (2014).
291 DHS (2014).
292 For further information on the pre-2002 approach, please see Haddal (2010).
293 GAO (2013); RAND Europe interview with anonymous US representatives, March 2017.

Other DHS components, such as Customs and Border Protection (CBP), have also allocated resources to activities linked to border security research. However, these bodies appear to focus more closely on the management of technology acquisition – an area that is beyond the scope of the study.[294] Given the focus of this study and the DNDO's narrow focus on nuclear detection capabilities, the following pages discuss S&T and USCG's research activities of relevance to border security research.

Science and Technology Directorate

S&T is the primary organisation for research within DHS. It is responsible for a research, development and innovation (RD&I) programme that conducts activities around basic and applied research, development, demonstration, testing and evaluation with a customer-focused and output-oriented approach.[295] RD&I activities focus on six 'thrust areas',[296] including border security. Within S&T, the Homeland Security Advanced Research Project Agency (HSARPA) focuses on identifying, developing and transitioning technologies and capabilities that are relevant to DHS missions and deployable in homeland security operations. HSARPA comprises five divisions focusing on different thematic areas, including the Borders and Maritime Security Division (BMD).[297]

S&T and BMD research activity in relation to border and maritime security focuses on technologies and solutions to: 1) secure the borders, territorial waters, ports, terminals, waterways, and sea transportation system of the US; and 2) prevent the illicit movement and illegal entry or exit of people, weapons, dangerous goods and contraband, and to manage the risk posed by people and goods in transit.[298] To create synergies and encourage cross-thematic research between BMD and other HSARPA divisions ('Chemical and Biological Defense', 'Cyber Security', 'Explosives', 'Resilient Systems'), HSARPA runs a series of cross-cutting Apex Programs and the Apex Technology Engines. Apex Programs are high-profile multidisciplinary research efforts that span different thematic areas aimed at developing technical capabilities and cost-saving processes.[299] Box 3.1 on the right provides an overview of an Apex Program with border security relevance.

Furthermore, the Apex Technology Engines function as technology and expertise platforms building a knowledge base and networks to serve the needs of S&T and DHS. The objectives of the engines are to: (i) increase return on investment by benefitting multiple Apex projects; (ii) reduce redundancy of Apex-only solutions; (iii) accelerate impact of Apex and other S&T research projects; and (iv) increase agility by adjusting to changing Apex needs. In practice, Apex Engines harness subject matter expertise and capabilities across DHS to provide continuous support for the needs of DHS bodies and of the broader homeland security enterprise. The Apex Engines include:[300]

- **Behavioral, Economic, and Social Science Engine (BESS-E)**, which provides analysis of the social and behavioural implications of new technologies, programmes and policies;
- **Communication and Networking (CN-E)**, which provides integrated communications and networking solutions in order to ensure interoperability across different network platforms;
- **Data Analytics Engine (DA-E)**, which provides expertise and tools for projects to leverage emerging storage, security, computation and analytics technologies in order to support decision making for homeland security systems, missions and operations.
- **Identity Access and Management (IDAM-E)**, which provides capabilities to give individuals and systems a digital identity, credentials, authentication and authorisation;
- **Manufacturing Engine (M-E)**, which provides expertise to inform efficient transition from project conception to full-scale manufacturing;

Box 3.1 **Multidisciplinary research projects: an Apex Program with border security relevance**

The Apex Air Entry/Exit Re-engineering (AEER) programme is a multi-year initiative that aims to transform the international arrivals process and implement a biometric capability in order to verify the departure of foreign nationals leaving from US airports of entry.

S&T and CBP collaborate to deliver AEER and are working to identify, develop, test and evaluate new operational concepts in order to enhance CBP traveller-screening processes. In particular, AEER aims to leverage commercially available technologies, re-engineer current processes and introduce new operational capabilities to:

- Increase security while facilitating trade and travel
- Implement operational capabilities required by US federal legislation
- Support the US National Travel and Tourism Strategy.

Programme delivery involves four interconnected tasks: technology identification, operations analysis, business case analysis and stakeholder engagement. AEER has engaged industry actors to conduct a market survey of commercially available technologies. To identify the best-performing technologies for integration into CBP processes, the AEER programme employs three phases of evaluation: laboratory testing, scenario-based testing and field trial testing. A sub-set of technologies identified are then used to evaluate the cost-effectiveness of entry and biometric exit concepts of operations. Finally, results of technology testing and an analysis of operational impacts inform a rigorous business case analysis. Supporting the CBP in its acquisition activities, business case analysis examines feasible technology solutions on the basis of performance, cost and risk.[301]

294 DHS (2016c).
295 Shea (2014).
296 With the term 'thrust area', S&T identifies the six issue areas under which RD&I activities are clustered. These are: APEX, Border Security, CBE Defense, Counter Terrorist, Cyber Security/Information Analytics, and First Responder/Disaster Resilience. Source: DHS S&T (2015c).
297 GAO (2013); DHS (2016a).
298 DHS (2017b; 2017d).
299 DHS (2017b; 2017d).
300 DHS (2015a; 2017b; 2017d).
301 DHS (n.d.-b).

- **Modelling and Simulation Engine (MS-E)**, which provides expertise and a repository for mission-based models, and modelling and simulation tools; and
- **Situational Awareness and Decision Support (SANDS-E)**, which provides S&T and Apex projects with assured and secure access to databases, knowledge repositories, modelling and simulation tools, and situational awareness products.

Furthermore, S&T manages a 'University Programs' function that supports critical homeland security-related research and education across US colleges and universities, with the aim of fostering expertise, building a new scientific workforce of homeland security experts, and developing strategic partnerships among universities and public agencies.[302] Within S&T, the University Programs function is managed by the Office of University Programs (OUP) through three initiatives:[303]

- **Centers of Excellence (COEs) Program**, which aims to harness expertise from US academic institutions to support research efforts and deliver tools, technologies, knowledge products, training and expertise for the homeland security enterprise;
- **Workforce Development Initiatives**, which aim to educate and train homeland security professionals; and
- **Minority Serving Institutions Programs**, which aim to build a diverse homeland security workforce through the COEs.

COEs are sponsored by the OUP and are selected through a competitive process. Funding opportunities for COEs are advertised on the website of the Grants.gov programme,[304] and are open to US-accredited universities and colleges. Applicants are also encouraged to partner with industry. A 2017 call for a new DHS COE on *Cross-Border Threat Screening and Supply Chain Defense* indicates that S&T employs a three-stage review process to select COE recipients. These stages are: (i) a scientific quality review of bids by a panel of peers external to DHS; (ii) an internal relevance review of bids by a panel of DHS subject matter experts; and (iii) site visits by a team of DHS subject matter experts. When applicable, the review process also entails an assessment of past performance by COE hosts bidding for their centre's renewal.[305]

Each COE is led by a university in collaboration with partners from other institutions, agencies, laboratories, think tanks and the private sector. DHS S&T COEs are organised as a network, bringing together hundreds of US universities and institutions working on developing customer-driven tools and technologies for stakeholders of the homeland security enterprise. COEs looking at issues pertaining to homeland security and border security include:[306]

- The Borders, Trade and Immigration Institute (BTI): BTI is led by the University of Houston and focuses on developing technology-based tools, techniques and educational programmes for border management, immigration, trade facilitation, and targeting and enforcement of transnational borders. The BTI COE was assigned to the University of Houston in 2015 with an initial grant of $3.4m.[307]
- The National Center for Border Security and Immigration (NCBSI): The NCBSI is co-led by the University of Arizona and the University of Texas at El Paso. The NCBSI's activities focus on developing technologies, tools and methods to balance immigration and commerce with effective border security.

S&T also manages and is the executive agency of two Federally Funded Research and Development Centers (FFRDCs), the Homeland Security Systems Engineering and Development Institute (HSSEDI) and the Homeland Security Operational Analysis Center (HSOAC).[308] HSSEDI was established to ensure that all DHS components could access a centralised systems engineering resource, providing them with rapid access to deep technical expertise.[309] HSOAC works with all DHS components, providing unique capabilities through early-stage activities, portfolio planning and analysis, policy development, acquisition planning, and support for the transition of products into government operations or licensing for use by others.[310]

S&T caters for a wide array of clients and components within DHS and the broader homeland security enterprise, focusing on a range of land borders, maritime borders, and port of entry issues.[311] While S&T classifies technology according to 9 TRLs (see Table 3.1), its research priorities are normally clustered by thematic area. Priorities pursued during financial year (FY) 2016 and FY2017 include:

- Air cargo screening
- Cargo forensics
- People screening
- Cargo and conveyance security
- Land and sea air cargo scanning
- Air based technologies
- Tunnel detection and surveillance
- Port and coastal surveillance
- Port resiliency
- Small dark vessel detection
- Arctic communications technologies.[312]

Table 3.2 provides an overview of the budgetary allocation for border security-related research over the course of FY2015 and FY2017 in S&T and USCG. The budget request for the S&T RD&I function for FY2017 was for $436 860m and 102 full time equivalent (FTE), accounting for 57.6 per cent of the total directorate budget request ($758 743m, 481 FTE). From the RD&I budget allocation, 21 per cent of funds ($90 014m, 21 FTE) were earmarked to support the DHS mission of securing and managing US borders.[313] With regard to border security as a specific S&T RD&I thrust area, FY2017 saw a budget request of $55 999m, marking a 71.3 per cent increase from FY2016 ($32 684m) and covering 12.8 per cent of the overall S&T RD&I budget.[314]

302 DHS (2017b; 2017d).
303 DHS (n.d.-c).
304 Grants.gov is a US e-government initiative operating under the governance of the US Office of Management and Budget. For further information, please refer to Grants.gov (n.d.).
305 Grant reference: DHS-16-ST-061-CBTS-Lead.
306 DHS (n.d.-d); University of Houston (2017a).
307 DHS (2015b).
308 DHS S&T (n.d-a.).
309 DHS S&T (n.d-b).
310 DHS S&T (n.d-c).
311 DHS S&T (2015a).
312 DHS (2017d).
313 DHS (2017b; 2017d).
314 DHS (2017b; 2017d).

Table 3.1 **S&T TRL structure**

Basic research	Applied research		Technology development	Technology demonstration	System development		System test and launch		System viability and operations
TRL-1	TRL-2	TRL-3	TRL-4	TRL-5	TRL-6	TRL-7	TRL-8	TRL-9	Technology deployment
Basic principles observed/ reported	Technology concept application formulated	Critical function or characteristic proof of concept	Validation in lab environment	Validation in relevant environment	System prototypes in relevant environment	System prototypes in operational environment	Actual system completed and qualified through test and demonstration	Actual system proven through successful mission operations	Actual system commences with regular and sustained operation (to be cleared by S&T)

Source: DHS (2017d).

Table 3.2 **Budgetary overview for border security research budgets in the US**

	FY2015		FY2016		FY2017	
Organisation	**$ (m)**	**FTE**	**$ (m)**	**FTE**	**$ (m)**	**FTE**
S&T RD&I function	479 564	114	454 883	106	436 860	102
S&T border security thrust area	51 100	-	32 684	-	55 999	-
USCG RDT&E function	17 892	87	18 019	96	18 319	96

Source: DHS (2017b; 2017d).

US Coast Guard

The USCG is the principal US maritime law enforcement authority. It is incorporated into DHS as a standalone agency with a mission to protect the public, the environment, and US economic interests in the maritime regions, including ports, waterways, coasts and international waters.[315] The USCG runs a research, development, test and evaluation (RDT&E) programme that comprises an Office of RTD&E and a Research and Development Center (RDC).[316] The USCG RTD&E programme focuses on providing support for strategic decision making, enhancing acquisition, capital investment and mission execution, and testing and evaluating activities supporting USCG operations. The RDC is the sole facility authorised to conduct RTD&E in support of the USCG, although it collaborates on an ad hoc basis with professionals in the public and private sectors.[317] There are six RTD&E priority research focus areas: (i) unmanned systems; (ii) Arctic operations; (iii) sensor optimisation, automation and visualisation; (iv) intelligence and cyber; (v) waterways management and environmental response; and (vi) operational performance improvement modelling.

The budget request for the USCG RDT&E in FY2017 was $18 319m and 96 FTE, equivalent to approximately 0.2 per cent of the USCG's overall budget ($10 321bn) and FTE (49 694). The budgetary request for FY2017 is consistent with FY2016 ($18 019m, 96 FTE, 0.16 per cent of the overall USCG budget and FTE) and for FY2015 ($17 892m, 87 FTE, 0.17 per cent of the overall USCG budget and FTE).[318]

Identification and prioritisation of research topics and project selection

A number of processes and procedures are in place within DHS to identify research priorities for border security. As a first step, the QHSR allows DHS to take stock of homeland security, to define the nature and purpose of key homeland security missions, and to identify the tools necessary to pursue these missions.[319] While the QHSR is not a research-specific process, the strategic vision outlined in this document is important in informing and shaping the priorities and plans of DHS components and the broader homeland security enterprise, including research entities.[320] The QHSR is the result of an inclusive consultation process that brings together a number of stakeholders from DHS, US Federal agencies, governmental and nongovernmental entities, and the public more broadly. Activities run under the QHSR include:

- Eight study groups with independent experts and representatives from 42 DHS directorates, held over a five-month period, to analyse DHS missions and issues related to DHS strategic management, national risk assessment, planning and capabilities;
- A steering committee with DHS leads and external facilitators meeting on a weekly basis to ensure consistency and integration of findings from different study groups; and
- DHS senior leadership meetings to review findings from study groups.

Furthermore, QHSR provides platforms and processes to capture input from other agencies and stakeholders. These include:

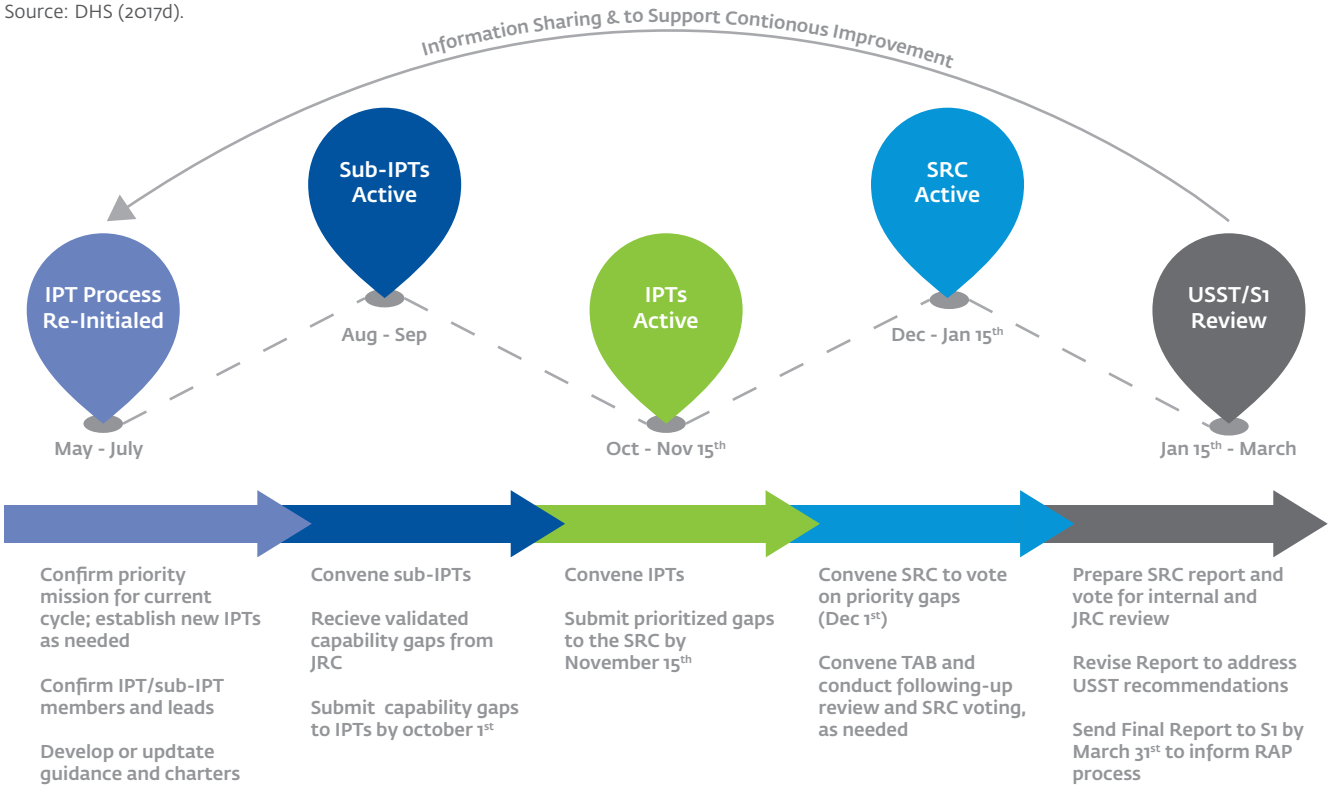
- Sub-interagency policy committees, gathering interagency input as study groups contents are developed;
- A strategy coordination group, bringing together strategy and policy planners from across the interagency community throughout the review;
- A final interagency vetting process before the review is submitted to Congress; and
- Traditional and online platforms for submission of papers and inputs by governmental and nongovernmental stakeholders, including the general public.[321]

In addition to the QHSR, S&T has developed a number of processes to keep its portfolio of work strategically aligned with the needs of DHS components and other actors in the homeland security enterprise.[322] The *Science and Technology Resource Allocation Strategy* (STRAS) is a

315 Haddal (2010).
316 USCG RDC (2016), DHS (2017b; 2017c).
317 USCG RDC (2016), DHS (2017b; 2017c).
318 DHS (2017b; 2017c).
319 US DHS (2010; 2014); RAND Europe interview with anonymous US representatives, March 2017; Shea (2014).
320 RAND Europe interview with anonymous US representatives, March 2017; DHS S&T (2015b).
321 DHS (2010; 2014).
322 DHS S&T (2015a; 2015b).

Figure 3.1 **DHS S&T annual IPT process and timeline**

Source: DHS (2017d).



coordinated framework that ensures that S&T efforts are aligned with operational requirements. STRAS records the work of operational components[323] and first responders to identify capability gaps and chart a course of action for filling these gaps.[324] Since 2010, S&T also runs an annual portfolio review process originally developed by Fortune 500 companies and deployed by laboratories of the US Department of Defense (DoD). The portfolio review helps ensure that S&T research efforts are aligned with strategic priorities, as well as with emerging and highest-priority needs of DHS components.[325]

To respond to Government Accountability Office (GAO) feedback on shortfalls of the DHS research-management and oversight mechanisms, S&T launched R&D *Integrated Product Teams* (IPTs) in 2015.[326] IPTs are tasked with identifying and coordinating DHS research efforts in priority mission areas, linking research activities with the work of the DHS Joint Requirements Council to close existing technology capability gaps. Through the IPTs, S&T (i) promotes a standardised approach to identifying and tracking research efforts; (ii) centralises mechanisms for gathering and reporting priority gaps; and (iii) provides a technology review platform to identify and mitigate overlap and duplication of research efforts within DHS. IPTs work on both basic and applied research, and on development. The IPT system comprises: (i) sub-IPTs tasked with data collection and initial capability gap identification; (ii) IPTs, performing a centralised, refined priority ranking of technology gaps identified by sub-IPTs; and (iii) the S&T Research Council (SRC), performing the final priority ranking for research investment with the support of a Technical Advisory Board (TAB).[327] Recommendations from IPTs are then reviewed by the S&T Under Secretary (USST) who makes recommendations to the Secretary of Homeland Security to inform the DHS Resource Allocation Plan (RAP) for the following FY. Figure 3.1 provides a visual overview of this year-long process.

While the DHS QHSR and S&T IPT processes contribute to priority identification and setting within the USCG, the USCG RTD&E program also relies on internal documents and procedures to identify research priorities and select programmes. Interviewees consulted as part of this study emphasised the role that USCG internal strategy documents have in setting the agenda for research and capability development (e.g. *USCG Western Hemisphere Strategy, USCG Arctic Strategy, USCG Cybersecurity Strategy*).[328]

Furthermore, the USCG employs an Idea Submission Review (ISR) process that allows for RTD&E project ideas to be submitted by a variety of USCG members and stakeholders across different operating levels. This process represents the first step towards transitioning a research idea into the USCG and is used to ensure that USCG RTD&E efforts are aligned with operational needs and existing technological gaps. Following the initial phase of the ISR, which allows for submission of ideas in the September–January period, prospective projects and ideas are

323 'Operational components' refer to the agencies and divisions that comprise DHS (see DHS, n.d-a.).

324 DHS S&T (2015b).

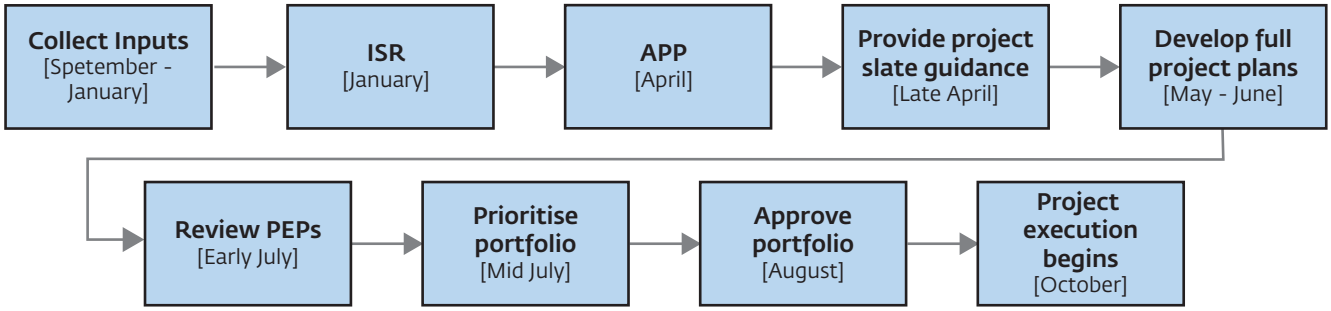
325 RAND Europe interview with anonymous US representatives, March 2017; Shea (2014).

326 Maurer (2014); DHS (2017e); RAND Europe interview with anonymous US representatives, March 2017.

327 DHS (2017e).

328 RAND Europe interview with anonymous US representatives, March 2017.

Figure 3.2 **USCG annual RTD&E business process and timeline**



Source: USCG RDC (2016).

reviewed by senior stakeholders during the Assessment of Prospective Portfolio (APP) phase in April.[329] Prospective projects are reviewed and ranked by Programme Offices before being reviewed at senior level and scored with a multi-level voting process. After this, a number of projects are selected for development into full project plans before a final round of review carried out by USCG Domain Leads and Branch Chiefs, who assess feasibility and the availability of resources to implement the proposed projects. Projects proposed for implementation are then reviewed by the USCG's upper management for sign-off and budget allocation before implementation commences.[330] Figure 3.2 provides an overview of the timelines and steps involved in the USCG annual RTD&E business process.[331]

The priority-identification processes described above are linked closely to the project award phase of S&T and the USCG's work. An interviewee consulted as part of this study suggested that there is no single approach in place within S&T for awarding projects. However, it was emphasised that S&T relies primarily on external implementers for conducting its research activities and projects.[332] By contrast, all RTD&E activities funded by the USCG are undertaken by its Office of RTD&E and RDC.[333]

329 USCG RDC (2016); RAND Europe interview with anonymous US representatives, May 2017.
330 USCG RDC (2016); RAND Europe interview with anonymous US representatives, May 2017.
331 USCG RDC (2016); RAND Europe interview with anonymous US representatives, May 2017.
332 RAND Europe interview with anonymous US representatives, March 2017.
333 RAND Europe interview with anonymous US representatives, May 2017.

Table 3.3 **DHS S&T SVIP OTS programme framework**

Phase	Funding	Duration	Output
Phase 1	$50k–200k	3–6 months	Proof-of-concept demo
Phase 2	$50k–200k	3–6 months	Demo pilot-ready prototype
Phase 3	$50k–200k	3–6 months	Pilot-test prototype in operation
Phase 4	$50k–200k	3–6 months	Test in various operational scenarios

Source: DHS (n.d.-f).

One mechanism used by S&T to stimulate proposal submission and select research projects for implementation is the DHS Small Business Innovation Research Program. DHS SBIR was launched in 2004 to increase the participation of US small businesses in federal research programmes and stimulate industry to provide innovative solutions for homeland security. Programme Managers in each S&T Division, including BMD, develop solicitations which are advertised on an annual basis through the DHS SBIR submission portal.[334] Solicitations are designed to address the needs of DHS operational components.[335]

Another programme used by S&T to engage with industry and stimulate proposal submission is the HSIP. The HSIP is used to fund innovative start-ups in order to solve challenges shared by homeland security and commercial investors. Through the HSIP, S&T leverages private sector investment to accelerate the transition of new technological solutions into operational use by DHS components and other stakeholders of the homeland security enterprise. Under the HSIP framework, S&T runs regional events and programmes across the US to engage with innovators, non-traditional DHS partners and other stakeholders.[336]

334 Please see DHS (n.d.-e).
335 DHS (n.d.-e).
336 DHS (n.d.-f).

One example of a HSIP regional programme is the Silicon Valley Innovation Program (SVIP). The SVIP was launched by S&T in 2015 and aims to link the DHS and other homeland security stakeholders with Silicon Valley companies. The goal of the SVIP is to develop a shared understanding among DHS and Silicon Valley actors of homeland security requirements, and of how innovation corridors can help address homeland security issues. Companies engaging in the SVIP can submit proposals under Other Transaction Solicitation (OTS) calls, which are scheduled to release up to $800 000 over a 24-month period.[337] Table 3.3 above provides an overview of the OTS funding mechanism.

DHS COEs can also fund research projects. Between 2015 and 2017, BTI has advertised three Requests for Proposals (RFPs) to fund research programmes focusing on borders, trade and immigration. Funding released under these RFPs ranged from $325 000 to $3 000 000 (with a cap of $500 000 per project). In its RFPs, BTI outlines a number of proposal topic areas and research questions to be investigated, which are coherent with the initial COE funding solicitation issued by DHS. Organisations eligible to bid for these RFPs include US colleges, universities, and for-profit and non-profit organisations. Proposals

337 DHS (n.d.-f).

submitted are then assessed by members of the academic and DHS community through a Scientific Quality Review and a Relevance Review process. Under the Scientific Quality Review process, proposals are rated from 1 to 5 (poor to excellent) against a number of criteria. Percentage-weighting factors are then applied to each criterion, as indicated in parenthesis below, to calculate the overall scientific quality rating:[338]

- Originality and/or innovativeness (25%)
- Proposed approach/methodology (25%)
- Qualifications of personnel and suitability of facilities (15%)
- Costs (10%).

Similarly, the Relevance Review involves scoring proposals from 1 to 5 (poor to excellent) against two additional criteria. These are then weighted and combined to calculate the overall relevance score. The factors considered are:

- Mission relevance (75%)
- Communicating/transitioning results (25%).

Monitoring and evaluation

The literature and interviews provided limited data on evaluation practice for border security research efforts. A report issued in 2013 by the US GAO found that evaluation practice for border- and maritime-related research could be improved, and that research customers reported mixed views on the impact of DHS's border and maritime research project deliverables.[339] The GAO emphasised the positive impact of customer-engagement mechanisms set in place by DNDO and USCG to gather and evaluate feedback from customers and determine the impact of their research efforts. A similar mechanism was found to be missing from S&T, although a later GAO report indicates that steps have been taken to obtain feedback and evaluate results of border and maritime research work.[340] Among these measures was the development of a new project management guide for S&T staff members, including templates for customer surveys and actions to be performed by S&T project officers to ensure the alignment of research efforts with customers' needs.[341]

In 2012, the GAO also found that DHS had limited capacity to take stock of and report on all of its ongoing research activities beyond DHS components with an explicit research mandate.[342] Further to this report, in 2014 the GAO emphasised that steps had been taken by DHS to mitigate shortcomings in its evaluation and coordination mechanisms, particularly through the development of clearer guidance and definitions around research efforts. However, the GAO also noted that a specific policy outlining research roles and responsibilities, as well a process for overseeing and coordinating research with other offices, had yet to be developed.[343]

3.1.3. Pathways to impact

There are several mechanisms used at various stages of the research pathway in order to foster impact, which in this context is taken to mean the successful transition to operational deployment of research products. The QHSR, IPTs, STRAS and the USCG RTD&E business process all feature mechanisms to help capture operational input from end users of research. These mechanisms not only ensure that resources are allocated in a way that is cognisant of operational needs, but also help end users develop a sense of involvement in ongoing research, thus facilitating the adoption of research outputs in an operational setting. For example, within S&T, the STRAS underpins the development of highly collaborative projects and stimulates cooperation between S&T, the project customer, and external partners and stakeholders. This occurs through quarterly meetings involving representatives from S&T, operational components and other departments. Stakeholder input at these meetings is used to steer activities and ensure that research efforts are focused on operational needs.[344]

To promote uptake of research products, S&T also employs a System Analysis process. While very little information regarding this process could be identified through the literature review and interviews conducted, System Analysis entails the application by S&T of analytical techniques (e.g. systems analysis and engineering support) to assist end users and operational components in identifying existing capability gaps, and assessing the risks and opportunities inherent in their work and missions. Through this process, S&T aims to improve the efficiency and effectiveness of end users' work, suggesting potential enhancements through changes to processes, training and technology.[345]

With regard to the USCG, study interviewees and the literature reviewed both emphasise that the inclusive nature of the ISR process supports the transition of RTD&E products to operational deployment.[346] Furthermore, the USCG S&T Transition and Innovation Centre (CG-STIC) was launched to more closely coordinate the efforts of the USCG and S&T and to create a culture of end user-focused innovation within both bodies. CG-STIC runs an Innovation Council and a series of Working Groups to develop its understanding of end user needs. On the basis of this understanding, it tailors existing technologies to fit end user requirements and to improve the delivery of operationally relevant and affordable technologies and solutions to operational components of the homeland security enterprise.[347]

Boxes 3.2 and 3.3 on the next page provide an overview of two instances of achieved and expected impact and operational results from research activities performed by S&T. This section takes impact to mean the successful filling through research of a technology gap connected to border and maritime security management. Within the USCG, impact is also expected to comprise (i) alignment of research outputs with overarching strategies; (ii) customer and sponsor support and buy-in; and (iii) development of competencies and leverage.[348]

3.1.4. Summary

Figure 3.3 on page 88 provides a visual summary of the US R&I pathway, including the various associated factors, stakeholders and inputs.

338 University of Houston (2017b; 2017c); DHS (2017f).
339 GAO (2013).
340 GAO (2013).
341 GAO (2013).
342 Maurer (2014).
343 Maurer (2014).
344 DHS S&T (2015b).
345 DHS S&T (2015b).
346 RAND Europe interview with anonymous US representatives, May 2017; USCG RDC (2016).
347 USCG RDC (2016).
348 USCG RDC (2016).

Box 3.2 **Achieved impact: An S&T Project with operational application**

As part of its work on land and sea cargo screening, HSARPA's BMD conducted a 'Rail Scanner Relocation' project in Brownsville, Texas. Through this project, the S&T created and transitioned into operational use the first data-link for sharing rail-scanning data connecting US and Mexican border authorities. This data-link provides real-time X-ray data to the US Customs and Border Protection authority and to its Mexican counterpart, operating on the Brownsville-Matamoros International Bridge. The project is reported to have helped combat illicit trafficking activities across the US-Mexico land border.[349]

Box 3.3 **Planned impact: An ongoing S&T project with a clear operational transition path**

DHS recognised that its agencies and divisions have insufficient ability to identify, prioritise, characterise and share actionable information and intelligence on maritime threats in a tactically relevant manner. To address this issue, S&T launched a 'Port and Coastal Surveillance' project. This project supports maritime situational awareness and helps foster a DHS 'unity-of-effort' approach by establishing a capability that allows DHS to (i) access more data sources, including space based sensors; (ii) make available decision-support tools to translate available data into actionable information and intelligence; and (iii) share actionable information and intelligence across different stakeholders of the homeland security enterprise.

S&T expects that this project will improve the operational effectiveness of DHS components active in the port and coastal surveillance space, enhancing the department's awareness in the maritime domain. In particular, S&T expects to see (i) improved measurement of illegal activities, leading to a better understanding of implications stemming from changes to resource allocations and strategies pursued; (ii) improved assessment of risks in the port and coastal surveillance space; and (iii) improved alignment of resources-to-risk for ongoing and future operations, both at the tactical and strategic levels. This project was launched inFY2012 with a budget of $3 134m, continuing in FY2013 ($6 684m), FY2014 ($7.25m), FY2015 ($9.5m), FY2016 ($6 686m), and FY2017 ($10.75m).

As of 2017, the project has led to the installation, testing and evaluation of Coastal Surveillance System operational nodes at strategic locations across the US. The pilot of this product involves USCG sectors (e.g. San Diego, Los Angeles Long Beach) and other state-level authorities (e.g. Maryland Natural Resource Police). Technical tests and demonstrations have also been conducted in different locations. It is now expected that during the current FY new operational nodes will be deployed, new technical demonstrations performed, and systems tested in an open-ocean setting. The operations of the project prototype 'Integrated Maritime Domain Enterprise' and 'Coastal Surveillance System' are also expected to be transitioned to the USCG and to the Customs and Border Protection forces during this FY.[350]

3.1.5. Lessons identified

Although there are few publicly available evaluations of US processes and initiatives for managing border security research, a number of lessons learned and good practices can be identified from the interviews and literature review conducted as part of this study.

Good practices

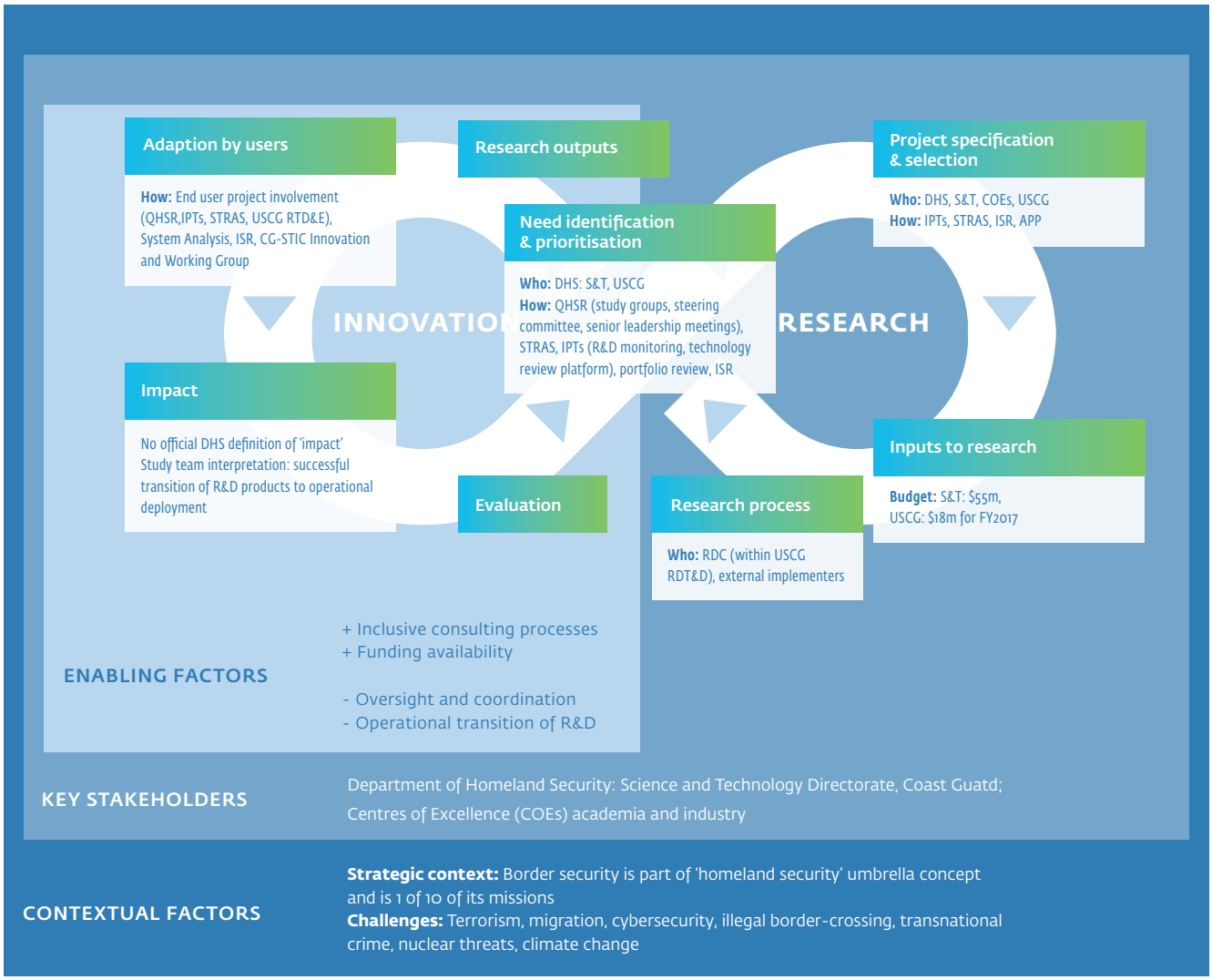
Study interviewees emphasised the importance of retaining a **flexible and dynamic approach to the identification of needs and priorities**, with one interviewee noting that it is essential to allow needs and priorities emerging from sudden changes in the threat landscape to be quickly captured and investigated through research work.[351] In the US context, the S&T STRAS, QHSR, IPTs and the USCG RTD&E processes exemplify this flexible approach to need identification. These mechanisms ensure that operational needs and emerging priorities are captured in a flexible and dynamic way before the allocation of resources to projects takes place. Based on different timelines, these processes facilitate a continuous capturing of research needs. This continuous approach is particularly important given the dynamic nature of the threat landscape and operational context.[352]

Employing a variety of research-funding mechanisms can help ensure that expertise within academia and industry can be drawn upon. The use of flexible, industry-specific funding mechanisms such as the HSIP, the SVIP and the SBIR helps ensure that DHS can stimulate industry partners, including innovative start-ups that may normally operate outside of the Homeland Security space, to work on homeland security-related issues. The use of funding mechanisms targeting academic institutions and think tanks, such as those underpinning the S&T COEs and FFRDCs, helps DHS to harness academic expertise while also building a diverse homeland security workforce.

Running evaluations of research processes and results is considered to have produced positive results. The US system for border security research has benefitted from evaluation and inclusive consulting processes. For example, DHS launched the IPTs in response to a GAO finding regarding DHS's limited supervision and coordination mechanisms for research activities.[353] Set up as a direct result of the recommendations from the GAO evaluation, IPTs are reported to have mitigated duplication of research efforts and stove-piping across the Department, providing a centralised and standardised platform for the identification and prioritisation of research needs across key issue areas. The establishment of IPTs and the results achieved highlight the

349 DHS (2016b).
350 DHS (2017d).
351 RAND Europe interview with anonymous US representatives, March 2017.
352 DHS S&T (2015b).
353 GAO (2013).

Figure 3.3 **US research and innovation pathway**



important contribution that evaluations can make to improving the work of a department or function.[354]

Challenges

Strengthening the link between research departments or activities and end users was identified by interviewees as a priority area for further development in the US context.[355] To facilitate the operationalisation of research products, it was suggested that operational actors should be involved as early as possible in research planning processes.[356] This would help ensure that research priorities are selected and funds allocated in a way that takes operational requirements into consideration, facilitating buy-in for research outputs from their potential end users. In this context, the USCG ISR was seen as a positive mechanism, allowing for the submission of research projects and ideas from across the USCG organisation.[357]

One study interviewee also highlighted the importance of reducing the **time gap between need identification by operational components and the launching of a research programme** aimed at addressing this requirement. The interviewee suggested that a prolonged lag between these two phases could lead to the development of research products addressing operational needs that have since changed or disappeared.[358]

3.2. Canadian border security research

3.2.1. Strategic context

In Canada, border management is considered a strategically important issue, particularly in relation to border security and maintaining the flow of people and goods across its 6 000-mile border

354 DHS S&T (2015b); GAO (2013).
355 RAND Europe interview with anonymous US representatives, March 2017; RAND Europe interview with anonymous US representatives, May 2017.
356 RAND Europe interview with anonymous US representatives, March 2017.
357 USCG RDC (2016); RAND Europe interview with anonymous US representatives, March 2017.
358 RAND Europe interview with anonymous US representatives, May 2017.

with the US.[359] Key threats to Canadian border security include drug smuggling, growing activity in the Arctic sea lanes and an increase in illegal border crossings.[360] As well as strengthening border management against these threats, the Canadian government continues to prioritise cross-border trade, as the US is Canada's largest trading partner.[361]

Further challenges to Canada's borders are ethical, technical and infrastructural. For example, the challenge of finding a balance between enhancing domain awareness (security), while promoting cross-border flows of people and goods (economy) has raised ethical concerns relating to data protection, privacy and the use of intrusive surveillance technology.[362] While preclearance of containers through the 'Beyond the Border' programme[363] and the maintenance of 'sterile' secure supply chains[364] are designed to speed up the flow of goods and cross-border trade, these initiatives have also created technical challenges. In the case of 'sterile' secure supply chains, the cost of introducing such measures and their associated technology has proved too high for many supply companies.[365] In relation to infrastructure, the level of cross-border road transportation has increased significantly in recent decades, while the quality of the road and transport infrastructure has lagged behind.[366]

Despite the perceived importance of border security in Canada, the level of funding for border security research is much lower in Canada than in the US (see Section 3.1). One study interviewee observed this, noting that border security has not been treated as a research priority in Canada.[367] Another interviewee reported that very few research projects are focused directly on borders, with many projects focusing on broader issues such as explosive detection for the air transport industry, biometric technology or closed-circuit television (CCTV) for security applications.[368]

3.2.2. Research pathway

Overview of the Canadian research landscape

At the strategic level, Public Safety Canada (PSC) is the overarching ministry tasked with leadership and coordination of border policy.[369] Four organisational actors are primarily responsible for the operational management of the Canadian border: the Canada Border Services Agency (CBSA); the Royal Canadian Mounted Police (RCMP); Immigration, Refugees and Citizenship Canada (IRCC); and Transport Canada. CBSA manages the various land, water and air ports of entry (POE),[370] RCMP is responsible for the wider 'open' spaces on the border,[371] IRCC facilitates the arrival of immigrants and provides protection to refugees,[372] and Transport Canada focuses specifically on traffic corridors.

Interviewees reported that most border security research funded in Canada emphasises operationally focused projects with high TRL potential.[373] While much of this technological research by the CBSA Science and Technology branch focuses on technology that is a few years from deployment at the borders, some of this research also focuses on technology that is more than five years from operational deployment.[374] More broadly, border security research funded by PSC in Canada is divided into three types: academic studies, technological development and technological application. Research funded in Canada tends to be outcome-oriented and focus on the strategic, operational and tactical aspects of border security.[375] While there is little information in the public domain regarding specific funding of border research projects, one study interviewee pointed out that as well as federal funding for research from PSC and other federal agencies, a number of smaller projects under Can$25 000 are allocated sole-source funding by local authorities and other individual organisations.[376]

Identification and prioritisation of research topics

With regard to border security research, PSC meets with the CBSA, RCMP and IRCC on an annual basis to enquire about their priorities and operational interests.[377] PSC then establishes a longlist of priorities and synthesises these into a document, which is then issued in the form of calls for proposals. Universities or research organisations submitting proposals are required to collaborate with a 'champion' or border guard agency on the proposed project. That agency (or one of its departments) is responsible for funding allocation and champions the research project. This is intended to ensure that the projects are delivered and to improve outcomes and accountability. The operational partner agency can also

359 RAND Europe interview with DRDC CSS representatives, 19 April 2017; RAND Europe interview with Phil Lightfoot, 19 April 2017; RAND Europe interview with Canadian representative, 21 April 2017; RAND Europe interview with Christian Leuprecht, 21 April 2017; RAND Europe interview with Joel Sokolsky, 25 April 2017.

360 RAND Europe interview with Canadian representative, 21 April 2017; RAND Europe interview with Christian Leuprecht, 21 April 2017.

361 RAND Europe interview with Phil Lightfoot, 19 April 2017; RAND Europe interview with Canadian representative, 21 April 2017.

362 RAND Europe interview with DRDC CSS representatives, 19 April 2017.

363 Ferguson (2017).

364 The use of 'sterile' secure supply chains involves transport companies complying with technological and security measures to ensure that goods and cargo cannot be accessed or tampered with, allowing them to be pre-screened and checked before arrival and transit at the border.

365 RAND Europe interview with Canadian representative, 21 April 2017.

366 RAND Europe interview with Canadian representative, 21 April 2017.

367 RAND Europe interview with Canadian representative, 21 April 2017.

368 RAND Europe interview with Phil Lightfoot, 19 April 2017.

369 For details on PSC, see Public Safety Canada (2017).

370 For details on the CBSA, see Canada Border Services Agency (CBSA) (2017).

371 For details on the RCMP, see Royal Canadian Mounted Police (RCMP) (2017).

372 For details on IRCC, see Immigration, Refugees and Citizenship Canada (IRCC) (2017).

373 RAND Europe interview with DRDC CSS representatives, 19 April 2017; RAND Europe interview with Phil Lightfoot, 19 April 2017.

374 RAND Europe interview with Phil Lightfoot, 19 April 2017.

375 Previous details in this paragraph are from RAND Europe interview with Christian Leuprecht, 21 April 2017.

376 RAND Europe interview with Canadian representative, 21 April 2017.

377 RAND Europe interview with Christian Leuprecht, 21 April 2017.

fund salaries, ensuring that the research projects are staffed appropriately.[378]

Selection of border security research projects

Much of this border security research funding has been coordinated through the Defence Research and Development Canada (DRDC) Centre for Security Science (CSS) programme.[379] When 'champion' border guard agencies request funding to support technical research, the CSS is responsible for evaluating these proposals against various criteria.[380] The CSS works with other departments to set research priorities and to promote developments in S&T. According to a study interviewee, the DRDC has been effective in bringing communities of practice together from federal border agencies, business (particularly transport) and academia.[381] Despite overall funding challenges, the financial resources that the CSS can leverage for individual projects can incentivise collaboration between research organisations in the private, academic and government spheres.[382]

Monitoring and evaluation

Interviewees reported that CSS M&E activities for funded research include the tracking of deliverables, biannual reporting updates, and regular meetings between the project manager, researchers and industry representatives involved in project delivery to check progress against previously agreed milestones.[383] Evaluation of projects by the CBSA Science and Technology branch is usually conducted through feedback from stakeholders via surveys of the border guards and officials utilising the technology. However, there is no formal evaluation of each completed project.[384] One study interviewee noted that a key problem with evaluating border research is the shortage of 'outcome measures' given the border's flexible nature and the large number of variables involved. Larger federally funded research projects are evaluated mainly on the basis of economic data focusing on, for example, whether a technological solution is developed and delivered within the project budget. In the case of the 'Beyond the Border' programme, the Auditor General produces regular reports which are submitted to Parliament.[385] When research projects are completed, a technical report is often distributed to stakeholders, and other communications materials (such as summaries or presentations) are also produced and shared with interested parties.

3.2.3. Pathways to impact

Within the DRDC-CSS programme, the implementation of research outputs in the field by border guards is viewed as a measure of success.[386] However, interviewees pointed out that the decision to deploy a technology or to implement the recommendations of border security research ultimately rests with operational agencies such as the CBSA or RCMP, and that the role of the CSS is only to generate the evidence for decision makers in those agencies.[387]

There are a number of examples of research undertaken by the CBSA Science and Technology branch being translated successfully into operational practice. One such case mentioned by a study interviewee involved a POE in a remote area could not be permanently manned. In response, the CBSA Science and Technology branch began work on a remote system using video, which can be controlled from hundreds of kilometres away. This transition from the initial research pilot to deployment phases lasted around one year, before the system was trialled and fully implemented another year later. The rapid development of the system from concept to deployment has meant that the POE can now be operated full-time, remotely, and without a CBSA officer present.[388]

According to study interviewees, the Canadian approach to the setup and management of border security research is based on collaboration between federal agencies, business and academia, along with innovation that utilises the latest technologies and develops new concepts and ideas.[389] This gives the government access to a wide range of expertise and enhances understanding of border security threats and priorities.[390] However, interviewees provided few specifics to substantiate these claims, with no concrete examples of how this collaboration works in practice. Interviewees also noted that there should be greater consultation with the academic community, highlighting the Cross Border Institute (CBI) at the University of Windsor, Ontario, as one of the few academic programmes that focuses on border security in Canada and that has established partnerships with public agencies, private firms, industry groups and community groups.[391]

3.2.4. Summary

Figure 3.4 on the right provides a visual summary of the Canadian R&I pathway, including the various associated factors, stakeholders and inputs.

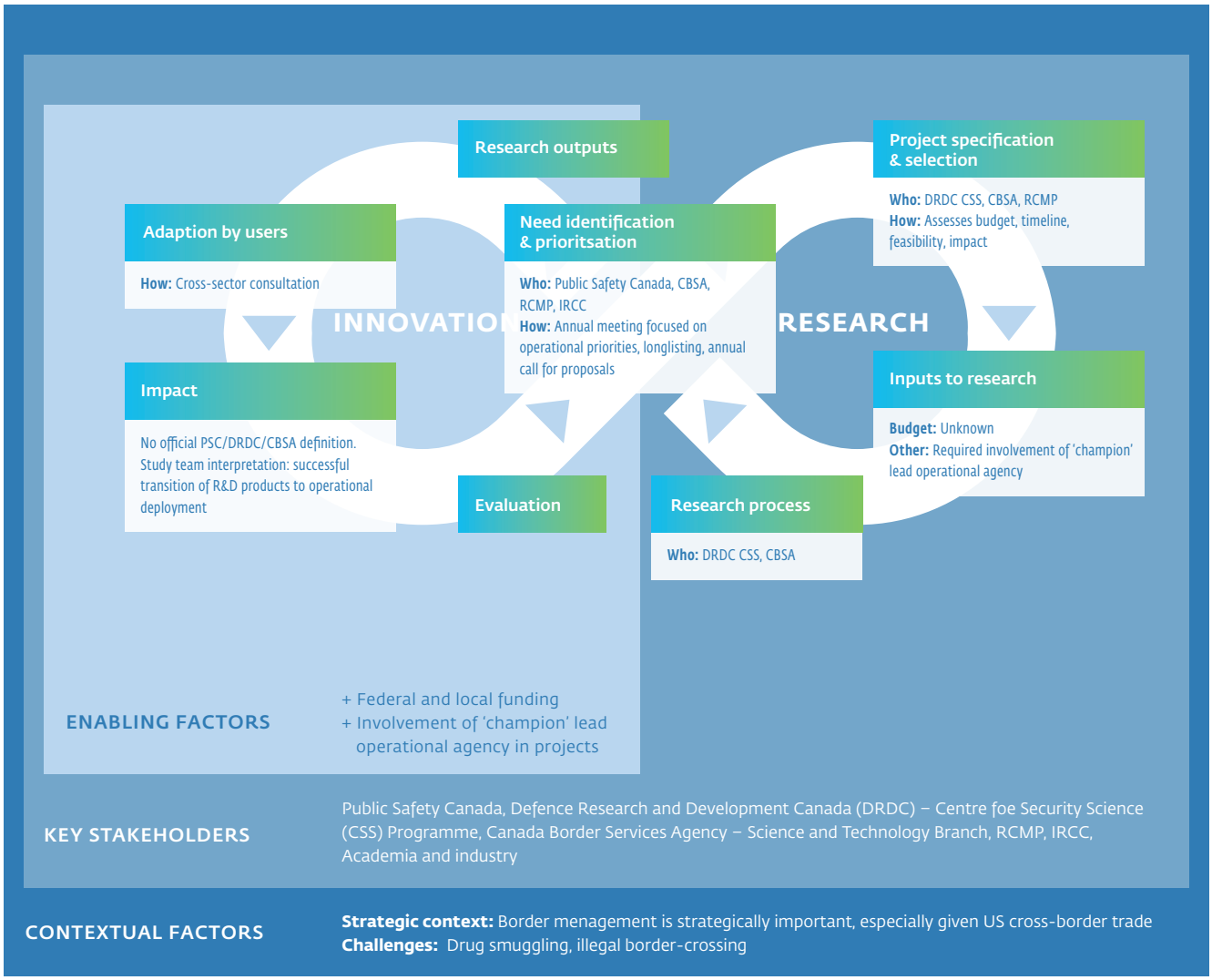
3.2.5 Lessons identified

Good practices

The **collaborative research approach of the DRDC CSS Programme** was viewed by several interviewees as a positive example of border security research management, although the interviewees did not provide specific examples of how this collaboration works in practice.[392] CSS

378 Details in this paragraph are from RAND Europe interview with Christian Leuprecht, 21 April 2017.
379 RAND Europe interview with Canadian representative, 21 April 2017; DRDC. (2014).
380 RAND Europe interview with DRDC CSS representatives, 19 April 2017.
381 RAND Europe interview with Phil Lightfoot, 19 April 2017.
382 RAND Europe interview with Phil Lightfoot, 19 April 2017.
383 RAND Europe interview with DRDC CSS representatives, 19 April 2017.
384 RAND Europe interview with Phil Lightfoot, 19 April 2017.
385 RAND Europe interview with Canadian representative, 21 April 2017; DHS (2017a).
386 RAND Europe interview with DRDC CSS representatives, 19 April 2017.
387 RAND Europe interview with DRDC CSS representatives, 19 April 2017.
388 RAND Europe interview with Phil Lightfoot, 19 April 2017.
389 RAND Europe interview with Christian Leuprecht, 21 April 2017.
390 RAND Europe interview with Joel Sokolsky, 25 April 2017.
391 RAND Europe interview with Joel Sokolsky, 25 April 2017; RAND Europe interview with Canadian representative, 21 April 2017.
392 RAND Europe interview with DRDC CSS representatives, 19 April 2017; RAND Europe interview with Phil Lightfoot, 19 April 2017; RAND Europe interview with Canadian representative, 21 April 2017.

Figure 3.4 **Canadian research and innovation pathway**



covers a broad spectrum of security, resilience and critical infrastructure research of a technical nature. This relates to 'first responders' and Chemical, Biological, Radiological and Nuclear (CBRN) threats, and brings together organisations in the private, academic and public sectors to conduct border security research. While this is said by interviewees to be achieved through collaborating as project partners and generating evidence for decision makers, the specific methods of collaborating and supporting decision makers are not clear from the evidence available to the RAND study team.[393]

The **required involvement of a 'champion' lead operational agency** in conducting federal CSS research facilitates links between academia and end users, helping ensure that research is informed by an understanding of operational needs, priorities and wider context. This focus on the end users of research ensures that any research proposals or technological solutions are designed to be practical and useful to the operators implementing them.[394]

Challenges

The **need for greater federal funding for border research**, particularly in the academic field, was highlighted as being a key challenge in Canada.[395] Consequently, one study interviewee said that the Canadian government should carry out more consultation with the academic community to ensure that finite resources for research are invested efficiently, but also suggested that this deficiency is a common characteristic of government-academic relations in most countries.[396] An associated challenge relates to resource allocation: while substantial resources are now being allocated to improving cross-border infrastructure, such as the CAN$4.8bn[397] construction of the Gordie Howe International Bridge between Windsor and Detroit, far less has been allocated to longer-term border security research and its implementation.[398]

393 RAND Europe interview with DRDC CSS representatives, 19 April 2017.

394 RAND Europe interview with Phil Lightfoot, 19 April 2017.

395 RAND Europe interview with Canadian representative, 21 April 2017.

396 RAND Europe interview with Joel Sokolsky, 25 April 2017.

397 Can$ – Canadian dollar.

398 RAND Europe interview with Canadian representative, 21 April 2017.

End users' resistance to the introduction of new technology was perceived by one study interviewee as being part of the problem of translating border research into operational practice.[399] The interviewee said this is a challenge because end users are operationally focused 'generalists' with a variety of tasks to undertake.[400] This operational focus means that while Canadian border agencies have proved adept at crisis management, their day-to-day focus has made it more difficult to integrate longer-term technology into their activities.[401] One study interviewee viewed this as part of a wider issue, noting that technology developments occur much more quickly than the public administration and protocol changes required to regulate them.[402]

3.3. Australian border security research

3.3.1. Strategic context

There are numerous border security challenges facing Australia, with the level of priority assigned to each shifting from year to year. The issue of irregular migration, encompassing matters such as people smuggling, human trafficking and organised visa fraud, is an ongoing concern – one which is intrinsically linked to regional and international geopolitical events such as instability and conflict, and global health and social crises. Balancing the security of Australia's borders with the legitimate movement of people is therefore a key strategic priority.[403] The Australian Border Force (ABF) has noted the growing scale and complexity of trade and travel patterns, as the range of goods being traded internationally increases along with the potential for biosecurity hazards and economic risks.[404] Illicit trade in drugs, firearms and tobacco has also continued to grow and is linked to organised crime gangs in Australia and the funding of terrorist organisations abroad.[405] In particular, international tobacco smuggling has recently been identified as an area of high financial yield for criminals and is the focus of substantial organisational effort by law enforcement agencies in Australia.[406]

Actors working to breach the country's borders are reportedly becoming more resilient, adaptable and sophisticated in response to efforts by law enforcement. The forces of globalisation and the increasing cross-border movement of people, goods and cash, as well as developing and converging technologies and emerging international markets, have all created opportunities for organised crime. Online international trade in both licit and illicit goods has also grown exponentially in recent years, with the ABF again identifying firearms, tobacco and drugs as key illicit markets.[407]

In the Australian context, public dialogue and research on border security is evolving rapidly. In 2015, the ABF was established as the operational arm of the Department of Immigration and Border Protection (DIBP), which itself was reorganised and renamed in 2013. DIBP is responsible for immigration, citizenship, trade and customs, offshore maritime security and revenue collection. The ABF is responsible for offshore and onshore border control enforcement, investigations, compliance and detention operations in Australia, with relevant policy, regulatory and corporate support delivered by DIBP. According to the ABF, its creation as 'the new front-line operational agency within the Department' reflects 'a greater focus on the border as a strategic national asset'.[408] In mid-2017, the Department fundamentally changed its approach to the commissioning and management of research. Whereas previously a formal department-wide research programme was set at the start of each financial year, research functions are now more deeply embedded in each of the policy teams within the Department. Furthermore, the focus and scale of research projects have shifted. Several interviewees noted that much of the research traditionally produced in this sphere tended to be long-term, based on quantitative analyses and focusing on topics such as migration trends.[409] With the recent change in approach, research projects are designed to be increasingly operationally focused and responsive to emerging issues, with individually commissioned pieces of research with shorter turnarounds becoming more common than long-term research relationships producing multiple deliverables.[410]

3.3.2. Research pathway

Overview of the Australian research landscape

DIBP is the main actor in border security research in Australia. The Department is divided into six Groups: Policy, Corporate, Intelligence and Capability, Visa and Citizenship Services, Support, and Operations. Research may be conducted internally or commissioned from external research organisations such as universities and think tanks. Most research comes through the Policy Group, although some of the more technical research is commissioned or conducted by the Intelligence and Capability Division.

Table 3.4 presents this organisational structure.

Much of the research produced or commissioned by the Department is not publicly available, although a suite of research outputs on topics related to migration is available online and is also utilised for a significant amount of cross-governmental research, for example with the Department of Social Services.[411] There is scant reference to

399 RAND Europe interview with Phil Lightfoot, 19 April 2017.
400 RAND Europe interview with Phil Lightfoot, 19 April 2017.
401 RAND Europe interview with Phil Lightfoot, 19 April 2017.
402 RAND Europe interview with Canadian representative, 21 April 2017.
403 Coyne (2015).
404 Australian Government – Department of Immigration and Border Protection (n.d.-a).
405 McKenzie (2016).
406 RAND Europe interview with two Australian representatives, 24 July 2017.
407 Australian Government – Department of Immigration and Border Protection (n.d.-a).
408 Australian Government – Department of Immigration and Border Protection (n.d.-b).
409 RAND Europe interview with Dr John Coyne, 20 March 2017; RAND Europe interview with two Australian representatives, 24 July 2017.
410 RAND Europe interview with Australian representative, 30 March 2017; RAND Europe interview with two Australian representatives, 24 July 2017.
411 RAND Europe interview with two Australian representatives, 24 July 2017.

Table 3.4 **DIBP organisational structure**

	Department of Immigration and Border Protection					
	Secretary of the Department of Immigration and Border Protection				ABF Commissioner	
Group	**Policy**	**Corporate**	**Intelligence and Capability**	**Visa and Citizenship Services**	**Support**	**Operations**
Division	Strategic Policy and Planning	Executive	Intelligence	Visa and Citizenship Management	Border Management	Maritime Border Command
	Immigration and Citizenship Policy	Corporate Services	ICT	Refugee and Humanitarian Visa Management	Border Force Capability	Strategic Border Command
	Traveller, Customs and Industry Policy	People	Major Capability	Community Protection	Children, Community and Settlement Services	Detention, Compliance and Removals
	International	Finance	Identity and Biometrics	Digital Transformation and Channels	Detention Services	Investigations
		Legal		Visa Reform Taskforce		OSB JATF
		Integrity, Security and Assurance				
		Health Services and Policy				
		Enterprise Strategy, Reform and Performance				

Source: DIBP (2017).

research in ABF's annual and corporate reports, although these do mention the Department's migration research programme.

There are a number of other government departments and research organisations conducting or commissioning research related to border security. The **Australian Research Council (ARC)** is a Commonwealth entity which advises the Federal Government on research matters, and allocates research funding to researchers at Australian universities through the National Competitive Grants Program (NCGP). The NCGP comprises two funding programs: 'Discovery', which supports fundamental research in innovation, and 'Linkage', which facilitates national and international collaboration and research partnerships between key stakeholders such as government, business, industry and end users. Where potential research projects relate to topics around immigration or border protection, the ARC may approach DIBP for guidance or co-sponsorship of the project, or contributions such as making Department staff available for workshops.[412]

The **Australian Nuclear Science and Technology Organisation (ANTSO)** offers a number of research partnerships, including: joint research appointments; joint supervision of research students; staff exchange; use of equipment; and negotiated arrangements specific to each partner, including joint grant applications, establishment of centres of excellence and participation in research networks. In addition, the **Commonwealth Scientific and Industrial Research Organisation (CSIRO)** carries out a wide range of scientific research activities to assist Australian industry and encourage or facilitate the application or utilisation of the results of such research. DIBP's Intelligence and Capability Division recently established a partnership with CSIRO's new technical research unit Data61, and one project undertaken within this partnership is seeking to put together a mathematically sound programme for cargo sampling.

Research institutes such as the **Australian Strategic Policy Institute (ASPI)** and the **Lowy Institute** also produce border security research through funding from the Australian government. These may be for specifically commissioned projects or for broad-ranging research activities such as discussion papers and other forms of outreach aimed at informing public discourse on border security.[413] The Lowy Institute is also engaged in a strategic partnership with DIBP for the commissioning of research and the secondment of a DIBP employee for 6–12 months every year. One interviewee stated that research produced by think tanks brings particular value because the institutions enjoy greater freedom to operate and are more aware of the public discussion on these issues than DIBP.[414] In addition, a number of Australian universities produce research in this space and engage in strategic partnerships undertaking specific research projects with DIBP.

As DIBP is the most significant player in border security research in Australia, it will be the focus of this section's analysis of the setup and management of research.

Identification and prioritisation of research topics

As noted above, DIBP has fundamentally changed its approach to research in recent months. Under this newly established process, the Thought Leadership section of the Statistics and Information Governance branch, which sits within the Policy Group, takes the lead in facilitating the identification and prioritisation of research topics. At the same time, the Department is seeking to make research functions more deeply embedded in each policy areas. In practice, this means that identification of research needs happens within these areas on an

412 RAND Europe interview with two Australian representatives, 24 July 2017.

413 RAND Europe interview with Australian representative, 30 March 2017.

414 RAND Europe interview with Australian representative, 30 March 2017.

ongoing basis, allowing a degree of flexibility in picking up projects as and when the need for them arises. Following the identification of a research topic, a process of engagement and consultation takes place with leadership across DIBP, managed by the Thought Leadership section, and consensus is reached on taking forward a research proposal to the Secretary of the DIBP.

Two study interviewees noted that alongside the changes to the process of identifying and prioritising research topics, the type of research prioritised by DIBP has changed. Previously, the Department's research agenda was set at the start of each financial year and related to topics of relevance at that point in time, and commissioned projects were long-term, often running to 12 or 18 months. As a result, by the time project outputs were delivered, interviewees reported that they had often ceased to be relevant to the needs of the Department. The interviewees reported that the current focus for identifying and prioritising research topics is on producing policy research which is current and operational. Research topics are more tightly scoped and can be delivered through individual, concise pieces of research rather than through long-term relationships producing occasional papers over the course of a number of years. Where research partnerships are still in place, DIBP can request specific research projects during the life of the partnership, rather than committing to long-term projects.[415]

Selection of border security research projects

Once the consultation process has concluded and topics for research have been identified, the Secretary of the DIBP makes the final decisions about which research proposals will be selected for commissioning. The Secretary also makes the final decision on the budget allocated to specific projects, following initial discussions and recommendations from leadership within the Policy Group. Overall, DIBP's research funding is carved out of the Department's operational budget rather than from a specific research allocation from the Government, and the amount of funding spent on research varies year by year according to decisions made within the Department about research and operational needs. As a result, information about the size of the Department's research budget is not publicly available. However, two interviewees estimated that annual research funding would typically be in the high six figures or low seven figures.[416] Another interviewee stated that budgets for individual projects range from around Aus$50 000[417] for smaller activities into the millions of dollars for more substantial, multi-year research studies.[418] Where the Department commissions an external organisation to conduct the project, a budget is set out in the invitation to tender.

However, a decision may be made to conduct the research internally if Department staff have access to the required resources and networks to conduct the study. For example, DIBP has collated some of the largest and most complex datasets in the Australian government, and utilises these where possible.[419] Internal research capacity is also a factor: some policy areas such as migration and citizenship tend to have more capacity than border protection. Two interviewees noted that an increasingly part of a policy officer's role is to conduct research, particularly as research resources are relatively constrained and commissioning studies externally may be too costly.[420] Typical project timelines are now between three and six months, with a small number of multi-year studies.[421]

DIBP does not have a centralised research contracts-management team.[422] Typically, the Thought Leadership section manages commissioned research and relationships with external researchers, although occasionally, for specific technical pieces of work, contracts management is handled within the relevant business area.[423]

Monitoring and evaluation

DIBP does not have a formal evaluation programme for its research. However, quality assurance provisions are usually built into contracts with commissioned research organisations. Interviewees noted that these provisions vary depending on the type of project being conducted and the business area which commissioned it.[424] For example, for the Future Capability Assessment and Engagement Section within the Intelligence and Capability Group, it was reported that M&E is performed by a board of Deputy Commissioners and Commanders. As part of this process, monthly reports are submitted on budget expenditure, progress relative to schedule, and risks and benefits related to the project, along with weekly project updates.[425] In general, when quality assurance provisions are being developed, the Thought Leadership section coordinates across Department stakeholders and gathers inputs on measuring the quality of the project and the relevance and utility of its findings.[426]

One study interviewee reported that for M&E of ASPI research activities for the Department, a biannual meeting at programme level is held with the entire DIBP executive, during which project progress is discussed in depth. Representatives from ASPI also meet with senior members from the executive on a monthly basis for management and project updates.[427]

3.3.3. Pathways to impact

Interviewees stated that the impact potential of a research proposal is the first consideration in deciding whether to

415 RAND Europe interview with two Australian representatives, 24 July 2017.
416 RAND Europe interview with two Australian representatives, 24 July 2017.
417 A$ – Australian dollar.
418 RAND Europe interview with DIBP representative, 29 March 2017.
419 RAND Europe interview with two Australian representatives, 24 July 2017.
420 RAND Europe interview with two Australian representatives, 24 July 2017.
421 RAND Europe interview with DIBP representative, 29 March 2017.
422 RAND Europe interview with Australian representative, 30 March 2017.
423 RAND Europe interview with two Australian representatives, 24 July 2017.
424 RAND Europe interview with Australian representative, 30 March 2017
425 RAND Europe interview with Australian representative, 29 March 2017.
426 RAND Europe interview with two Australian representatives, 24 July 2017.
427 RAND Europe interview with Dr John Coyne, 20 March 2017.

take it forward,[428] and that there is increasing emphasis on shaping policy research on topics with implications for the way the Department operates and the achievement of specific policy outcomes.[429] When identifying and prioritising research topics, the DIBP Policy group focuses on topics' impact. While 'impact' does not appear to have been assigned a formal definition by the Policy group, one study interviewee offered a definition that is presented in Box 3.3.

However, a number of study interviewees commented that 'impact potential' is not measured in terms of specific outcomes.[430] It was reported that the Future Capability Assessment and Engagement section has no formal processes to facilitate the impact of border security research, but rather considered impact to be a matter of ongoing engagement and keeping relevant stakeholders informed about research activity.[431]

As the vast majority of border security research is focused on policy outcomes, the Policy group is the predominant body within DIBP in terms of implementing the outputs of research projects funded by the Department. Within the Policy group, research projects tend to inform the development of a policy, which can then be taken to Cabinet.[432] Within the Future Capability Assessment and Engagement section, a report is produced at the conclusion of a research activity for the senior sponsor, who can then determine whether they wish to take the research further.[433]

As regards externally funded research, ASPI's Border Security Program engages with DIBP on multiple levels to maximise the impact of its research activities. This includes, for example, executive sessions at the governmental level, and presentations on reports and policy recommendations at the policy level, where staff may informally review the results of the study.[434]

Beyond the connection between research and policy, few links are made between research and impact, as it is the impact of policy more broadly which is assessed by governments. For example, no direct connection is made between a piece of research and its financial impact: it is the impact of the policy that is assessed, rather than that of the individual pieces of research that informed it. However, in translating research into operational practice, one interviewee emphasised the need to have senior personnel within DIBP who can review research, assess its implications, consider how it can be operationalised, and then take forward recommendations to government.[435]

3.3.4. Summary

Figure 3.5 overleaf provides a visual summary of the Australian R&I pathway, including the various associated factors, stakeholders and inputs.

3.3.5. Lessons identified

There are mixed views on the effectiveness of Australian approaches to the management of border security research, which may reflect the period of transition that DIBP is undergoing. The following paragraphs extract a number of useful lessons from this case study.

Box 3.1 **DIBP Policy group definition of 'impact'**

According to one study interviewee, the DIBP Policy group measures the impact of research topics according to: (i) the extent to which the piece of research becomes a basis for policy; and (ii) the extent to which it is influential and elicits a response from relevant policy stakeholders and the Australian public.[436]

Box 3.2 **Case study: Operationalisation of border security research**

Smartgate is an automated border control system which uses the information in passports and facial biometrics technology to perform checks, usually conducted manually by ABF officers, on arriving and departing international passengers. In developing this technology, the now dissolved Customs and Border Protection Services conducted a feasibility study on automated departures processing, with a technology panel of 16 vendors offering different biometric options. Tests were conducted in a Canberra laboratory, followed by live trials of the technology in Brisbane airport.[437]

In 2014, DIBP received Aus$50.1m of funding to expand the use of departure SmartGates. Between July 2015 and June 2016, 77 departure SmartGates were rolled out and they are now operational at all eight of Australia's international airports. As of 30 June 2016, approximately 6.9m departing travellers had been successfully processed through the gates, with around 85 per cent of all eligible travellers using the SmartGates. Arrival SmartGates are also available at these airports for use by travellers with ePassports from eight countries.

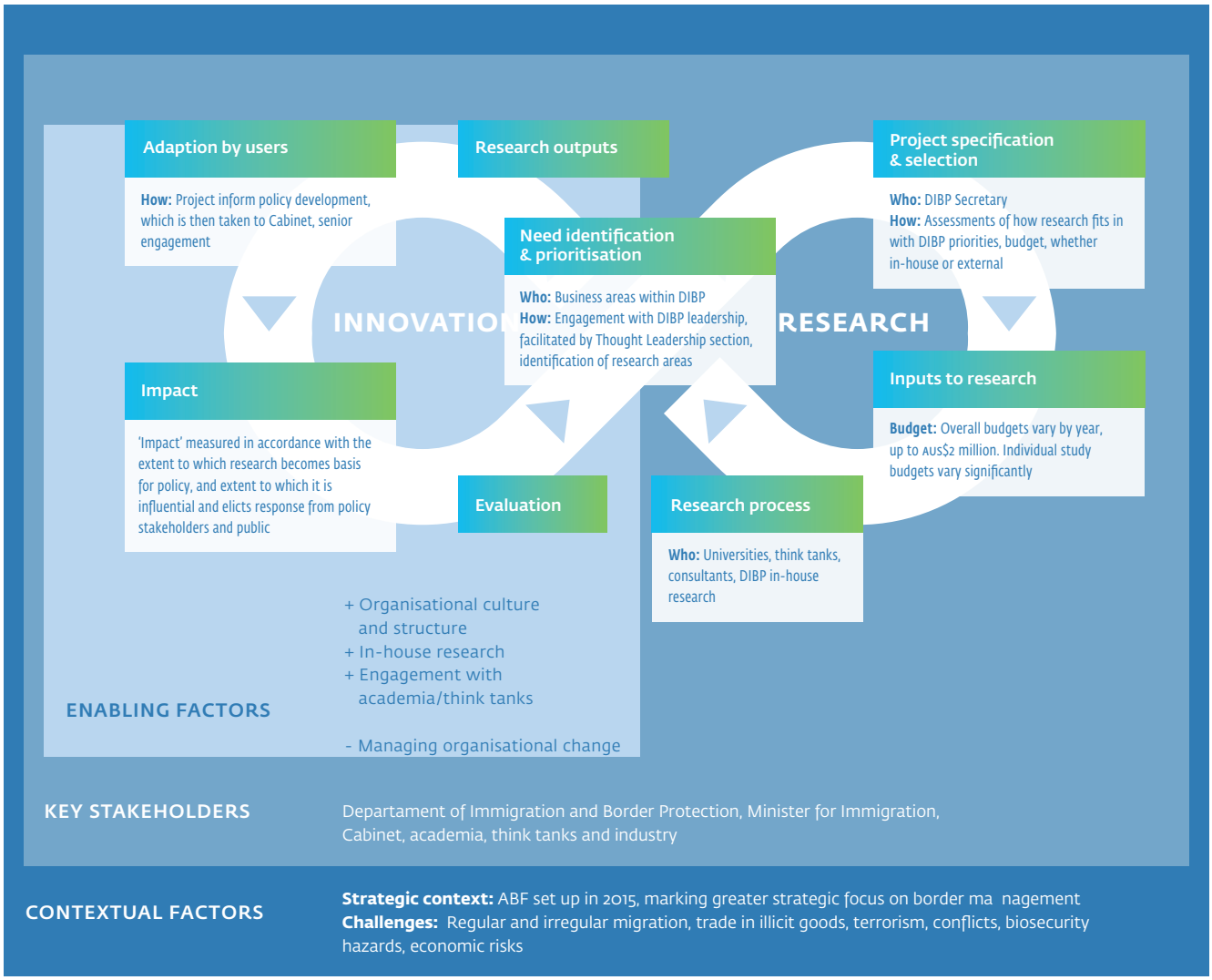
Automated border processing may support border agencies in managing high traveller volumes and facilitating a faster and less intrusive border process for travellers deemed to be of low risk.[438]

Good practices

Interviewees noted the positive effects of **embracing organisational and cultural change** within DIBP. In particular, greater openness to innovation in research, the development of responsive research plans, and flexible engagement with academia and think tanks for fresh, objective analysis were all highlighted by interviewees as positive developments.[439]

428 RAND Europe interview with Australian representative, 30 March 2017; RAND Europe interview with two Australian representatives, 24 July 2017.
429 RAND Europe interview with two Australian representatives, 24 July 2017.
430 RAND Europe interview with Australian representative, 30 March 2017; RAND Europe interview with two Australian representatives, 24 July 2017.
431 RAND Europe interview with DIBP representative, 29 March 2017.
432 RAND Europe interview with Australian representative, 30 March 2017
433 RAND Europe interview with DIBP representative, 29 March 2017.
434 RAND Europe interview with Dr John Coyne, 20 March 2017.
435 RAND Europe interview with Australian representative, 30 March 2017.
436 RAND Europe interview with Australian representative, 30 March 2017.
437 Griffith (2014).
438 Department of Immigration and Border Protection (DIBP) (2016).
439 RAND Europe interview with Dr John Coyne, 20 March 2017; RAND Europe interview with two Australian representatives, 24 July 2017.

Figure 3.5 **Australian research and innovation pathway**



Beyond the recent change in the Department's approach to research, interviewees saw these developments as functions of strong engagement at the senior leadership level in encouraging innovation, research partnerships and secondments with think tanks to drive up interest in research,[440] as well as increased emphasis on strong research backgrounds in the Department's recruitment activities.[441] Two interviewees also reported that the faster pace of research topic identification and commissioning has proved effective in preparing for challenges as they emerge, reportedly resulting in an increase in the impact of their research. Furthermore, the interviewees stated that even in the short space of time since the new approach to research was initiated, they have seen more innovation and variety in the research ideas put forward within DIBP.[442]

Interviewees also reported that DIBP is **engaging more closely with academic institutions and thought leaders** in Australia.[443] Across the country, there are now a number of well-regarded public policy schools within universities that cover a range of issues relevant to border security, and that can offer research services tailored to the Department's evolving requirements. Engagement with academia can take a number of forms. For example, the National Security College, based at the Australian National University, runs an executive development programme where junior and senior leaders undertake courses in executive development in national security. According to one study interviewee, the interaction may teach managers how they can make use of the academic environment and the agencies which are engaging with academics, and develop relationships with these institutions.[444] As noted above, the Department is moving towards funding think tanks and policy institutes not

440 RAND Europe interview with Dr John Coyne, 20 March 2017; RAND Europe interview with Australian representative, 30 March 2017; RAND Europe interview with DIBP representative, 29 March 2017.

441 RAND Europe interview with Dr John Coyne, 20 March 2017.

442 RAND Europe interview with Dr John Coyne, 20 March 2017.

443 RAND Europe interview with Dr John Coyne, 20 March 2017; RAND Europe interview with two Australian representatives, 24 July 2017.

444 RAND Europe interview with Dr John Coyne, 20 March 2017.

Table 3.5 **Summary of findings for non-EU case studies**

	Border security context	Key stakeholders	Needs identification and prioritisation	Project specification and selection	Inputs to research	Research process	Pathways to impact
US (Section 3.1)	**Strategic context:** Border security is part of 'homeland security' umbrella concept and is 1 of 5 of its missions. **Challenges:** Terrorism, migration, cybersecurity, illegal border-crossing, transnational crime, nuclear threats, climate change.	Department of Homeland Security (DHS): ■ S&T ■ USCG Academia and industry.	**Who**: DHS: S&T, USCG. **How:** QHSR (study groups, steering committee, senior leadership meetings, strategy coordination group, sub-interagency policy committees); STRAS; IPTs (research monitoring, technology review platform); portfolio review; ISR.	**Who**: DHS: S&T, USCG, COEs. **How:** No single S&T approach in place for awarding projects – IPTs, STRAS, ISR, Assessment of Prospective Portfolio, HSIP, SVIP, SBIR. **What:** While S&T classifies technologies according to 9 TRLs, research priorities are clustered by thematic area.	**Budget**: S&T – $55m; USCG – $18m for FY2017.	**Who**: RDC (within USCG RDT&D), external implementers.	**How:** End user project involvement (QHSR, IPTs, STRAS, USCG RTD&E); System Analysis; ISR; CG-STIC Innovation and Working Groups. **Challenges:** Work remains to be done to strengthen links between research and end users; time gap between need identification and research programme launch.
Canada (Section 3.2)	**Strategic context:** Border management is strategically important, especially given cross-border trade with the US. **Challenges:** Drug smuggling, illegal border crossings.	■ Public Safety Canada ■ DRDC – CSS ■ CBSA – S&T Academia and industry.	**Who**: Public Safety Canada, CBSA, RCMP, IRCC. **How:** Annual meetings focused on operational priorities, longlisting of priorities, annual call for proposals.	**Who**: DRDC – CSS, CBSA, RCMP. **How:** Proposal selection assesses budget, timeline, feasibility, impact. **What:** CSS and CBSA reportedly prioritise operationally focused research with high TRL potential.	**Budget**: Unknown. **Other**: Required involvement in project of 'champion' operational agency.	**Who**: DRDC – CSS, CBSA, academia, 'champion' operational project partners.	**How:** Cross-sector consultation. **Challenges:** Only so much research providers can do as the decision to operationalise research rests with operational agencies.
Australia (Section 3.3)	**Strategic context:** ABF set up in 2015, marking greater strategic focus on border management. **Challenges:** Terrorism, migration, conflict, biosecurity hazards, economic risks.	■ DIBP ■ Minister for Immigration ■ Cabinet ■ Academia and industry	**Who**: Business areas within DIBP. **How:** Engagement with senior DIBP leadership, preliminary research conducted internally, capability plan, ad hoc identification of research areas.	**Who**: DIBP Executive Committee, Secretary of the DIBP. **How:** DIBP releases request for tender; proof of concept; 'impact' as a key assessment criterion. **What:** An increasing focus on shorter-turnaround studies with greater responsiveness to emerging issues.	**Budget**: Unknown.	**Who**: Universities, think tanks, consultants, DIBP research-management apparatus.	**How:** Projects inform policy development, which is then taken to Cabinet; senior engagement. **Challenges:** Beyond connection between research and policy, few links between research and impact.

only through commissioned research, but also through seed money and grants which the organisations can use to fund projects aimed at informing public discourse on border security through discussion papers and other forms of outreach.

Challenges

One interviewee suggested that **the DIBP is still not well integrated** internally in terms of managing and achieving impact from its research programme,[445] although another interviewee emphasised that organisational restructuring is ongoing.[446] Furthermore, it was reported that **research findings are often used only to inform existing processes**,[447] or are focused mainly on longstanding academic debates in border security rather than on driving forward innovation – although interviewees again noted ongoing efforts to change these practices and use research more effectively.[448] On a related point, **ensuring policy relevance and impact** was also highlighted as an area for improvement,[449] with interviewees reporting increased focus on why research is commissioned, what it is intended to deliver, and how to make the best use of it.[450] Interviewees also noted the **resource constraints** under which the DIBP operates, and the challenge of making the most of a relatively small research allocation. In particular, the interviewees stated that particular business areas see a real need to be able to commission expert external advice as the need arises, but funding for this must be found from within operational budgets.[451]

Table 3.5 provides a summary of the findings presented above.

3.4. Border security research in North Africa and Turkey

A high-level overview of border security research activities and structures in North Africa and Turkey is presented in Boxes 3.5 and 3.6, respectively. While the RAND study team had hoped to gain greater insight into the conduct and implementation of research in these countries, the limitations of the available evidence meant that very little analysis was possible in this regard.

445 RAND Europe interview with Dr John Coyne, 20 March 2017.

446 RAND Europe interview with DIBP representative, 29 March 2017.

447 RAND Europe interview with Dr John Coyne, 20 March 2017; RAND Europe interview with DIBP representative, 29 March 2017.

448 RAND Europe interview with Dr John Coyne, 20 March 2017.

449 RAND Europe interview with Dr John Coyne, 20 March 2017. RAND Europe interview with DIBP representative, 29 March 2017; RAND Europe interview with Australian representative, 30 March 2017.

450 RAND Europe interview with Australian representative, 30 March 2017.

451 RAND Europe interview with two Australian representatives, 24 July 2017.

Box 3.3 **Border security research in North Africa**

The implementation of border security measures in Egypt, Morocco and Tunisia is of critical relevance to Europe.[452] This significance is clear in three main areas of concern for those countries: refugee migration, terrorism and organised crime. Much of the regional instability contributing to these three issues emanates from Libya and its porous borders with neighbouring countries. In addition to the problems posed by terrorism and the migration of refugees, North African countries lie on major smuggling and trafficking routes from Sub-Saharan Africa, the Sahel and North Africa, and across the Mediterranean into southern Europe.[453]

These threats have had an impact not only with North Africa, but also on southern Europe. In response to these threats, most North African countries' borders have been highly militarised, with the main actors involved in border protection being the army and various other border guards, *gendarmes* and police.[454] For example, efforts to secure the Libyan border[455] include a 70km ditch between Tunisia and Libya and the installation of CCTV along the border.[456]

The army and security forces in Egypt and Tunisia have primary responsibility for identifying and prioritising border security research topics.[457] However, given the frequency and severity of the on-the-ground border management issues they face, one study interviewee reported that these actors do not have the time, resources or political inclination to set up and manage a large portfolio of border security research.[458] According to one study interviewee, the little research that is commissioned in North Africa tends to focus on 'hardware' or 'technology', rather than on 'softer' social science approaches.[459]

As a result, there are said to be few specialists in the domain of border security research in most North African countries, aside from historians, psychologists and sociologists working to create think tanks. An example of one such think tank is the Arab Reform Initiative (ARI), which produces research and policy analysis, as well as supporting Arab scholars in the region financially.[460]

However, these endeavours are reportedly impeded by national funding shortages and a lack of individuals specialising in this field of research, resulting in much of the border research being completed in collaboration with European partners and funders, such as the EU's FP7 and H2020 projects (see Section 2.1).[461] An example of EU-funded joint European and North African research is the European University Institute (EUI) Robert Schuman Centre's support for the BORDERLANDS project.[462] This FP7 project examines relations between the EU and North African countries, exploring the processes by which the EU extends its legal and functional borders, rules and practices to North Africa. There appears to be no information available concerning the impact of BORDERLANDS given that it is a relatively recent project running from 2011 to 2016. Additional challenges affecting the conduct and management of border security research include interruptions to funding streams, limited access to research findings and issues regarding research management.[463]

In terms of improving border security research management in North African countries, one interviewee suggested that border security research should be assigned more funding, more think tanks should be established to increase the expertise available, and research should not be led only by national Ministries of Defence or Ministries of Interior.[464] Another lesson concerns the importance of increasing collaborative research on border security involving researchers from across North Africa and Europe.[465]

452 See for example Limam and Del Sarto (2015).
453 See Hanlon and Herbert (2015).
454 For a detailed examination of North African countries' border security forces, see Hanlon & Herbert (2015, 29–41).
455 RAND Europe interview with Egyptian representative, 29 April 2017.
456 RAND Europe interview with Faycal Cherif, 25 April 2017.
457 RAND Europe interview with Egyptian representative, 29 April 2017; RAND Europe interview with Faycal Cherif, 25 April 2017.
458 RAND Europe interview with Faycal Cherif, 25 April 2017.
459 RAND Europe interview with Faycal Cherif, 25 April 2017.
460 See for example Jrad (2015).
461 RAND Europe interview with Faycal Cherif, 25 April 2017.
462 See for example Limam and Del Sarto (2015).
463 RAND Europe interview with Egyptian representative, 29 April 2017; RAND Europe interview with Faycal Cherif, 25 April 2017.
464 RAND Europe interview with Faycal Cherif, 25 April 2017.
465 RAND Europe interview with Egyptian representative, 29 April 2017; RAND Europe interview with Faycal Cherif, 25 April 2017.

Box 3.4 **Border security research in Turkey**

Following the attempted coup in Turkey in July 2016.[466] many police and military officials, civil servants and academics have been dismissed from their jobs, leading to reluctance to discuss border security and related research. This political climate has also been fostered by an earlier communiqué released by the government's Higher Education Council (YOK) in April 2015 stating that academics require permission from 'relevant ministries' in order to conduct any survey or fieldwork concerning Syrian refugees.[467] It appears that such developments will have profound implications for the commissioning and conduct of border research in Turkey for the foreseeable future.[468]

According to a study interviewee, an IBM organisation was established in 2013 but it has reportedly not been very visible in the field.[469] The Turkish Army currently has primary responsibility for securing the Turkish border, which is highly militarised. The Army is supported at POE and other locations by the Jandarma (Gendarmerie) and Turkish National Police (TNP). Many other government agencies are also involved in border management, including the Ministry of Economy for Trade, the Ministry of Health, and Customs.[470]

These organisations face various issues along long and very porous borders, particularly those with Iraq and Syria. As well as the security threats posed by Islamic State (IS), al-Qaeda (AQ) affiliate groups and the Partiya Karkeren Kurdistan (PKK – Kurdish Workers Party), these agencies face significant cross-border challenges relating to drug smuggling, other forms of organised crime, and the arrival of over 3 million refugees from Iraq and Syria.[471]

Due to the sensitivity of the political situation, there is currently very little research being conducted on border security issues. Researchers do not have access to government data, which creates challenges for maintaining an up-to-date understanding of the security situation. Even when contact is established with officials or policymakers, the post-coup dismissals have led to a high turnover of personnel, meaning that it is difficult for continuous relationships to be established. Additionally, many academics, researchers and officials are now said to be applying a measure of self-censo'ship.[472]

466 Al Jazeera (2016).
467 Kayaoglu (2015).
468 RAND Europe interview with Turkish representative, 3 May 2017.
469 See Sert (2013).
470 Republic of Turkey, Ministry of Customs and Trade (n.d.).
471 European Commission (2017e).
472 RAND Europe interview with Turkish representative, 3 May 2017.

4. Case studies: Operational models (WP3)

This chapter provides an overview of how different organisations, including those outside of the border security domain, seek to operationalise research findings. The six case studies include two European examples (European Space Agency and European Institute of Innovation and Technology) and four from the US (Defense Innovation Unit Experimental, Small Business Innovation Research, Homeland Security Innovation Programs and DHS S&T Centres of Excellence). The following sections provide summaries of the case study organisations and of their vision and governance, before exploring the types of activities they undertake to support innovation. These activities relate to the functional roles mapped onto the R&I pathway provided in Chapter 2 of the main report.[473]

4.1. European Space Agency

4.1.1. Summary

The European Space Agency is the coordinating entity for European civilian space activities. First established in 1975, ESA has its headquarters in France but also maintains a number of sites across Belgium, Germany, Italy, the Netherlands, Spain and the United Kingdom. ESA is responsible for the design and delivery of the European space programme with the goal of defining and implementing a long-term space policy that allows Europe to remain competitive in the field of space technology.[474] While ESA conducts a range of activities, the following sections discuss programmes and initiatives that upon review were found to be most relevant for the scope and objectives of this study.

4.1.2. Vision

Mission

ESA's mission is to provide and promote, for exclusively peaceful purposes, cooperation among European states in space research, technology and applications, with a view to their being used for scientific purposes and for operational space application systems.[475]

Objectives

To fulfil its mission, ESA is tasked with designing a unified space policy and a related industrial policy, recommending space objectives to participating Member States (pMS) and integrating national programmes into the activities of the European programme.

4.1.3. Governance

Organisational governance

ESA is governed by a Council, which provides basic policy guidelines within which ESA develops the European space programme.[476] Each pMS is represented on the Council and has one vote, irrespective of its size or financial contribution.[477] The Council is responsible for approving activities and programmes by a majority of all pMS, and determining – by a unanimous decision of all pMS – the level of resources to be made available to ESA for the coming five-year period. Another function of the Council is to adopt annual ESA work plans and to determine the order of priority of programmes in the course of their implementation.[478]

Leadership and membership

ESA is an intergovernmental organisation with 22 pMS from across Europe.[479] In addition to its headquarters, ESA maintains several sites in a number of European countries:

- The European Astronauts Centre (EAC) in Cologne, Germany;
- The European Space Astronomy Centre (ESAC) in Villanueva de la Canada, Spain;
- The European Space Operations Centre (ESOC) in Darmstadt, Germany;
- The ESA centre for Earth Observation (ESRIN) in Frascati, Italy;
- The European Space Research and Technology Centre (ESTEC) in Noordwijk, the Netherlands;
- The European Centre for Space Applications and Telecommunications (ECSAT) in Harwell, United Kingdom; and
- The ESA Redu Centre in Redu, Belgium.

ESA is headed by a Director General who is elected by the Council every four years. Individual research sectors are headed by Directorates that report directly to the Director General.[480]

473 A full description of these functional roles is presented in Appendix D.
474 Turner (2009).
475 ESA (2007).
476 Bonnet et al. (1994).
477 However, a pMS does not have the right to vote on matters concerning programmes in which it does not take part. Source: ESA (2010).
478 ESA (2010).
479 ESA comprises Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the United Kingdom. Slovenia is an Associate Member, and Canada takes part in some projects under a cooperation agreement. Bulgaria, Cyprus, Malta, Latvia, Lithuania and Slovakia have cooperation agreements with ESA, and discussions are under way with Croatia. See European Space Agency (2017a).
480 European Space Agency (2017a).

Organisational funding

The ESA space science programmes and general budget are funded through financial contributions from all pMS. Individual pMS contributions are calculated on the basis of countries' gross national product. In 2017, ESA's total budget amounted to €5.75bn, supporting the work and activities of a worldwide staff of 2 200.[481]

ESA has a policy of cooperation with various partners based on the assumption that pooling resources and sharing work will increase the effectiveness of its programmes.[482] In cases where pMS vote unanimously, ESA can cooperate with other international organisations and institutions and work with governments, organisations and institutions of non-pMS. This cooperation can take the form of non-pMS or international organisations participating in ESA programmes, with detailed arrangements for this cooperation being defined by the Council by a two-thirds majority of programme participants.[483]

4.1.4. Activities

ESA's work includes a range of mandatory activities in which all pMS participate, and optional activities involving all pMS except those that formally declare that they are not interested in participating.[484] For mandatory activities, ESA has a delivery and coordination role. In terms of delivery, ESA is directly responsible for delivering technological research, educational activities and a scientific programme. ESA's coordination role involves collecting and disseminating information concerning existing gaps and duplication of activities, and providing assistance for the harmonisation of national and international programmes. The Agency also performs the role of 'honest broker'[485] within its stakeholder community as it engages with and facilitates interactions among users of space technologies, pMS and the private sector.[486] ESA also fulfils other functions, for example providing training and education through its EAC,[487] and hosting innovation through its ESA Business Innovation Centre.[488]

In the area of space applications, ESA is also mandated to conduct operational activities under conditions defined by the Council by a majority of pMS. In these cases, the Agency may offer its facilities for use by the operating agencies concerned and ensure the launching, placing in orbit and control of operational application satellites.

The following sections discuss a number of ESA's mandatory and optional activities, which were selected due to their relevance to the scope and objectives of this study. Large-scale programmes such as those discussed necessarily entail a range of smaller activities that pertain to multiple FCs presented in Appendix D of this report. To facilitate navigation of the case study, the following sections present programmes under the single FC to which the programme or initiative most directly contributes. Where relevant, the text also highlights other FCs to which the programme or initiative contributes and how.

Funding

ESA runs a range of programmes and initiatives which entail the **provision of direct research, development and innovation funding to stakeholders involved in the space domain (O6.1)**. The following paragraphs provide a succinct overview of the ESA **Technology Research Programme (TRP)**, the ESA **Science Core Technology Programme (CTP)**, and the ESA **Integrated Applications Promotion (IAP)**. Other programmes and initiatives discussed in the following sections also entail the provision of direct funding for research and development, but since this was not their main rationale they are discussed under different FCs.

The **TRP** is a mandatory ESA programme which was established to promote the undertaking of so-called 'blue-sky' research (i.e. scientific research where ideas are first developed, with a focus on creativity and challenging established approaches, and then put through proof-of-concept testing only at a later stage). The TRP is designed to help ESA plan and define future space missions and activities. The programme is structured around a two-year work plan for technology development sustained through two initiatives. The first initiative is the *Innovation Triangle Initiative*, which supports disruptive innovation efforts for space applications led by industry and academia. The second initiative is the *Programme Space Technology Advancements by Resourceful, Targeted & Innovative Groups of Experts & Researchers* (*StarTiger*), which focuses on prototyping advanced technologies.[489] Procurement plans under the TRP are made on an annual basis. Contracts under these initiatives are assigned on an open, competitive basis to industry and academia. Invitations to tender are issued continuously throughout the year on ESA's *Electronic Mailing Invitation to Tender System* (EMITS) web portal. Through the TRP, ESA aims to strengthen European competitiveness. Technologies developed through the TRP and its associated initiatives are reportedly successful in reaching and penetrating wider markets spanning beyond Europe. The programme is reported to have produced some of ESA's most advanced technologies, including, for example, the advanced ion engines propelling the Bepi Colombo mission to Mercury.[490]

The **CTP** is a mandatory ESA programme which focuses on developing in advance the critical enabling technologies required for the planning and undertaking of ESA's future science missions. While the early stages of technology development leading up to experimental validation are carried out through ESA's TRP, the CTP applies new technologies developed to the specific technical requirements of future science missions. CTP-funded activities advance technologies to higher stages of technological

481 ESA (20170)
482 For example, ESA signed an Administrative Arrangement with the EDA in 2011 in order to explore the added value and contribution of space assets to the development of European capabilities in the area of crisis management and the Common Security and Defence Policy. See EDA (2017).
483 ESA (2010).
484 ESA (2010).
485 An honest broker is an organisation that actively seeks and encourages partnership-oriented relationships with external actors. See Freeman et al. (2015).
486 ESA (2010).
487 ESA (2017b).
488 ESA BIC (2017).
489 ESA (2017c).
490 ESA (2017d).

maturity, up to full-scale engineering models fully tested in appropriate environmental conditions. The process of scientific and technological development involves the conduct of detailed studies which define future mission concepts and identify relevant technology requirements. CTP activities are then initiated for all platform and payload technologies for which ESA has responsibility. The CTP focuses on the development stage, which moves technologies from embryonic concepts to tailored products catering to specific mission requirements and which are feasible on technical, financial and programmatic levels. The CTP operates on a three-year cycle, but has its technology plan revised on an annual basis. CTP proposals are issued continuously throughout the year on ESA's EMITS web portal (for further details on this see the section below on information sharing) and are available to all European firms on a 100 per cent funding basis.[491] As CTP research is contracted out to industry, the programme strengthens the European space sector's capacity for innovation and precision engineering. ESA's track record of science missions also provides evidence of the CTP's success: to date, only one of more than 20 ESA science missions has had to be cancelled.[492]

The **IAP** focuses on developing operational services and products catered to the needs of a wide array of users by adapting and using space technology assets and products. The IAP is managed by the Telecommunications and Integrated Applications (TIA) directorate of ESA and is part of the TIA's broader Advanced Research in Telecommunications Systems (ARTES) programme.[493] The overarching goal of the ARTES programme is to develop space-based applications, services and solutions for the needs of European citizens and society at large.[494] In line with this, the main objective of the IAP is to achieve positive socio-economic impact through the development of commercially sustainable products, based on pre-existing space and terrestrial/in situ systems.[495] The programme focuses on the development of technologies and systems for which needs and requirements have been identified in close partnership with future users and customers.[496] The IAP touches on a wide range of issue areas, including health, safety, development, energy and transport.[497]

Projects under the IAP are contracted through two mechanisms: direct negotiations between ESA and potential implementers, and a permanent call for proposals under which requirements for different thematic areas are advertised on a quarterly basis. Projects under the IAP are funded by ESA at different levels of co-funding, with a view to future users and clients of the product or technology to be developed providing at least 50 per cent of the funding required during the advanced phases of a project's implementation. To facilitate stakeholder buy-in and sponsorship, requirements and needs presented under thematic calls are first identified by ESA through a survey of needs and requirements of potential project stakeholders, including public entities and operational agencies such as European Civil Aviation authorities, Eurocontrol, the European Defence Agency and Frontex.[498] In particular, stakeholders are invited to provide through standardised templates an overview of their operational capacity in their domain of interest, highlighting current operational limitations and desired improvements to be achieved over the course of a 2-year timeframe.[499] Where addressing needs and requirements through the adapting of existing space technologies could lead to the development of a commercially sustainable product or service, those needs and requirements are presented by ESA under thematic calls. As such, activities performed under this phase of the IAP also contribute significantly to ESA's role as an **honest broker**, as IAP activities facilitate cooperation and interaction among a range of operational agencies and industry stakeholders.

Projects funded under the IAP go through two to three phases of implementation. First, a *Kick-start* phase may be advertised through a competitive call. Under the Kick-start phase, up to approximately €65k can be provided to industry implementers to perform a rapid scan, over a period of 3 to 4 months, of opportunities for adapting space technologies to other purposes in a given market segment.[500] ESA funds kick-start activities at a 100 per cent rate.[501]

Following the Kick-start phase, or as a first step for issue areas where needs or opportunities have been identified by ESA or in cooperation with other stakeholders, a *Feasibility Study* is undertaken. Feasibility studies last on average up to 9 months and have a value of up to €150k. ESA provides 100 per cent funding for feasibility studies that it initiated autonomously, and between 50 and 70 per cent for those stemming from direct negotiations with potential implementers. The goal of feasibility studies is to explore the technical and economic feasibility of developing a product or service on the basis of existing space technologies, as well as of identifying risks and opportunities associated with such endeavours.[502]

Feasibility studies that are deemed successful in terms of their results and findings are then continued under the *Demonstration phase*. Demonstration-phase projects vary significantly in their duration and scope according to their underlying complexity. Projects usually last between 1 and 2 years and receive funding between €700k and €2m. For projects at this phase, the ESA may provide up to 50 per cent of the funding required. The goal of Demonstration-phase projects is to develop a technology or system up to the pre-operational stage. Following this, it is anticipated that if a commercially sustainable product has been developed, industry and users associated with the project will be able to continue the development of the technology or service with support from internal and external funds.[503]

491 ESA (2017e).
492 ESA (2017e).
493 ESA (2017f).
494 ESA (2017f).
495 RAND Europe interview with anonymous, 26 October 2017; UK Space Agency (2017).
496 RAND Europe interview with anonymous, 26 October 2017.
497 UK Space Agency (2017).
498 RAND Europe interview with anonymous, 26 October 2017; ESA (2017f).
499 RAND Europe interview with anonymous, 26 October 2017.
500 RAND Europe interview with anonymous, 26 October 2017.
501 RAND Europe interview with anonymous, 26 October 2017.
502 RAND Europe interview with anonymous, 26 October 2017.
503 RAND Europe interview with anonymous, 26 October 2017.

Information sharing

Stakeholders interested in working with ESA can find relevant information through **a centralised repository of information on funding opportunities (role 3.1).** The ESA EMITS web portal[504] has been operational since the 1980s with the objective of guaranteeing the principle of fair competition and access to ESA's procurement from all interested parties.[505] The EMITS portal provides industry, research institutions, universities and ESA pMS delegations with the following services:

1. **List of current Intended Invitations to Tender (IITT):** Listed IITTs consist of a summary of the work to be carried out, an estimated price range, the planned publication date and the initiating services within ESA. This list is updated at least once a month.
2. **List of current Invitations to Tender (ITT):** Each listed ITT contains a summary of the project and its associated technical, administrative and contractual requirements.
3. **ESA standard administrative and technical reference documentation and relevant information for industry:** Documents presented in this section provide private sector actors with guidance on how to develop their tenders in compliance with ITTs and ESA's requirements.
4. **Industry Web Portal:** This service provides industry with a wide range of information on how to do business with ESA through forums, news, a directory of companies working with ESA, and publications.

Hosting innovation

ESA hosts innovation by **running a network of Business Incubation Centres (BICs) (role 5.3)** across Europe. The BICs initiative was launched with the aim of stimulating and working with entrepreneurs and young (i.e. less than 5 years old) start-ups that have ideas for adapting and transferring a space technology or system to a non-space commercial environment.[506] Figure 4.1 provides a visual overview of the centres' location across the continent.

Figure 4.1 **ESA Business Incubation Centres Network**

SOURCE: European Space Agency (2017g).

ESA BICs run open calls for proposals which allow potential beneficiaries to submit project ideas at any time. While procedures and requirements for joining BICs are specific to each centre, bidding procedures broadly entail a five-step process, comprising the following:[507]

1. Engagement with the relevant BIC Support Manager;
2. Submission of required Business and Activity Proposal (BAP) documentation;
3. Review of submitted BAP documentation by the Tender Evaluation Board (TEB);
4. Oral presentation by bidder and Q&A with TEB; and
5. Invitation to contract negotiation.

At the BICs, entrepreneurs and start-ups receive a wide range of incentives and support, including:

1. **Cash incentives and funding:** These may include cash incentive schemes for product and service design, prototyping, market studies and IP protection, as well as access to a range of funding sources, including ESA's Open Sky Technologies Fund. In light of the provision of direct cash incentives and funding, this stream of BICs' activities also pertains to ESA's portfolio of work under the funding FC discussed above.[508]
2. **Access to technical expertise and facilities:** This may include access to laboratory space, rooms, workshops, 'hot labs', high specification science equipment, test facilities, and

504 ESA emits. 2017.
505 ESA EMITS (2017).
506 ESA (2017g).
507 See for example ESA BIC Harwell (2017).
508 ESA BIC (2017).

hands-on business-development support and advice.[509]

3. **Business support:** This may include access to investor readiness workshops, as well as more access to targeted support in areas such as (i) research and development; (ii) business planning; (iii) legal and finance; (iv) market research and strategy; (v) team building and human resources; and (vi) investor readiness.[510]
4. **Networking and community:** This includes access to a wide array of networking events targeting BICs' 'incubatees', alumni, investors and other stakeholders.[511]

According to ESA, the BICs initiative supports more than 140 start-ups each year, and since its inception it has already resulted in the establishment of more than 500 start-ups and the creation of thousands of jobs.[512]

Thought leadership

To support its efforts in the area of thought leadership, ESA **conducts research in house (role 2.1)** through its General Studies Programme (GSP). The GSP interfaces with all of ESA's programmes and functions as a 'think tank' that lays the groundwork for the agency's future activities. The GSP is designed to help formulate the overall ESA strategy, to study the feasibility of new mission concepts ready for selection, to prepare the case for new optional programmes, and to analyse trends and test new working methodologies. Covering a broad range of topics, studies tend to last 1 to 2 years, and 30 to 50 new studies are typically initiated during each cycle of 1 to 2 years. The GSP encourages interdisciplinary work, for example through the biannual internal *Call for Study Ideas* and through its requirement for GSP proposals to involve representatives from at least three different ESA directorates.[513]

One of the GSP's objectives is to obtain a balanced level of participation between industry and experts in all pMS, with GSP activities drawing on the inputs of industry through workshops, visits and hearings, and thus contributing to overall **honest broker** activities performed by the agency. The majority of GSP studies are undertaken by companies of all sizes and by academia under the technical guidance of ESA staff.[514] Set up and supported by the GSP, ESA's Advanced Concept Team operates a specific tool named Ariadna to facilitate access to the GSP for the academic world. This is achieved by performing collaborative research projects between the Advanced Concepts Team and selected academic partners.[515]

Training and education

One the activities conducted by ESA pertains to the **provision of education and training for astronauts through the European Astronaut Centre (role 3.4).** The EAC was established in 1990, houses a team of more than 100 professionals and is located in Cologne, Germany. The centre is also supported in its activities by specialists from the German Aerospace Centre (DLR), the French space agency (Centre national d'études spatiales – CNES), and industry. The EAC is tasked with selecting and recruiting new ESA astronauts, planning and scheduling their tasks and assignments, and preparing and implementing astronaut training programmes for space missions to the International Space Station.[516]

Training provided by EAC is structured around the following components:

1. **Basic training:** An initial 16-month course, which comprises of four phases: (i) an *Introduction* phase, providing orientation about major spacefaring nations, space agencies, major manned and unmanned space programmes, and space law and intergovernmental agreements governing the worldwide cooperation in space; (ii) a *Fundamentals* phase, which provides basic knowledge on various technical and scientific disciplines; (iii) a *Space Systems and Operations* phase, which provides a detailed overview of all ground systems and Space Station on-board systems; and (iv) a *Special skills* phase, which focuses on skills such as generic robotic operations, rendezvous and docking, Russian language, human behaviour and performance.[517]
2. **Advanced training:** This 16-month training provides astronauts with an initial knowledge of the International Space Station's elements and how to conduct experiments on board.[518]
3. **Increment-specific training:** This 18-month training phase is launched once astronauts are assigned to a space mission. In this phase, all crewmembers prepare for their mission training together.[519]

Honest broker

An important role performed by ESA through the programmes discussed in previous sections is that of honest broker, **facilitating coordination, cooperation and the development of links between pMS, industry, academia and ESA itself (role 4.2).** For example, as evidenced in previous paragraphs, networking and coordination activities are embedded in a variety of programmes, including the IAP and the BICs. These are also embedded in the European Component Initiative, to be discussed in the following section.

Requirements identification and setting

A number of programmes and activities undertaken by ESA entail the **identification of innovation opportunities (role 1.1)** and the **analysis of operational needs and requirements of potential clients, customers, and stakeholders of its programmes (role 1.2).** Among those discussed in previous sections, the IAP entails a phase of engagement with potential beneficiaries and partners of the work to be commissioned before calls for proposals are issued. This activity provides ESA with an overview of emerging needs and requirements and envisioned solutions that the programme could help tackling over the course of a 3-to-4-year window to achieve

509 ESA BIC (2017).
510 ESA BIC (2017).
511 ESA BIC (2017).
512 ESA BIC (2017).
513 ESA (2017h; 2017i).
514 ESA (2017i).
515 ESA (2017n).
516 ESA (2017b).
517 ESA (2017j),
518 ESA (2017k).
519 ESA (2017l).

its goal of having a tangible, positive socio-economic impact.[520]

In addition, ESA launched the **European Component Initiative (ECI)** in 2004. The ECI seeks to develop a European industrial base for delivery of critical technologies needed for space missions with a view to diminishing Europe's dependence on non-European component suppliers. The ECI pursues this objective by identifying critical space technologies and developing capabilities to manufacture them in Europe. The initiative is an open cooperative project with ESA and partner national space agencies, with each drawing on their own funding to participate. Beginning in 2005, the ECI initially involved consolidating end user requirements for industry and implementing activities to advance components' technology levels up to space-qualified status. This activity was performed through the European Space Component Coordination (ESCC), a body representing stakeholders from component manufacturers to prime contractors. The second phase of the ECI commenced in 2008. At the beginning of 2011, approval was given for a third phase, which focuses on providing longer-term access to strategic components and technologies. Members of the European space components industry and equipment manufacturers can participate in ESCC working groups or contact ECI project officers to propose future technologies and indicate emerging needs and requirements that ECI activities could focus on in the near future. The ECI initiative reportedly contributed to turning Europe from a net importer of components into a net exporter over the course of a decade.[521]

4.1.5. Results

ESA is the coordinating entity for European civilian space activities. It is responsible for the design and delivery of the European space programme with the goal of defining and implementing a long-term European space policy that allows Europe to remain competitive in the field of space technology. Table 4.1 provides an overview of the main benefits and associated costs that characterise ESA's approach and programmes discussed above.

Table 4.1 **Overview of ESA benefits and associated costs**

Benefits	Costs
■ Actively engaging with the users of space technologies provides ESA with a feedback loop to ensure its programmes and efforts are directed towards existing needs and requirements of the stakeholder community.	■ Running of the ECI, coordinating inputs and views from all of ESA pMS to identify innovation opportunities and consolidate overview of emerging needs and requirements. ■ Running of coordination and engagement activities as part of a wide array of the ESA's programmes and initiatives – these activities may include networking events, outreach efforts and appointment of programme ambassadors to increase awareness about ESA's efforts.
■ Positive socio-economic impact is achieved by hosting innovation through incubation networks and application programmes. These activities provide ESA with the capacity to foster economic growth, facilitating the development of technology start-ups and companies across Europe.	■ Running of the BICs, maintaining a European-wide network of expert centres and facilities providing business support, financial incentives, and a community to engage with to entrepreneurs and young start-ups active in the field of space technology. ■ Running of IAP programme to identify opportunities for converting space technologies into commercially sustainable services and products.
■ Performing in-house research to be a thought leader in the space domain provides ESA with an opportunity to lay the groundwork for its future activities, and influence developments in the space domain and industrial space policy at pMS level.	■ Conducting in-house research through the GSP, an in-house think tank focusing on a broad range of interdisciplinary work.

4.2. European Institute of Innovation & Technology

4.2.1. Summary

The European Institute of Innovation & Technology was created in 2008. It is part of H2020 and the Innovation Union, which looks to increase European competitiveness globally,[522] but is an independent body with its own organisational and funding model. The EIT was founded as a way of promoting innovation across Europe by increasing collaboration between academic institutions, businesses and researchers through a Knowledge and Innovation Community (KIC).[523] KICs are centres of excellence around specific topics of importance to Europe and are comprised of groupings of businesses and academic and research institutions which can access direct EIT funding through calls for proposals. While the EIT provides strategic direction and sets thematic priorities, the KICs build networks, create educational programmes at the Master's and PhD levels, provide training, and host innovation through co-location centres.[524]

4.2.2. Vision

Mission

The EIT's mission is twofold:

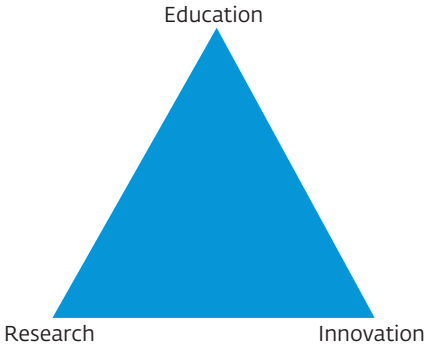
1. Expand Europe's competitiveness in the global economy and support employment opportunities and sustainable economic growth through the development of networks between innovators, researchers, universities, businesses and other stakeholders; and
2. Create an environment and mindset within Europe that fosters creativity, innovation, entrepreneurship and the space to develop and thrive.[525]

Objectives

European Commission research has shown that Europe 'lacks an innovation culture',[526] and linkages are not always present to help develop ideas into products or services. The EIT was set up with the goal of creating these linkages by increasing innovation, enhancing entrepreneurship and supporting talent throughout Europe. To do so, the

520 RAND Europe interview with anonymous, 26 October 2017.
521 ESA (2017m).
522 EIT (n.d.-b).
523 EIT (n.d.-b).
524 EIT (n.d.-a).
525 EIT (n.d.-b).
526 European Court of Auditors (2016).

Figure 4.2 **The EIT knowledge triangle**



Source: Adapted from Technopolis (2012).

EIT uses the 'knowledge triangle' (see Figure 4.2), a framework to increase collaboration between education, research and innovation stakeholders. Through its KICs, the EIT aims to connect different communities, set up new companies and promote economic growth, and educate a new generation of entrepreneurs. The EIT sets the overarching strategies of the KICs, as well as the activities that contribute to the knowledge triangle through individual Framework Partnership Agreements and Specific Grant Agreements.[527]

4.2.3. Governance

Organisational governance

The EIT has a Governing Board providing 'strategic leadership and overall direction of the operational activities implemented by the EIT Headquarters'.[528] The Governing Board is made up of 15 people, with 12 appointed as members and 2 as representative members. The Governing Board decides, independently and autonomously, on the KICs to be put forward in the call for proposals, and it is responsible for their selection, evaluation and subsequent support.[529] There is also an Executive Committee comprised of the EIT Governing Board Chairperson and three appointed Governing Board members. Its role is to support the activities of the Governing Board and the implementation of strategic decisions.[530]

In terms of the KICs, these are set up as their own legal entity, each with their respective chief executive, and they possess the autonomy to 'define their legal status, internal organisation and working methods',[531] as well as their business plan. This model provides the KICs with the flexibility to respond rapidly to new challenges and changing environments. The KICs are given seven years' funding to deliver their goals, with annual milestones along the way, and as explained in Section 4.2.4, they are expected to source funding from various private and public sources. Each KIC has various locations across Europe,[532] including a head office, its own management system and a network of partners.

Leadership

The appointed members of the Governing Board serve a mandate of 4 to 6 years, and are identified through a call for expressions of interest. The representative members, who provide the perspective of the KICs within the Governing Board, are chosen from a list of candidates from the higher education, research and innovation partner institutions of the KICs.[533]

Organisational funding

Both the Strategic Innovation Agenda (SIA)[534] and the EIT's Regulation define the framework for the EIT's operation between 2014 and 2020. Ahead of the start of a new European funding period, the EIT submits a draft SIA to the European Commission, where the strategic direction is determined.[535] As a part of H2020, the EIT has received over €2.4bn for the 2014 to 2020 period. This money goes towards the development of KICs and grant funding.[536]

The EIT's funding model involves funding newly created KICs. According to the model, 'the EIT's financial contribution does not exceed 25 per cent (on average) of an Innovation Community's overall resources over the Innovation Community's lifetime'.[537] KICs should become financially independent, seeking funding from private sources, national or regional funding, or other EU funding, such as through the H2020 programme or the European Structural and Investment Funds.[538]

4.2.4. Activities

The EIT's activities mainly revolve around funding, hosting innovation, providing training and education, and being an honest broker. However, many of the activities tend to overlap with each other. The following paragraphs discuss these four activities in greater detail, highlighting how they relate to the functional roles presented in Appendix D of this report.

Funding

The main activity and purpose of the EIT is to provide direct R&I funding for the creation of KICs (O.6.1). KICs are described by the EIT as 'dynamic, cross-border partnerships'.[539] Through the KICs, the EIT provides direct research funding to a variety of research organisations, higher education institutions and businesses, in consortia, who bid for different KICs. The EIT organises bi-yearly calls for proposals on pre-selected topics. As mentioned in Section 4.2.3, the strategic direction and topics for the KICs are chosen by the EIT Governing Board.[540] Each specific prospective KIC 'set[s] their objectives, develop[s] a business model, and devise[s] a structure to deliver the results'.[541] The role of the KICs is to 'help with developing innovative services and products, setting up new companies, and training a new generation of entrepreneurs'.[542]

The award criteria are set by the Governing Board and encompass certain admissibility, eligibility, exclusion, selection, and financial and operational

527 EIT (n.d.-a).
528 EIT (n.d.-c).
529 EIT (n.d.-c).
530 EIT (n.d.-c).
531 EIT (n.d.-a)
532 See EIT (n.d.-m).
533 EIT (n.d.-c).
534 Official Journal of the European Union (2013).
535 EIT (n.d.-e).
536 EIT (n.d.-d).
537 EIT (n.d.-k).
538 EIT (n.d.-k).
539 European Commission (n.d.-p).
540 The analysis of future KIC themes is carried out through the submission of a draft Strategic Innovation Agenda by the EIT and consultation with the wider innovation community (i.e. academic institutions, research centres and businesses). Further detail on the selection of KIC themes is available on pp.902–903 of the 2013 *Strategic Innovation Agenda*. Source: Official Journal of the European Union (2013).
541 EIT (n.d.-f).
542 European Commission (n.d.-p).

capacity criteria.[543] Proposals are also scored on technical evaluation criteria, which include:

- Strategy: Strategic approach, KIC partnership innovation potential, synergies;
- Operations: KIC leadership team and operational structure, KIC business model and financial plan; and
- Impact: Impact and KIC scorecard, dissemination of results and communication.[544]

Box 4.1 **Example of a recently awarded KIC: EIT Food**

The EIT was looking to set up a KIC on the topic of 'Sustainable Supply Chain from Resources to Consumers', and EIT Food was advertised in the 2016 Call for Proposals. The winning consortium is composed of 50 partners across 13 countries. The aim of EIT Food is to 'engage consumers in the change process, improve nutrition and make the food system more resource-efficient, secure, transparent, and trusted.'[545] The EIT awarded the consortium a start-up grant of 'up to €4m to ensure that it is fully operational as soon as possible.'[546] This KIC could also receive around €400m in funding from the EIT over the next years, as well as funding from the private and public sectors. Specifically, it aims to support the establishment of 350 start-ups and train over 10 000 Master's and PhD graduates in the next seven years; 'develop 290 new or improved products, services, and processes by 2024; and decrease greenhouse-gas emissions in the European food system by 40 per cent by 2030.'[547]

Proposals that reach or exceed the threshold of 70 per cent of points allocated by the Panel of Experts[548] will proceed to the next evaluation stage, which involves hearings with the EIT Governing Board. The Governing Board evaluates proposals against the three criteria (strategy, operations, impact) above. These points are added to the points allocated by the Panel of Experts, and the proposal with the highest number of points is chosen for funding.[549]

To date, six KICs have been set up on the topics of food, climate, digital, health, raw materials and sustainable energy. A further two KICs are being tendered out on the topics of urban mobility and added value manufacturing. KICs are granted funds from the EIT on a yearly basis. In 2018, the amount available for KICs to apply for will be between €1.5m and €4m.[550]

Hosting innovation

The EIT has a number of different activities aimed at hosting innovation, such as hosting prize competitions (**role** 5.2) and hosting 'co-location centres' – or innovation incubators – within the KICs (**role** 5.3). These include the KICs, the EIT Awards[551] and the EIT Regional Innovation Scheme (see section below on training and education). Through these activities, the EIT fosters innovation and seeks to promote an entrepreneurial mindset. The EIT Awards are annual awards recognising entrepreneurship, promoting innovation and celebrating European success. These are awarded to start-ups, innovative projects and young entrepreneurial talent across Europe with prize money ranging from €15 000 to €50 000.[552]

KICs themselves host innovation in the development of new services, processes and products, helped by the interchange of ideas through the knowledge triangle.[553] This process is also helped by the existence of 'co-location centres', an EIT invention which take the form of regional innovation hubs used to aggregate each individual KIC's activities and knowledge flow.[554] Each KIC has several hubs – having a physical location is important in order to facilitate interactions among members of each KIC, and the functioning of the knowledge triangle (see Figure 4.2). The co-location centres are usually part of existing buildings or offices of KICs' core partners.[555] KICs also make use of their co-location centres as a base for implementing EIT RIS activities (described in the section below on training and education) and act as platforms for 'interaction and brokerage, as well as a channel for the sharing of knowledge and good practices related to KTI [Knowledge Triangle Integration] acquired by the KICs'[556] for the EIT RIS.

Training and education

The EIT and its KICs facilitate knowledge transfer (**role** 3.3) and deliver training (**role** 3.4) by providing education programmes at Master's and PhD level, in order to promote a mindset of innovation and entrepreneurship. The EIT also looks to share knowledge on innovation and entrepreneurship to countries or regions that do not have this basis.

KIC education programmes

Through the KICs, the EIT has developed educational programmes with a heavy emphasis on entrepreneurship skills and innovation knowledge, which are tailored to the European innovation system. These are Master's and PhD programmes, offered by the higher education institutions of each respective KIC. These graduate programmes are delivered in conjunction with various businesses and research centres part of the KIC, and these degrees offer 'international and cross-sectorial mobility experiences, as well as applied innovation and entrepreneurship education'.[557] The EIT-labelled degrees are monitored by the EIT in terms of their 'quality and consistent implementation across KICs'.[558]

543 See EIT (2017a).
544 EIT (n.d.-g).
545 EIT Food (n.d.).
546 EIT (2016).
547 EIT Food (n.d.).
548 The 2016 Panel of Experts involved 6 evaluators, of which 4 were thematic subject matter experts and 2 were 'horizontal' experts. These are high-level, independent external experts, covering the Knowledge Triangle. Source: EIT (n.d.-g).
549 EIT (2017b).
550 EIT (2017a).
551 EIT (n.d.-l).
552 EIT CHANGE Award for EIT Masters or PhD programme graduates; EIT Innovators Award for innovation teams within KICs; and EIT Venture Award for 'successful entrepreneurial start-ups.' Source: EIT (n.d.-l).
553 EIT (n.d.-f).
554 EIT (n.d.-f).
555 EIT (n.d.-f).
556 EIT (2017a).
557 EIT (n.d.-h).
558 Official Journal of the European Union (2013).

EIT Regional Innovation Scheme

The EIT RIS is included in all KICs' activities. Each KIC designs its own EIT RIS, including objectives and activities. In this way, organisations and individuals in RIS countries (see Table 4.2 below) can work in partnership with KICs and access specific services and expertise.[559] Specifically, the EIT RIS aims to encourage countries that have no participating organisations in the existing KICs and are 'moderate and modest innovators'.[560] Through the EIT RIS, the EIT looks to share information and good practices on innovation and entrepreneurship opportunities in Europe, increasing overall cooperation and 'know-how' in the field of innovation and entrepreneurship. The creation of the EIT RIS is a way of enhancing local innovation eco-systems in areas that do not have a high reported level of innovation or entrepreneurship. This endeavour is set to help widen participation in KIC activities, and in the long term, strengthen ties and networks between businesses, researchers and other stakeholders across Europe.

Table 4.2 **Countries eligible for the EIT RIS**[561]

EU Member States	H2020 Association European Countries
Bulgaria	Albania
Croatia	Armenia
Cyprus	Bosnia and Herzegovina
Czech Republic	Faroe Islands
Estonia	Former Yugoslav Republic of Macedonia
Greece	Georgia
Hungary	Moldova
Italy	Montenegro
Lithuania	Serbia
Malta	Turkey
Poland	Ukraine
Portugal	
Slovakia	
Slovenia	
Spain	
Romania	

Honest broker

The EIT plays the role of an honest broker by bringing together academics, students, innovators, businesses, entrepreneurs and researchers through its KICs. It also serves to facilitate coordination and cooperation between KICs and organisations and individuals in countries less used to innovation through the EIT RIS. Overall, the EIT forms and supports an innovative and entrepreneurial community through the EIT Alumni community for all KIC students and alumni, effectively creating a pool of people the EIT can draw upon, and reinforcing innovation across Europe.[564]

559 EIT (n.d.-j).
560 According to the European Innovation Scorecard. See European Commission (2017g).
561 EIT (n.d.-j).

Table 4.3 **Overview of EIT benefits and associated costs**

Benefits	Costs
■ The EIT and its KICs are helping to overcome the 'fragmented European innovation landscape' by bringing together the various stakeholder communities.[562] This helps improve the chances of operationalisation of research results.	■ Evaluations have noted accountability issues raised by the European Commission due to the EIT's comparatively complex operational framework, which runs differently to that of the European Commission and H2020. This results from the EIT's difference in governance style due to its novel model, which aims to promote flexibility.[565]
■ KICs provide excellent research and innovation hubs. The 2008 evaluation found that the process for selecting the winning KIC has been shown to be effective and has delivered consortia of strong reputation and excellence.[563]	■ Due to its relatively autonomous status, the EIT receives little oversight from external bodies such as the European Commission and the European Council on how the EIT governing team prioritises the institution's strategic direction. This has brought up issues around the transparency of the EIT's decision making.[566]
■ The co-location centres, a concept invented by the EIT, have been very successful, as they offer a physical innovation hub, facilitating exchanges between different types of stakeholders and enabling the creation of networks, which is the ultimate goal of the EIT's KICs.	■ KICs' lack of transparency relating to their governance undermines public trust in how funding is allocated to each KIC. For example, there have been cases where a consortium member has also been part of the committee scoring proposals and selecting the projects.[567]
	■ There is little robust reporting, monitoring and evaluation of the KICs' performance, and no overview of their impact. The lack of substantive monitoring structures and defined KPIs means that it is hard to make an overall assessment of the value of the EIT and its KICs.[568]

4.2.5. Results

Since the EIT has been set up, it has undergone several evaluations and audits. Overall, these have shown that the EIT has been filling a gap in the European R&I cycle, and that the KICs have brought a number of benefits. However, there have been areas where the EIT has been viewed less favourably, as shown in Table 4.3 above.

562 European Commission (n.d.-p).
563 Ecorys (2011).
564 EIT (n.d.-i).
565 Ecorys (2011); European Court of Auditors (2016).
566 Ecorys (2011).
567 European Court of Auditors (2016).
568 Ecorys (2011); European Court of Auditors (2016).

4.3. Defense Innovation Unit Experimental

4.3.1. Summary

US defence policy in the modern era has been characterised by a focus on the development of strategies to counter opponents' strengths through the use of alternative means, in order to tip the balance of military capability in favour of US forces. In the context of the US defence establishment, innovation, research and development have therefore relied on targeted 'offset strategies'. US defence offset strategies are policy approaches entailing a clearly articulated problem space, and a high degree of industrial collaboration and competition supported through federal funding. Most recently, the so-called *Third Offset Strategy* was launched with a view to delivering military capability over the next 5 to 15 years and using current and future technology through a series of focused programmes.[569]

In this context, the Quadrennial Defense Review conducted by the DoD

569 The first offset was a 'large scale expansion in the number of U.S. nuclear weapons and their roles in military operations', while the second offset relied on key technologies, such as stealth, information networks and 'a new strategy of deep attack'. Source: Goure (2016).

in 2014 identified innovation as a central line of effort in the US national defence strategy. The 2014 QDR emphasised in particular the steady erosion of asymmetric technological capabilities enabling the US to maintain a decisive military advantage over its adversaries and peer competitors.

In 2015, the US Secretary of Defense established the Defense Innovation Unit Experimental. This was done in recognition that the DoD was unable to outpace innovation and technological developments independently, and that commercial investments now propel the majority of groundbreaking technological developments.[570] DIUx is designed to provide funding, in the form of non-dilutive capital,[571] for both traditional and non-traditional defence contractors, to carry out prototype projects with a view to leveraging commercially based innovation for defence purposes. Projects funded by DIUx have direct relevance to enhancing the mission effectiveness of military personnel and the supporting platforms, systems, components, or materials proposed to be acquired or developed by the DoD.

4.3.2. Vision

Mission

Traditional DoD procurement practices are characterised by high barriers to entry and long timelines for contracting. Furthermore, the DoD has historically relied on a quasi-monopsonistic business approach[572] that further discourages participation in public procurement by a range of companies which rely on commercial customers to rapidly realise a large return on investment. The mission of DIUx is to accelerate the development, procurement and integration of commercially derived disruptive capabilities into the US DoD.[573]

570 DIUx (2016).
571 Non-dilutive financing does not require the sale of a company's shares, and hence does not cause dilution of existing shareholdings.
572 This refers to the fact that the DoD was often the single buyer controlling a large portion of the defence market.
573 DIUx (2016).

Objectives

To achieve its mission, DIUx aims to function as a bridge between the DoD and commercial actors at the cutting edge of technological developments, be they defence contractors, large civilian corporations or start-ups. Through its projects, DIUx focuses on applying small modifications to proven technologies, with a view to delivering capability within 1 to 5 years to tackle current military problems and shortfalls.[574] In particular, the programme revolves around five focus areas:[575]

1. **Artificial intelligence**, to leverage artificial intelligence and machine learning for operational impact;
2. **Autonomy**, to adopt and counter autonomous systems, with a focus on human-machine interaction and scalable teaming;
3. **Human systems**, to counter emerging biological threats while enhancing survivability, training, biomedical protection and performance;
4. **Information technology**, to make combat information open and accessible for operational forces;
5. **Space**, to develop on-demand access to space, persistent satellite capabilities and broadband space data transfer.

4.3.3. Governance

Organisational governance

In a bid to provide DIUx with an agile decision-making mechanism and access to the highest level of decision making within the DoD, since May 2016 DIUx has been structured as a standalone organisation reporting directly to the Secretary of Defense.[576] However, following orders from Congress, the DoD established a plan to be implemented by 1 February 2018 to split the existing Undersecretary of Defense for Acquisition, Technology and Logistics (AT&L) into two smaller organisations: the Undersecretary of Defense for Research and Engineering (USDR&E), and the Undersecretary of Defense for Acquisition and Sustainment (USDA&S).

574 DIUx (n.d.-a).
575 DIUx (n.d.-a).
576 Mehta (2016); DoD (2017).

As part of this plan, DIUx will be relocated within the USDR&E, moving the programme leadership and reporting to the USDR&E. The AT&L restructuring programme was still a proposal at the time of writing this report and further changes to DIUx's organisational governance and location may have occurred since.[577]

Leadership and membership

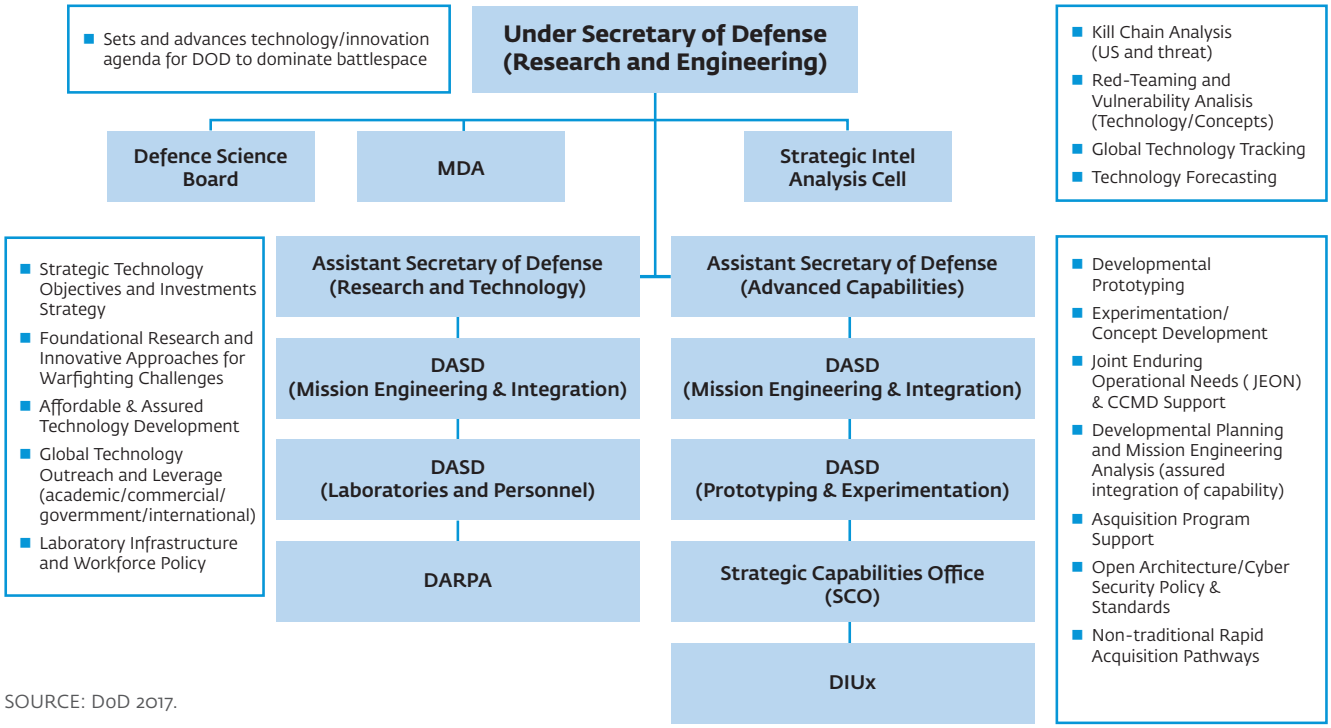
DIUx is led by a Managing Partner who oversees a four-person board. The arrangement of the DIUx leadership structure was inspired by those of the innovative start-ups that the programme aims to engage and work with.[578] DIUx maintains offices in Silicon Valley, Boston, Massachusetts, and Austin, Texas. It has a team of approximately 50 professionals including civilian and active duty personnel, as well as reserves and contractors.[579]

Organisational funding

DIUx's funding stems from the overall US DoD budget for Research, Development, Test, and Evaluation activities.[580] During its first year of activity, in the 2016 US fiscal year (1 October 2015 to 30 September 2016) DIUx awarded projects to contractors for a total of $36m. For the 2017 US fiscal year, budget appropriations for DIUx were lowered from an initial request of $30m to $10m.[581] DIUx's funding activities are discussed in greater detail in the section below, but it should be noted that for projects awarded through DIUx, it is expected that DoD customers bear most of costs using resources from the DoD RTD&E budget.[582]

577 DoD (2017).
578 Mehta (2016).
579 DIUx (N.D.-b; 2016).
580 Thomas (2017).
581 Thomas (2017); DoD (2017b, 261).
582 DIUx (2016).

Figure 4.3 **USDR&E proposed organogram and DIUx institutional location**



SOURCE: DoD 2017.

4.3.4. Activities

Funding

The core of DIUx's activities revolves around **providing non-traditional[583] US DoD vendors and contractors with funding (O6.1) and facilitating access to existing funding resources (O6.2)** to develop innovative technology solutions, or adapt existing ones, to tackle current challenges and military capability gaps.[584] DIUx can opt to provide co-financing from its own investment budget for projects, but normally expects DoD customers to bear most costs through the broader DoD RTD&E budget.[585]

DIUx provides non-dilutive funding. To do this, DIUx moved away from traditional funding mechanisms and developed an innovative acquisition mechanism called the Commercial Solutions Opening (CSO). The CSO brings together aspects of solicitation methods used in traditional US Broad Agency Announcements (BAAs) with those of a prototype instrument, the Other Transaction authority. OTs are legally binding instruments that can be used for a wide array of research and prototype projects. OTs can best be defined by describing what they are not. OTs are not standard procurement contracts, grants or cooperative agreements. As such, and as opposed to standard BAAs, OTs are usually not subject to US federal laws and regulations (e.g. Federal Acquisition Regulation) that apply to government procurement contracts, and thus offer more flexible contracting opportunities. The DIUx CSO relies on OTs for awarding prototype projects. These are defined by DIUx as follows:

> *A prototype project can generally be described as preliminary pilot, test, evaluation, demonstration, or agile development activity used to assess the viability, technical feasibility, application, or military utility of a technology, process, concept, end item, system, methodology, or other discrete feature. The quantity or tenure should be limited to that needed to effectively assess the prototype.*[586]

In practice, the DIUx operates through a multi-step investment model that broadly follows six stages, as illustrated in Figure 4.4 on the next page.

The first two stages of the DIUx project award process are described in greater detail below, under the FCs to which they most closely pertain. This section describes procedures in place for the request for initial proposals, the pitch, the request for full proposals and the awarding of contracts.

Request for initial proposals

Following completion of the Problem statement identification and market survey phases, DIUx issues a request for initial proposals. Solicitations are posted by DIUx as *Areas of Interest* (AOIs) on its website.[587] AOIs briefly describe problems to be solved or particular technologies that DIUx is interested in, rather than detailed specifications and requirements. DIUx maintains that keeping AOIs broad enables it to receive a broader spectrum of possible solutions from vendors. As such, AOIs may comprise just a few sentences or paragraphs, explaining in simple language, rather than specialist jargon, the

583 DIUx defines a non-traditional contractors as '(...) an entity that is not currently performing and has not performed, for at least the one-year period preceding the solicitation of sources by the DoD for the procurement or transaction, any contract or subcontract for the DoD that is subject to full coverage under the cost accounting standards (...)'. See DIUx (2016).

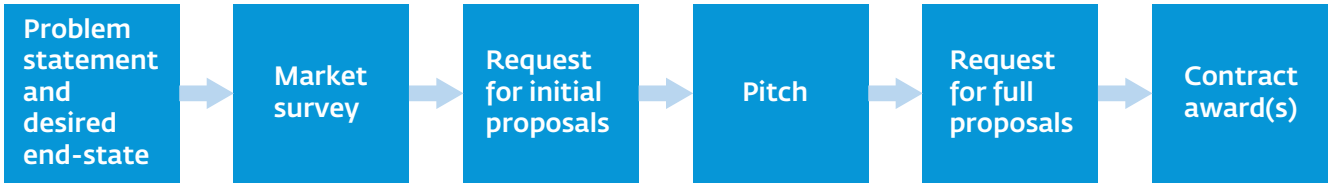
584 DIUx (2016).

585 DIUx(2016).

586 DIUx (2016).

587 DIUx (n.d.-d).

Figure 4.4 **DIUx project award process**



Source: RAND Europe elaboration on DIUx (2016).

problem or technology of interest. AOIs are posted on the DIUx website for a variable period of time, spanning from a week to several months.[588] Proposals presented under this phase should consist of no more than 5 pages or 15 slides, presenting only information about the company bidding and the technology of relevance. Proposals are submitted directly through the DIUx website, rather than the standard website for US federal business procurement.[589]

In this phase, DIUx evaluates a company's solution brief based on four factors:[590]

1. **Relevance:** Is the company's submission relevant to the posted AOI?
2. **Technical merit:** Can the company's proposed solution feasibly address the AOI?
3. **Business viability:** Is the company strong enough to effectively accomplish this work?
4. **Innovation:** Does the solution represent a unique, innovative or previously under-utilised solution?

The evaluation team is generally led by DIUx and comprises problem and technical experts from both DIUx and relevant DoD customers. Initial proposals are evaluated against the four factors listed above, but not against other bids. Since AOIs are broad and do not contain specific work that companies must propose to conduct, bids are evaluated independently. Under each AOI, DIUx may decide to award any number of contracts, or award no contracts.[591]

Based on the results of the evaluation, bidders will either receive a non-selection letter from the Agreements Officer providing a short summary of why the solution brief was not selected, or an invitation to continue to the next phase. In traditional US defense contracting, companies whose proposals are not selected may request and be entitled to a full debriefing explaining the rationale behind this decision. Since DIUx only requests minimal information from companies at the initial proposal stage, DIUx does not provide significant feedback beyond a rejection letter following this first evaluation. Under this phase, DIUx issues its feedback to bidders within 30 days of reception of initial proposals.[592]

Pitch

Following the request for initial proposals, successful bidders are invited to present a pitch for their proposals to DIUx, mirroring the mechanism employed in the world of venture capital. The pitch is delivered to the DIUx leadership, relevant DoD customers and the contracting office, either in person, via videoconference or by phone. During the pitch, bidders present their technologies and potential projects in greater detail. Within this engagement, DoD customer(s) and the DIUx discuss potential uses and project structures with bidding companies. During the pitch, companies are also required to indicate a rough order of magnitude (ROM) cost and schedule for their proposals. Following the pitch, the evaluation team re-evaluates the company on the criteria listed above, as well as against the following:[593]

1. **Cost**: Does the ROM cost meet the government's allocated budget?
2. **Schedule:** Does the ROM schedule meet the government's timeline?
3. **Data rights:** Are there any data rights issues to be cognisant of moving forward?

Request for full proposals

Successful pitches trigger the issuing of a *Request for Prototype Proposal*, inviting the company to submit a full proposal. Once this is issued, DIUx schedules a kick-off meeting with the company, the DoD customer(s) and the Agreements Officer. At the kick-off meeting, companies are introduced to contracting mechanisms to be employed (i.e. OTs), what should be in the proposal, and how the negotiation process works. Additionally, the DIUx will provide an initial model OT to companies, allowing them to become familiar with the base terms and conditions of the project agreement to be entered as they develop their proposal.[594]

An important function of the kick-off meeting is to introduce the concept of collaborative design. While traditional government solicitations require little to no contact between the vendor and the customer, the CSO enables a different approach. Rather than the government independently developing the project Statement of Work (SOW), the vendor develops the SOW in collaboration with DIUx and the DoD customer(s). This collaboration results in a prototype project and scope that is best designed to meet the needs of both parties. An important part of the collaborative design effort entails reaching an agreement on payment milestones and tranches of the project. Different contractors may require or prefer different schedules (e.g. a large project payment may be needed up-front to meet investor deadlines or to pay for heavy capital expenditures).[595]

Once the final SOW has been designed, the DIUx evaluation team does not review the full proposal for technical merit, but rather issues a recommendation that the company and proposal meet the statutory requirements for an OT award. The rationale behind this is

588 DIUx (2016).
589 DIUx (2016).
590 DIUx (2016).
591 DIUx (2016).
592 DIUx (2016).
593 DIUx (2016).
594 DIUx (2016).
595 DIUx (2016).

that the SOW is the result of a shared agreement between the service provider and its customers. The evaluation team does perform an analysis to ensure that the proposed price is acceptable to the government. In this phase, DIUx balances consideration around the need for the government to avoid overpaying for any service with the need to move at speed, work within industry (not government) norms, and balance price against other variables.[596]

Contract award

Once the final evaluation is complete, the terms and conditions of the project OT are negotiated with the company. DIUx aims to negotiate, award and sign a contract, and begin project work, within a maximum of 60 days.[597] Since DIUx does not control all of the required knowledge or funding to fully execute a project at once, DIUx projects are usually structured in tranches comprising discrete pieces of work. When a tranche of a project has been completed, DIUx may decide to continue or discontinue the project. This agile approach allows for quick exits with minimal losses in the case of non-performance, while still maintaining a flexible development approach that can accommodate modifications.[598] Furthermore, through its contract, DIUx maintains a flexible IP approach, as many of the technologies acquired through OTs are also commercial products sold to commercial customers (i.e. not only sold to defence).[599]

Honest broker

The work performed by DIUx under the Funding FC also has relevance for DIUx's role under the **honest broker** functional roles. In particular, the collaborative SOW process presented above facilitates **coordination and cooperation between DoD customers and industry (role 4.2), especially non-traditional defence contractors.**

Further to this, DIUx contributes to the delivery of role 4.2 responsibilities during the *Market survey* phase of the investment process presented in Figure 4.4 on the next page. Prior to posting an AOI, DIUx leverages its networks of contractors and implementers to understand the potential scope of the existing commercial market to answer to the AOI posted and the vendors who may respond to it. During this phase, DIUx also works with its network to reach out to communities and encourage non-traditional vendors to respond to its solicitation.[601]

Table 4.4 **Overview of DIUx benefits and associated costs**

Benefits	Costs
■ As of September 2017, DIUx has awarded approximately $184 million for 59 pilot contracts and 2 follow-on production contracts in the areas of autonomy, artificial intelligence, human systems, information technology and space. Furthermore, as October 2017, DIUx handed off two pilot projects with commercial firms. This includes a $750m, five-year contract with the US Army.[600] ■ These results suggest that since its establishment DIUx has successfully linked the DoD with private, non-traditional DoD contractors at the forefront of technological developments, facilitating access by DoD components to innovative commercial solutions for military challenges and addressing capability gaps.	■ Adoption of the ad hoc CSO procedure and OT contracting mechanism to stimulate engagement by target communities. ■ Integrated teams bringing together stakeholders and dedicated project managers from DIUx, DoD customers and DoD contracting authorities are required to oversee and manage all phases of a proposal and project to completion. ■ Employment of a collaborative design approach enabling DIUx, DoD customers and commercial suppliers to jointly define and develop prototype project SOWs. ■ Employment of ad hoc payment schedules for projects providing, where necessary, resources upfront to cover capital-intensive acquisitions. ■ Flexible IP arrangements that leave IP ownership to implementers and move the DoD away from its traditional monopsonistic business model.
■ DIUx has the ability to access over a short timeframe technology innovators and developers to mitigate an existing operational need or capability gap.	■ Compressed decision-making procedures with limited time for internal feedback loops and oversight for decision-making procedures – this is offset by the adoption of a contract award system which embeds flexibility and a tranche-based project design, providing DIUx and DoD customers with flexibility to reverse or adjust decisions taken upon the initiation of a project.

Requirements identification and setting

Finally, DIUx facilitates the **analysis of operational needs (role 1.2)** during the *Problem statement and desired end-state* phase of the investment process presented in Figure 4.4. During this phase, an armed service branch of the DoD may approach DIUx with a problem or identified improvement opportunity. This is then elaborated in a requirement specification articulating a concise problem statement and the desired end state. To be considered for a DIUx project, the requesting DoD customer is required to make two commitments:

1. Adequate funding for the project duration
2. A client project manager to oversee the delivery of the project and work alongside the DIUx and contractor project managers – this should preferably be a person experienced in working with fast-paced commercial contractors who operate in the technology development and innovation field.

While DIUx project managers will be responsible during project delivery for the administrative aspects of the project, the DoD customer project managers are expected to manage the technical aspects of the prototype project.

4.3.5. Results

DIUx is an organisation within the US DoD that functions as a bridge between DoD components and commercial actors at the cutting edge of technological developments. Through its projects, DIUx aims to deliver military capabilities within 1 to 5 years, leveraging new or existing technologies that may be adapted for DoD requirements and purposes. Figure 4.4 provides an overview of the main benefits and associated costs that characterise the DIUx approach and programme discussed above.

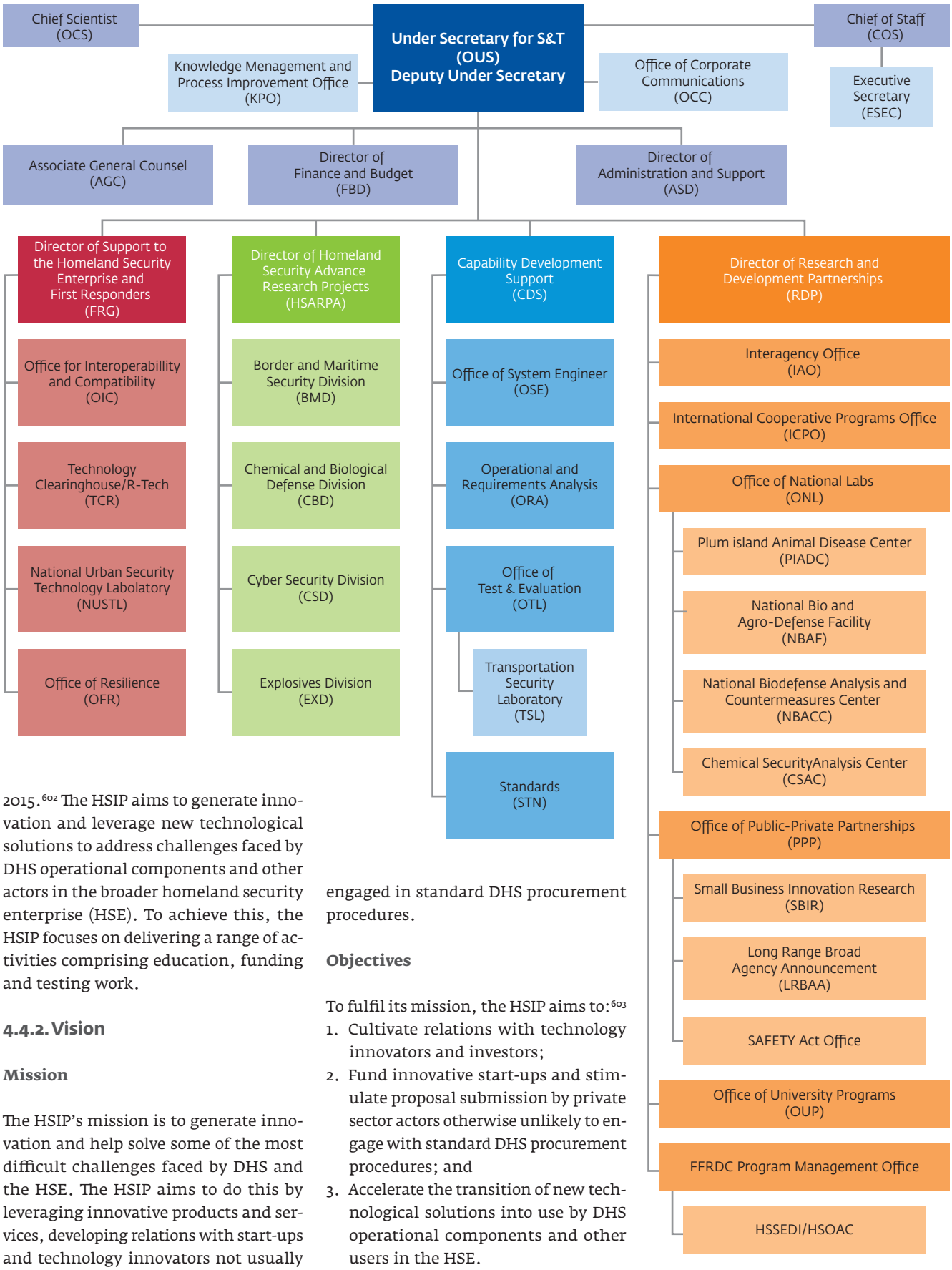
4.4. Homeland Security Innovation Programs

4.4.1. Summary

The Homeland Security Innovation Programs is a programme which is run by the DHS S&T and was launched in

596 DIUx (2016).
597 DIUx (2016).
598 DIUx (2016).
599 DIUx (2016).
600 Mehta (2017); DIUx (n.d.-c).
601 DIUx. 2016.

Figure 4.5 **S&T organogram as of October 2017**



SOURCE: DHS (2017); DHS (n.d.-g).

2015.[602] The HSIP aims to generate innovation and leverage new technological solutions to address challenges faced by DHS operational components and other actors in the broader homeland security enterprise (HSE). To achieve this, the HSIP focuses on delivering a range of activities comprising education, funding and testing work.

4.4.2. Vision

Mission

The HSIP's mission is to generate innovation and help solve some of the most difficult challenges faced by DHS and the HSE. The HSIP aims to do this by leveraging innovative products and services, developing relations with start-ups and technology innovators not usually engaged in standard DHS procurement procedures.

Objectives

To fulfil its mission, the HSIP aims to:[603]

1. Cultivate relations with technology innovators and investors;
2. Fund innovative start-ups and stimulate proposal submission by private sector actors otherwise unlikely to engage with standard DHS procurement procedures; and
3. Accelerate the transition of new technological solutions into use by DHS operational components and other users in the HSE.

602 DHS (n.d.-f).

603 DHS (n.d.-f).

4.4.3. Governance

Organisational governance

The HSIP is run by the S&T under its Office of Public and Private Partnerships (PPP). The PPP is located within the Research and Development Partnerships Group (RDP), which is tasked with providing DHS and the wider HSE with access to science-based capabilities and solutions. To do so, the RDP sponsors research, development and innovation activities such as those of the SBIR. In its work, the RDP engages with a wide range of stakeholder communities, comprising private sector actors, academia, national laboratories, other governmental departments and agencies, and international partners. Figure 4.5 provides an overview of the DHS S&T organogram, highlighting the location of the SBIR within it.[604]

Leadership and membership

The programme has a small labour footprint and is run primarily through a team of five individuals. The team comprises a Program Manager, two contractors located in Washington D.C. and two contractors based in Silicon Valley.[605] In addition to these, as indicated by a study interviewee, an important role in the success of the HSIP is played by so-called 'champions'.[606] These are contact points within DHS operational components and other DHS actors who liaise with the HSIP team, facilitating a number of activities. For example, champions can assist in the identification of departments or offices best suited to participate in the pilot testing of an innovative technology, or aid with the translation into clear technology requirements of existing challenges faced by individual DHS components and HSE actors.[607]

Organisational funding

Funding for HSIP activities stems from the S&T budget; no detailed figures regarding the programme budget could be identified.[608] Further details on the funding provided by the HSIP to external contractors and the mechanisms employed for assigning this funding are available in Section 4.4.4 (Funding) below.

4.4.4. Activities

Activities undertaken by the HSIP can be clustered under three main headlines:[609]

1. **Educate:** Activities under this headline aim both to educate start-ups about DHS and HSE needs and requirements, and to generate feedback from technology innovators and funders about developing ways for working in partnership.
2. **Fund:** Activities under this headline aim to provide funds to innovative start-ups and other private sector actors that would normally be outside the scope of DHS activities.
3. **Test:** Activities under this headline aim to facilitate a quicker transition of new technological solutions into operational use by operational components and other actors in the HSE.

The following paragraphs discuss HSIP activities in greater detail. However, rather than focusing on the headlines presented above, this section highlights how HSIP activities relate to the functional roles presented in Appendix D of this report.

Funding

A pivotal element of HSIP activities is represented by the **provision of direct funding (role 4.2)** to innovative start-ups and other technology innovators and private sector actors that are normally outside the reach of DHS RD&I programmes.

Companies engaging in the HSIP can submit proposals under OTS calls, which are scheduled to release up to $800 000 over a 24-month period.[610] The HSIP funds projects at different maturity levels, ranging from projects aiming to deliver a proof-of-concept demonstration (Phase 1), to those entailing testing in different operational settings and meant to result in a commercially viable product (Phase 4). A study interviewee noted that because the programme was only recently established, it is not yet possible to identify examples of projects having completed Phase 3 and Phase 4 of the funding scheme and having made a full transition into operational use.[611]

Table 4.5 on the right provides an overview of the OTS funding mechanism employed by the HSIP.

Projects funded by the HSIP cover a number of issue areas relevant to homeland security, spanning from Internet of Things security to active cyber defence for financial services, wearable technologies and small unmanned aircraft systems.[612] Projects funded by the HSIP also look at border- and maritime-specific issues. For example, a recently launched project aims to enhance airport passenger processing through the development of a smartphone-based interview capability which allows the remote verification of travellers' identity using biometric information and behavioural/trend analysis.[613]

A study interviewee emphasised that an important aspect of HSIP funding activities are the streamlined bidding procedures developed to cater to the needs of start-ups and technology innovators usually accustomed to engaging with venture capitalists, rather than governmental tendering procedures.[614] Thanks to HSIP procedures, the contracting of external providers requires approximately 45 days, as opposed to standard DHS tendering procedures that can take between 9 and 12 months before a project is launched. The first step in the HSIP bidding process is the submission of a short (10 pages maximum) application responding to a problem set and published by the HSIP. In this application, bidders are invited to highlight what an existing innovative technology or approach can deliver, and how this could be adapted to cater to DHS or HSE needs outlined in the problem. Following this,

604 DHS (2015c).
605 RAND Europe interview with anonymous, 14 September 2017.
606 RAND Europe interview with anonymous, 14 September 2017.
607 RAND Europe interview with anonymous, 14 September 2017.
608 For further details on this, please see Robertson et al. (2017).
609 RAND Europe interview with anonymous, 14 September 2017.
610 DHS (n.d.-f).
611 RAND Europe interview with anonymous, 14 September 2017.
612 DHS (n.d.-f).
613 DHS (n.d.-f).
614 RAND Europe interview with anonymous, 14 September 2017.

shortlisted bidders are invited to deliver an 'elevator pitch' presentation, either in person or via video teleconferencing, with up to 15 minutes for questions and discussion. Following this presentation, a decision is made by the HSIP team on the same day on whether or not to fund a project. Since December 2015, the HSIP has advertised 9 calls for proposals, receiving a total of approximately 220 applications from both US and international companies, and providing funding of approximately $4m.

Table 4.5 **DHS S&T SVIP OTS programme framework**

Phase	Funding	Duration	Output
Phase 1	$50k–200k	3–6 months	Proof-of-concept demo
Phase 2	$50k–200k	3–6 months	Demo pilot-ready prototype
Phase 3	$50k–200k	3–6 months	Pilot-test prototype in operation
Phase 4	$50k–200k	3–6 months	Test in various operational scenarios

Source: DHS (n.d.-f).

Table 4.6 **Overview of HSIP benefits and associated costs**

Benefits	Costs
■ Access to start-up and venture capitalist communities otherwise not interested in other DHS programmes.	■ Adoption of ad hoc procedures and contracting mechanisms to stimulate engagement by target communities. ■ Need to adapt to start-up culture and approach throughout engagement with this community. ■ Potential lack of IP ownership and/or adoption of other contractual measures to accommodate start-up requirements.
■ Access over a short timeframe to technology innovators and developers to address an existing operational need.	■ Compressed decision-making procedures with limited time for internal feedback loops. ■ Access to champions and/or liaison officers across different operational components providing details of needs and access to suitable departments for piloting and testing.
■ Exposure to and increased understanding of DHS's internal functioning for start-ups interested in branching into homeland security issues. ■ Increased attractiveness to venture capitalists of start-ups that successfully delivered work for a governmental programme such as the HSIP.	■ Greater risks to delivery as compared to contracting with large, top-tier companies – this may require greater focus from project managers to facilitate the development and delivery of projects.

Honest broker

A number of activities undertaken by the HSIP pertain to the honest broker functional roles. The HSIP works to **facilitate coordination and cooperation between (role 4.2) and bring together (role 4.1) start-ups, investors, and DHS and HSE actors and components.** To achieve this, the HSIP regularly undertakes the following:[615]

1. Organising events showcasing individual DHS operational components: these are designed to facilitate interaction between start-ups and DHS operational components, establishing links among them and facilitating a reciprocal understanding of operational challenges and potential technological innovations.
2. Organising industry days upon publication of a call for proposals: these are events designed to provide start-ups and industry actors interested in responding to a call for proposals with an opportunity to have face-to-face interactions and discussions in order to better understand the problems outlined in the call, the operational context, and the solution required by DHS components.
3. Participating in strategic events and engagements: activities such as (conferences and technology days are designed to raise awareness about the HSIP, and engage more broadly with industry, start-ups, and venture capitalists.

An example of a programme run by the HSIP that aims to facilitate coordination among DHS and private sector stakeholders is the Silicon Valley Innovation Program. The SVIP is one of the HSIP's regionally focused programmes which aims to link DHS and other homeland security stakeholders with Silicon Valley companies. The goal of the SVIP is to develop a shared understanding among DHS and Silicon Valley actors of homeland security requirements, and of how innovation corridors can help address HSE issues.[616]

Requirements identification and setting

Education and stakeholder engagement activities undertaken by the HSIP in its role as a honest broker also have implications for the programme's ability to **identify innovation opportunities and understand how to exploit them (role 1.1).** In particular, a study interviewee emphasised how engagement and education activities conducted with start-ups and venture capitalists allowed the HSIP to obtain a better understanding of barriers to cooperation between DHS and these stakeholders. It was suggested that HSIP gained an understanding of ways to overcome those barriers to cooperation, for example:[617]

1. Streamlining the bidding procedure for responding to calls for proposals, making the HSIP process akin to those employed by venture capitalists; and
2. Adopting adjustment measures concerning IP ownership upon project conclusion (e.g. renouncing IP ownership and adjusting requirement to the reception of a technical report) to increase the appeal of HSIP's calls for start-ups.

Furthermore, a study interviewee emphasised that an important aspect of the HSIP's establishment was an initial period of engagement which was conducted before the programme was officially launched. This allowed the HSIP to make adjustments to its approach and maximise its ability to engage and gain access to technology innovators.[618]

Lastly, by maintaining links with so-called champions across different DHS components and HSE actors (see

615 RAND Europe interview with anonymous, 14 September 2017.

616 DHS. (n.d.-f).

617 RAND Europe interview with anonymous, 14 September 2017.

618 RAND Europe interview with anonymous, 14 September 2017.

Section 4.4.3), the HSIP continuously **analyses operational needs of DHS actors (role 1.2)** and can facilitate access to and understanding of this information among start-ups and venture capitalists interested in working on HSE issues.[619]

4.4.5. Results

The HSIP is designed to facilitate engagement and access to private sector actors who normally would not engage with standard DHS RTD&I programmes and funding opportunities. Table 4.6 provides an overview of the main benefits and associated costs that characterise the HSIP programme.

4.5. DHS S&T Centers of Excellence

4.5.1. Summary

The DHS S&T funds and manages a programme for academic Centers of Excellence. DHS S&T COEs comprise a network of US academic institutions tasked with developing multidisciplinary, customer-driven science and technology solutions for real-world homeland security challenges. By funding COEs, the DHS S&T also aims to facilitate the development of cadres of new experts and researchers engaged in homeland security issues and cognisant of operational requirements and challenges.[620]

4.5.2. Vision

Mission

The mission of the DHS S&T COEs programme is aligned with that of the S&T Office of University Programs through which it is managed. In particular, the OUP's mission is to strengthen US scientific leadership in homeland security research and education, to foster the development of a broader homeland security science and engineering workforce, and to develop strategic partnerships among universities and public agencies.[621]

Objectives

To fulfil its mission, the S&T COE programme pursues a number of objectives, which are consistent with those of the OUP. Specifically, COE-relevant objectives of the OUP are to:[622]

1. Build a stable community of homeland security researchers and educators at US colleges and universities;
2. Foster a homeland security culture within the academic community through research and educational programs;
3. Generate and disseminate knowledge and technical advances to advance the homeland security mission;
4. Integrate homeland security activities across agencies engaged in relevant academic research; and
5. Develop a permanent science and engineering workforce for homeland security.

4.5.3. Governance

Organisational governance

The OUP is tasked with managing the DHS S&T *University Programs* function, which comprises three initiatives:[623]

- **COEs,** which aim to harness expertise from US academic institutions to support research efforts and deliver tools, technologies, knowledge products, training and expertise for the homeland security enterprise;
- **Workforce Development Initiatives**, which aim to educate and train homeland security professionals; and
- **Minority Serving Institutions Programs**, which aim to build a diverse homeland security workforce through the COEs.

Figure 4.6 on the next page provides an overview of the DHS S&T organogram, highlighting the location of the OUP within it.[624]

Leadership and membership

Each COE is led by a university, in collaboration with partners from other institutions, agencies, laboratories, think tanks and the private sector. DHS S&T COEs are organised as a network, bringing together hundreds of US universities and institutions. Currently, there are 9 COEs and 5 Emeritus COEs active. Emeritus COEs are COEs that no longer receive base funding from the OUP but can continue to advertise their affiliation and receive funding from DHS operational components through DHS Basic Ordering Agreements (BOA).[625] Current COEs looking at issues pertaining to border and maritime security include:[626]

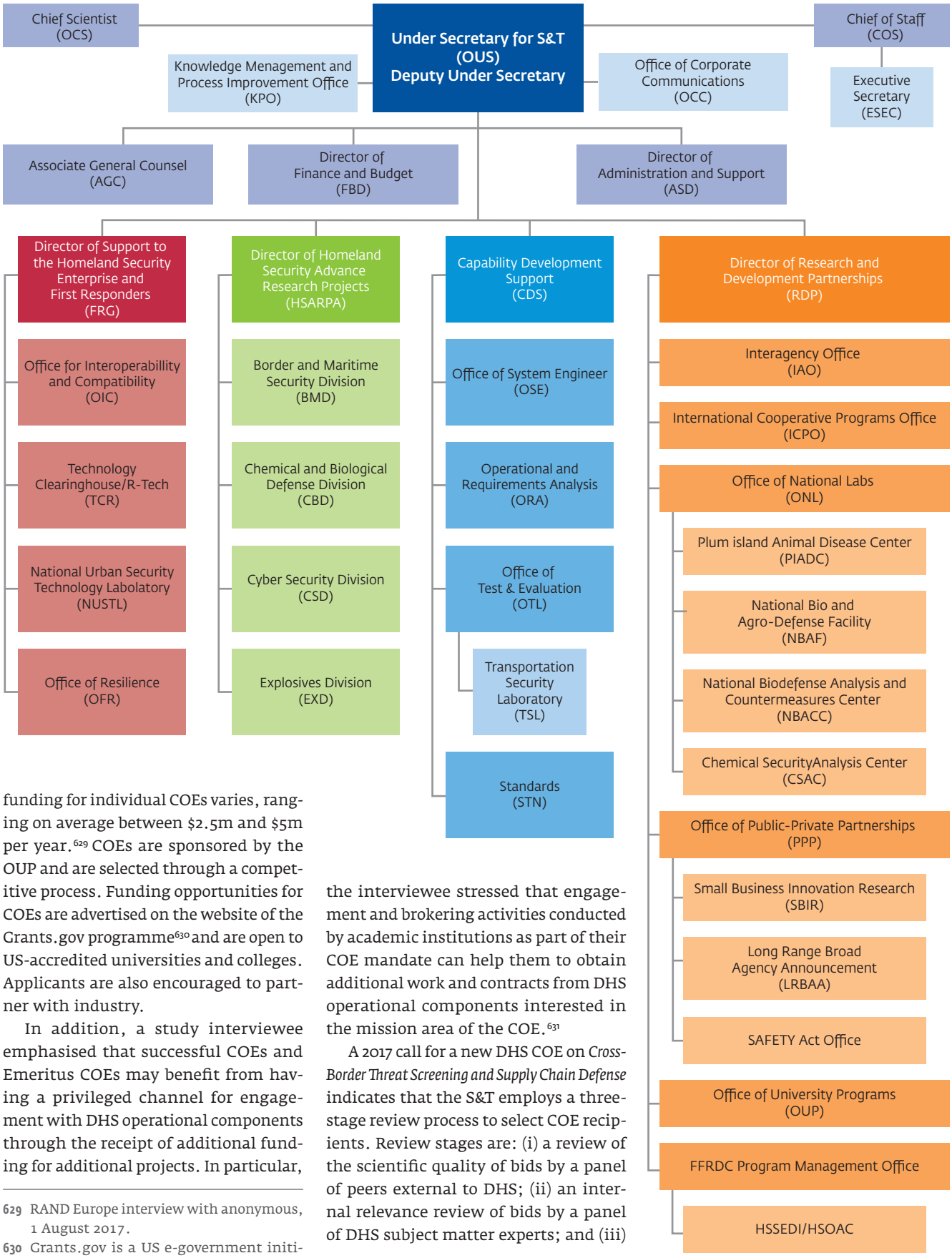
- **Borders, Trade and Immigration Institute:** BTI is led by the University of Houston and focuses on developing technology-based tools, techniques and educational programmes for border management, immigration, trade facilitation, and targeting and enforcement of transnational borders. The BTI COE was established in 2015 with an initial grant of $3.4m to a consortium led by the University of Houston and comprising more than 25 academic, industry and government experts.[627]
- **National Center for Border Security and Immigration:** The NCBSI is co-led by the University of Arizona and the University of Texas at El Paso. The NCBSI's activities focus on developing technologies, tools and methods to balance immigration and commerce with effective border security.
- **Maritime Security Center of Excellence (MSC):** The MSC is led by the Stevens Institute of Technology. Its activities aim to enhance maritime domain awareness and to develop strategies to support Marine Transportation System resilience and educational programs for current and aspiring homeland security practitioners.

Organisational funding

Funding for DHS S&T COEs stems from the broader DHS S&T budget.[628] A study interviewee indicated that annual

619 RAND Europe interview with anonymous, 14 September 2017.
620 RAND Europe interview with anonymous, 1 August 2017; DHS (n.d.-g).
621 DHS (n.d.-c).
622 SBIR (n.d.-a).
623 DHS (n.d.-c).
624 DHS (2015c).
625 RAND Europe interview (August 2017); Homeland Security University Programs (n.d.-a).
626 DHS (n.d.-d); University of Houston (2017a).
627 DHS (2015b); BTI (n.d.-a).
628 For further details on this, please see Robertson et al. (2017).

Figure 4.6 **S&T organogram as of October 2017**



SOURCE: DHS (2017); DHS (n.d.-g).

funding for individual COEs varies, ranging on average between $2.5m and $5m per year.[629] COEs are sponsored by the OUP and are selected through a competitive process. Funding opportunities for COEs are advertised on the website of the Grants.gov programme[630] and are open to US-accredited universities and colleges. Applicants are also encouraged to partner with industry.

In addition, a study interviewee emphasised that successful COEs and Emeritus COEs may benefit from having a privileged channel for engagement with DHS operational components through the receipt of additional funding for additional projects. In particular, the interviewee stressed that engagement and brokering activities conducted by academic institutions as part of their COE mandate can help them to obtain additional work and contracts from DHS operational components interested in the mission area of the COE.[631]

A 2017 call for a new DHS COE on *Cross-Border Threat Screening and Supply Chain Defense* indicates that the S&T employs a three-stage review process to select COE recipients. Review stages are: (i) a review of the scientific quality of bids by a panel of peers external to DHS; (ii) an internal relevance review of bids by a panel of DHS subject matter experts; and (iii)

629 RAND Europe interview with anonymous, 1 August 2017.

630 Grants.gov is a US e-government initiative operating under the US Office of Management and Budget. For further information please refer to Grants.gov (n.d.).

631 RAND Europe interview with anonymous, 1 August 2017.

site visits by a team of DHS subject matter experts. When applicable, the review process also entails an assessment of past performance by COE hosts bidding for a COE's renewal.[632]

4.5.4. Activities

Funding

After receiving funding from the DHS S&T, COEs can also independently **advertise calls for proposals and provide funding for research and development projects (O6.1)** that are consistent with the mission outlined in their funding solicitation. For example, between 2015 and 2017, BTI has advertised three RFPs to fund research programmes focusing on borders, trade and immigration. Funds released under these RFPs ranged from $325 000 to $3m (with a cap of $500 000 per project). In its RFPs, BTI outlined a number of proposal topic areas and research questions relevant to the initial COE funding solicitation issued by DHS. Organisations eligible to bid for these RFPs include US colleges, universities, for-profit and non-profit organisations. Proposals are assessed by members of the academic and DHS community through a Scientific Quality Review and a Relevance Review process. Under the Scientific Quality Review process, proposals are rated from 1 to 5 (poor to excellent) against a number of criteria. Percentage-weighting factors are then applied to each criterion, as indicated in parenthesis below, to calculate the overall scientific quality rating:[633]

- Originality and/or innovativeness (25%)
- Proposed approach/methodology (25%)
- Qualifications of personnel and suitability of facilities (15%)
- Costs (10%).

Similarly, the Relevance Review involves scoring proposals from 1 to 5 (poor to excellent) against two additional criteria. These are then weighted and combined to calculate the overall relevance score. The factors considered are:

- Mission relevance (75%)
- Communicating/transitioning results (25%).

A study interviewee emphasised that COEs are well placed to conduct or coordinate R&D projects of a conceptual and abstract nature. For example, the study interviewee suggested that issues akin to algorithm development, business process reform and data visualisation are most suited to COEs.[634] Equally, the same interviewee stressed that the different business model and pace of work that characterise academia may represent a risk or barrier to the delivery of work. In particular, the interviewee suggested that universities' pace of work may result in drawn-out delivery processes, as compared to those of private sector actors, thus requiring more focused engagement and monitoring by programme managers through a variety of techniques and stimuli.[635]

Information sharing

Universities, colleges and other stakeholders interested in responding to either COE funding solicitations or calls for proposals issued by COEs can find relevant information through **a centralised repository of information on funding opportunities (role 3.1).** The *Homeland Security University Programs* web portal[636] provides information about such funding opportunities, as well as a repository of resources on existing COEs, their projects, COE-related events, and projects' results and achievements. In addition to this, each of the existing COEs provides further information and details about its activities, projects and RFPs through its individual website.

Training and education

An important element of the COE model is the **provision of training and education (role 3.4)** to facilitate the development of a diverse, highly capable technical workforce for DHS and the broader HSE.[637] COEs perform this function in both indirectly and directly. On an indirect level, the undertaking of research and development projects through COEs provides both graduate and undergraduate students enrolled in universities involved in COEs to contribute to homeland security related projects, developing their knowledge and understanding of real-world homeland security issues and requirements.[638] COEs perform this activity in a more direct way by taking part in *Workforce Development Initiative* activities organised by the OUP. In particular, COEs contribute to:[639]

1. **Summer internships:** Under this initiative, graduate and undergraduate students can participate in an internship lasting up to ten weeks during the summer period. During internships, participants conduct research in DHS mission-relevant areas, either at US federal research facilities or at COEs.
2. **Military Service Academies Program:** This programme provides faculty and student teams from US military academies with the opportunity to conduct research at universities affiliated with COEs or participate in field studies sponsored by DHS. The programme aims to increase research collaborations between DHS and the DoD, targeting senior cadets and midshipmen.

Honest broker

The COE programme also facilitates the **coordination and cooperation between academia, industry and governmental stakeholders (role 4.2).** This occurs at two levels. Firstly, at a higher level, calls for the establishment of COEs encourage universities and colleges to partner with industry and private sector stakeholders and representatives as they prepare their bid.

Secondly, individual COEs undertake several activities aimed at facilitating interaction, cooperation and coordination with other stakeholders from the HSE.

632 Grant reference: DHS-16-ST-061-CBTS-Lead.
633 University of Houston (2017b; 2017c); DHS (2017f).
634 RAND Europe interview with anonymous, 1 August 2017.
635 RAND Europe interview with anonymous, 1 August 2017.
636 Homeland Security University Programs (n.d.-c).
637 Homeland Security University Programs (n.d.-b).
638 RAND Europe interview with anonymous, 1 August 2017; BTI (n.d.-a).
639 Homeland Security University Programs (n.d.-b).

Table 4.7 **Overview of DHS S&T COE benefits and associated costs**

Benefits	Costs
■ DHS can have access to a pool of skilled researchers and academics at a comparatively low cost to investigate a wide array of real-world homeland security challenges.	■ The pace and rhythm of academic life may lead to longer delivery timelines as compared to standard private sector companies contracted by DHS. ■ Skills and resources available to academic implementers suggest the programme may be more suitable for abstract and conceptual issues and challenges, rather than issues requiring the development of resource-intensive technological or hardware solutions.
■ The programme fosters the development of a broader scientific and engineering workforce engaged with homeland security issues and cognisant of operational constraints and requirements.	■ Resource investment for running of initiatives and programmes targeting graduate and undergraduate students to facilitate their engagement with homeland security.
■ Academic institutions involved with COEs can use interface opportunities associated with this programme to secure additional work and contracts with DHS components and other HSE actors.	■ Costs associated with organisation and running of stakeholder engagement activities, both by DHS and COE managers, to facilitate interaction with operational components and other potential clients from HSE.

COEs work with their DHS programme managers to facilitate frequent engagement with DHS stakeholders, especially operational components, both on the COE site and during field visits.[640] Such engagement activities may also involve industry representatives and academic partners, depending on the topics and objectives of engagements. There are two key objectives of stakeholder meetings. Firstly, they are designed to help COEs gain insights on the needs and requirements of operational components and other HSE actors. Secondly, attending stakeholders, who in this context are seen as potential end users, have an opportunity to learn about the progress of COEs' research. In this regard, these meetings may also be seen to fulfil a **technology demonstration function (role 5.1)**, helping COEs to showcase their products and results, and helping them identify, with support from stakeholders, potential challenges or opportunities for the transition to operational use of COEs' work.[641]

4.5.5. Results

The DHS S&T COEs are designed to develop a network of US academic institutions working to develop (i) science and technology solutions for real-world homeland security challenges; and (ii) a new workforce of homeland security experts and scientists. Table 4.7 provides an overview of the main benefits and associated costs that characterise the DHS S&T COEs programme.

4.6. Small Business Innovation Research

4.6.1. Summary

The Small Business Innovation Research programme is run by DHS through the S&T and the DNDO as part of the US government's broader SBIR initiative. The SBIR initiative was launched in 1982 by the US government in an effort to facilitate participation in governmental procurement activities by small companies (i.e. those with fewer than 500 employees) at the forefront of innovation and technological developments. The DHS joined the SBIR programme in 2004, becoming one of 11 government agencies engaged in the initiative.[642] In light of the relevance of the S&T's areas of work to Frontex, this case study will focus on the functioning of the S&T SBIR programme.

4.6.2. Vision

Mission

The mission of the S&T SBIR programme is aligned with that of the broader SBIR initiative.[643] It aims to support scientific excellence and technological innovation through investment in research, development and innovation funds, with the goal of helping to build a strong national economy. To that end, the S&T SBIR works to facilitate participation in procurement activities by small US companies at the forefront of innovation and technological development that can help tackle and mitigate some of the challenges faced by DHS and the HSE more broadly.[644]

Objectives

To fulfil its mission, the S&T SBIR pursues a number of objectives, which are consistent with those of the governmental SBIR initiative. Specifically, the SBIR initiative's objectives are to:[645]

1. Stimulate technological innovation;
2. Meet federal R&D needs;
3. Foster and encourage participation in innovation and entrepreneurship by women and socially or economically disadvantaged persons; and
4. Increase private sector commercialisation of innovations derived from federal R&D funding.

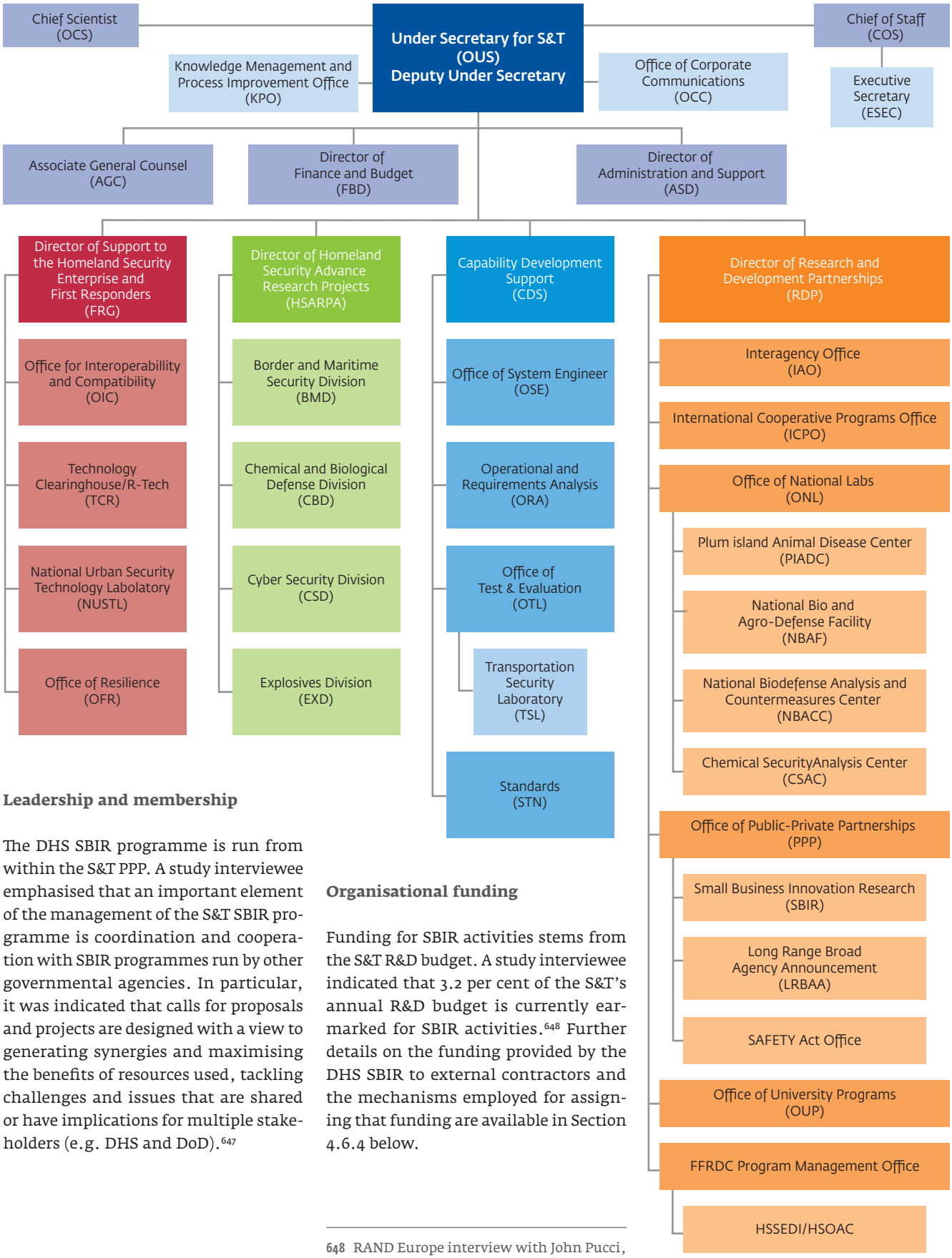
4.6.3. Governance

Organisational governance

The SBIR is run by the S&T under the PPP. The main purpose of this office is to develop and implement programmes that identify technologies, evaluate them and facilitate their commercialisation as products or services. The PPP is located within the RDP. The RDP is tasked with providing DHS and the HSE more broadly with access to science-based capabilities and solutions. To do so, the RDP sponsors research, development and innovation activities such as those of the SBIR. In its work, the RDP engages with a wide array of stakeholder communities, comprising private sector actors, academia, national laboratories, other governmental departments and agencies, and international partners. Figure 4.7 overleaf provides an overview of the DHS S&T organogram, highlighting the location of the SBIR within it.[646]

640 Maritime Security Centre (2016).
641 Maritime Security Centre (2016).
642 Please see DHS (n.d.-e).
643 RAND Europe interview with John Pucci, 15 September 2017.
644 RAND Europe interview with John Pucci, 15 September 2017; SBIR (n.d.-a).
645 SBIR (n.d.-a).
646 DHS (2015c).

Figure 4.7 **S&T organogram as of October 2017**



SOURCE: DHS (2017); DHS (n.d.-g).[649]

Leadership and membership

The DHS SBIR programme is run from within the S&T PPP. A study interviewee emphasised that an important element of the management of the S&T SBIR programme is coordination and cooperation with SBIR programmes run by other governmental agencies. In particular, it was indicated that calls for proposals and projects are designed with a view to generating synergies and maximising the benefits of resources used, tackling challenges and issues that are shared or have implications for multiple stakeholders (e.g. DHS and DoD).[647]

Organisational funding

Funding for SBIR activities stems from the S&T R&D budget. A study interviewee indicated that 3.2 per cent of the S&T's annual R&D budget is currently earmarked for SBIR activities.[648] Further details on the funding provided by the DHS SBIR to external contractors and the mechanisms employed for assigning that funding are available in Section 4.6.4 below.

647 RAND Europe interview with John Pucci, 15 September 2017.

648 RAND Europe interview with John Pucci, 15 September 2017. For further details on this, please see Robertson et al. (2017).

649 DHS (n.d.-g).

Table 4.8 **DHS SBIR funding scheme**

Phase	Funding	Duration	Output
Phase I	Up to $100k	6 months	Concept feasibility paper
Phase II	Up to $1M	24 months	Prototype demonstration
Phase III	External to DHS	NA	Commercial product or service

Source: RAND Europe interview (September 2017).

4.6.4. Activities

Funding

A fundamental element of the SBIR's activities is the **provision of direct funding (O6.1)** to small companies that are at the forefront of innovation and technological developments, but would otherwise be unable to compete with primes under larger DHS procurement initiatives.

The SBIR funding mechanism is structured around three phases. The first two phases are supported by the SBIR through direct funding or co-funding. The third phase covers the final transition of a product or service to commercial sustainability. This phase is not supported by SBIR through funding, but companies undertaking Phase I and Phase II projects are supported through training, mentoring and other activities in their search for funding.

In Phase I of SBIR funding, over the course of six months, implementers are required to develop a concept feasibility paper demonstrating how a new technological solution could be developed or adapted to respond to an operational challenge faced by a DHS component. Projects that successfully complete Phase I can then compete for Phase II funding. Under Phase II, over the course of 24 months, implementers are required to complete the development of a functioning prototype of their service or product. Phase III targets the achievement of commercial sustainability of products and services developed. The SBIR programme does not provide funding to cover this phase of work; however, a number of activities described in the sections below are designed to maximise exposure of SBIR-supported companies to venture capitalists and increase their likelihood of success in obtaining funding required for Phase III work.[650]

Table 4.8 above provides an overview of the funding mechanism employed by the DHS SBIR.

Projects funded by the DHS SBIR cover a number of issue areas relevant to homeland security. Study interviewees suggested that non-classified issues of a technical nature and with clearly scoped requirements are better suited for this type of programme than broader RD&I matters.[651] For example, one interviewee stressed that several challenges faced by first responders had been successfully tackled or mitigated through solutions stemming from SBIR funding.[652] The S&T SBIR presents success stories from projects that completed Phase III through online publications.[653]

Topics for SBIR solicitations are developed by S&T programme managers to address the needs of DHS operational components, as well as first responders. Solicitations usually cover topics relevant to the work of a range of S&T divisions, including:[654]

- Borders and Maritime Security Division
- Chemical and Biological Defense Division
- Cyber Security Division
- Explosives Division
- First Responders Group.

A study interviewee stressed that an important lesson learned throughout the first years of the DHS SBIR programme was the need to design better benchmarking and monitoring mechanisms to ensure a higher rate of transition between Phase I and Phase II of the programme. Measures were therefore taken to minimise the risk that companies may pursue SBIR funding and purposely deliver only up to Phase I, or submit proposal that is too ambitious or unrealistic to be suitable for funding under Phase II.[655]

Furthermore, a study interviewee suggested that topics put forward in SBIR solicitations should not provide overly detailed specifications of problems faced or requirements pursued. It was argued that this may draw boundaries around issues, barring submission from innovators who may have identified opportunities or challenges that had not initially been taken into consideration.[656] It was also emphasised that SBIR solicitations are usually tailored to address forward-looking needs and requirements, rather than current ones, since products and services emerging from SBIR projects come to fruition only after a period of 3 to 4 years.[657]

Information sharing

Small companies interested in responding to SBIR solicitations are provided with **a centralised repository of information on funding opportunities (role 3.1)** by both the S&T SBIR programme and the broader SBIR initiative. The S&T SBIR maintains an online programme portal[658] which provides information about current and past solicitations, news and events connected to the programme, details of awarded funds, statistics about the programme, and a repository of resources for companies interested in learning about and joining the bidding process.

Similarly, a government-wide SBIR online portal is available.[659] This portal provides similar information about the broader SBIR initiative, as well as links and references to agency-specific SBIR portals, such as the DHS example discussed above.

Hosting innovation

Part of the work of the S&T SBIR programme entails **the running of technology demonstrations (role 5.1)** with a view to presenting a product or service

650 RAND Europe interview with John Pucci, 15 September 2017.

651 RAND Europe interviews with anonymous, 1 August 2017 and with John Pucci, 15 September 2017.

652 RAND Europe interview with anonymous, 1 August 2017.

653 DHS (2016d).

654 DHS (n.d.-h).

655 RAND Europe interview with anonymous, 1 August 2017.

656 RAND Europe interview with anonymous, 1 August 2017.

657 RAND Europe interview with John Pucci, 15 September 2017.

658 DHS SBIR (n.d.).

659 SBIR (n.d.-b).

Table 4.9 **Overview of SBIR benefits and associated costs**

Benefits	Costs
■ Access to small businesses at the forefront of innovation and technological developments otherwise unable to compete in larger DHS procurement programmes and initiatives.	■ Greater risks to delivery as compared to contracting with large, top-tier companies – this may require greater focus from project managers to facilitate the development and delivery of projects.
■ Ability to tackle forward-looking issues through innovative approaches and solutions that translate into commercial products or services.	■ The scope of problems to be tackled needs to be well defined and scoped upon project launch. ■ Need to identify emerging requirements for which DHS components or HSE stakeholders will have an appetite over a 3-to-4-year period.
■ Exposure to and increased understanding of DHS internal functioning for small businesses interested in HSE issues. ■ Increased attractiveness to venture capitalists of small businesses that have successfully delivered work for a governmental programme such as SBIR.	■ Greater risks to delivery as compared to contracting with large, top-tier companies – this may require greater focus from project managers to facilitate the development and delivery of projects. ■ Provision of ad hoc training to small businesses with limited knowledge and understanding of upscaling and transition towards a commercially successful and sustainable product or service.

prototype to convince stakeholders and potential investors about its relevance and feasibility. These activities represent the culmination of projects conducted as part of Phase II of SBIR funding discussed above.

Training and education

A study interviewee indicated that a number of companies engaged in the SBIR programme receive **training and education (role 3.4)** as part of their work with the S&T. In particular, companies and implementers may be asked to participate in a six-week course organised by the National Science Foundation (NSF) called *Innovation Corps* (I-Corps).[660] I-Corps is designed to provide implementers working on an S&T SBIR project with a better understanding of how to achieve the successful commercialisation of their products and ensure the continued development and sustainability of results achieved with SBIR funding through Phase III.

Honest broker

The **facilitation of coordination and cooperation between small companies, DHS operational components, and investors (role 4.2)** represents an important aspect of the S&T SBIR's work. A study interviewee emphasised that the programme actively contacts relevant businesses, informing them of upcoming calls and requirements of DHS components.[661] As part of such efforts, events and webinars are hosted to engage with the small businesses community, investors, technology-oriented entrepreneurs and others interested in high-technology research and development.[662] Furthermore, study interviewees identified additional benefits companies participating in the SBIR and engaging in such events, including:[663]

- Access and exposure to internal DHS work and mechanisms, facilitating understanding among external firms of the department's work and functioning;
- Increased trust from and exposure to venture capitalists and other funders who are more likely to fund companies with a successful track record of work with government departments through the SBIR; and
- Training opportunities and development support provided throughout contract delivery by SBIR programme officers and managers engaging with a firm.

4.6.5. Results

The S&T SBIR programme is designed run as part of the broader DHS SBIR and US governmental SBIR initiative. It aims to facilitate engagement in governmental procurement activities by small companies at the forefront of technological developments and innovation more broadly that would otherwise be unable to compete in standard procurement activities. Table 4.9 provides an overview of the main benefits and associated costs that characterise the S&T SBIR programme.

660 RAND Europe interview with John Pucci, 15 September 2017; NSF (n.d.-a).

661 RAND Europe interview with John Pucci, 15 September 2017.

662 DHS (n.d.-i).

663 RAND Europe interviews with anonymous, 1 August 2017; RAND Europe with John Pucci, 15 September 2017.

Appendix A: List of interviewees

We are grateful to the numerous border security practitioners, policy officials, industry representatives and academic experts who took part in interviews and informed the conclusions of this study. Where consent has been given, their names and/or affiliations are listed in the table below. Contributions have been anonymised in Table A.1 and throughout the report in certain cases where interviewees have asked to remain anonymous.

Table A.1 **List of interviewees**

Name	Organisational affiliation	Case study expertise	Date of interview
Anonymous	EU policy official	EU	21 March 2017
Anonymous	FP7 project coordinator	EU	31 March 2017
Anonymous	EU project coordinator	EU	3 April 2017
Anonymous (*3 representatives*)	European organisation	EU	3 April 2017
Dragos Voicu	Research officer, Frontex	EU	11 April 2017
Anonymous	Academic expert, Finland	EU	13 April 2017
Anonymous	Frontex	EU	19 April 2017
Lilian Gaichies & Eric Lebegue	COO and CEO advisor, StreamWIDE	EU	19 April 2017
Triantafyllos Karatrantos	Senior researcher, Centre for Security Studies (KEMEA)	EU	20 April 2017
Anonymous (*2 representatives*)	EU institution	EU	24 April 2017
Anonymous	EU Project Officer	EU	26 June 2017
Dr John Coyne	Head of Border Security, Australian Strategic Policy Institute	Australia	20 March 2017
Anonymous	Australian Department of Immigration and Border Protection	Australia	29 March 2017
Anonymous	Anonymous	Australia	30 March 2017
Anonymous (*2 representatives*)	Anonymous	US	24 March 2017
Anonymous (*2 representatives*)	Anonymous	US	5 May 2017
Anonymous (*2 representatives*)	Defence Research and Development Canada – Centre for Security Science	Canada	19 April 2017
Phil Lightfoot	Canada Border Services Agency	Canada	19 April 2017
Christian Leuprecht	Royal Military College of Canada	Canada	21 April 2017
Anonymous	Anonymous	Canada	21 April 2017
Joel Sokolsky	Royal Military College of Canada	Canada	25 April 2017
Anonymous	Anonymous	Turkey	3 May 2017
Anonymous	Anonymous	Egypt	29 April 2017
Faycal Cherif	Institut Supérieur d'Histoire de la Tunisie Contemporaine. (ISHTC)	Tunisia	25 April 2017
Anonymous	EU Project Officer	EU	26 June 2017
Anonymous (*2 representatives*)	Anonymous	Australia	24 July 2017
Anonymous	Anonymous	US	1 August 2017
Pantelis Michalis & George Leventakis	Centre for Security Studies (KEMEA)	EU	30 August 2017
Anonymous	Anonymous	US	14 September 2017
Peter Ryman	Swedish Coast Guard	EU	20 September 2017
John Pucci	DHS SBIR Program Director, DHS Science and Technology Directorate	US	15 September 2017
Anonymous	Anonymous	EU	26 October 2017

Appendix B: List of interview questions

This appendix provides an outline of the types of questions asked during the research interviews. The interviews were semi-structured, which means that the RAND study team used the list of questions as a guide to touch on the key topics relevant for this study, rather than following a rigid protocol.

Three interview protocols are presented in this appendix:

- The WP1–2 protocol focuses on border security research in the case study countries and regions. Box B.1 presents the protocol used for EU interviewees as an illustrative example of the interview questions used during the study. While the discussion was framed around the same topics across the case studies, the questions were tailored to the specific regional focus of the interview.
- In response to comments from the Steering Committee, additional WP1 interviews were conducted with EU project coordinators in order to focus on the operationalisation of EU-funded research. Box B.2 outlines the additional set of questions developed for these interviewees.
- The WP3 protocol focuses on case studies of selected EU and non-EU organisations in order to develop a better understanding of different operational models (see Box B.3).

Box B.1 **List of interview questions: EU**

Part A: Introduction

- Study team introduction and study context.
- Do you have any questions about the study before we begin?
- Please could you start by tell us briefly about your role, describing how your professional background and interests relate to EU border security research?

Part B: Wider Context for Border Security Research Management

1. **Contextual factors:**
   - What are the main border security challenges affecting the EU at present? [*e.g. illegal border crossings, smuggling, cross-border crime*]
   - How much strategic importance is assigned to border security in the EU? How is 'border security' ranked among the EU's policy priorities? [***Prompts:*** *high (i.e. top 3 policy priorities), medium (i.e. top 3–10 policy priorities), low (i.e. not in top 10 policy priorities)*]
   - Who are the main actors (types of organisation) involved in commissioning border security research? [***Prompts:*** *national border guard agency, wider government, industry/SMEs, academia, other (please specify)*].
   - What are the main challenges affecting the conduct and management of border security research in your country? [*e.g. interruptions to funding streams, poor access to research findings, inadequate research management*]

Part C: Research Setup and Management

2. **How are border security research topics identified and prioritised in the EU?** [***Prompts:*** *who (main stakeholders involved), how (relevant processes and associated timelines/costs)*
3. **How are border security research projects selected in the EU?** [*both in terms of specification and award*] [***Prompts:*** *who, how*]
4. **What are the main inputs to border security research?** [***Prompts:*** *budget management, key actors, Terms of Reference*]
5. **How is the progress of border security research projects monitored and evaluated?** [***Prompts:*** *who, how*]
6. **How are the findings of EU border security research implemented in practice?** [***Prompts:*** *who, how*]

Part D: Lessons Learned and Way Forward

7. **Perceived Effectiveness of Border Security Research Management Approaches:**
   - How effective do you consider border security research management approaches in the EU (in terms of how well research findings are integrated into operational practice)?
   - Why do you consider these approaches effective/ineffective (as applicable)?
8. **Benefits of Border Security Research Management Approaches:**
   - In your view, what works well in the setup and management of border security research in the EU?
   - Why does this work well?
9. **Shortcomings of Border Security Research Management Approaches:**
   - In your view, what works less well in the setup and management of border security approaches in the EU?
   - Why does this work less well?
10. **Lessons Learned:**
   - How can the ways in which border security research is managed be improved?
   - Are you aware of 'good practices' applied elsewhere that could help improve EU processes? [***Prompts:*** *other countries, sectors, organisations*]

Part E: Interview Close

- Are there any further comments or observations that you would like to make?
- Can you think of anyone else it would be useful for us to talk to in this area? Is there any relevant literature that you would suggest we look at?
- Thank you for your time and insights. If we have any further questions or clarifications, would you be happy for us to contact you again?

Box B.2 presents the protocol used for the additional EU interviews conducted to further explore the operationalisation of EU-funded research.

Box B.2 **List of interview questions: EU additional interviews**

Introduction

- Research team introduction and study context
- Do you have any questions about the study before we begin?
- Please could you tell us briefly about your current role and responsibilities?

Interview Questions

1. Please describe your involvement in [specific FP7/H2020 project].
2. How far were the results of this project adopted into your operational practice?

a. [*If yes*]: Please describe the impact of this research on your operational practice. What factors have enabled this change?

b. [*If no*]: What factors have prevented you from operationalising the research results?

3. Are you aware of any EU-funded projects where research results have been successfully operationalised? [*If yes*]: Please elaborate.
4. In your view, are there ways in which EU-funded research could be more effectively operationalised? Please elaborate.
5. How do you think Frontex could facilitate the adoption of EU-funded research into practice? What role could they play in this process? [***Prompts:*** *see checklist below*]

Checklist (see Q5)

- Sharing information on R&D opportunities
- Facilitating access to DHS/NATO funding instruments
- Bringing government, industry, academia and other actors together
- Conducting in-house R&D
- Providing debt and risk sharing schemes
- Hosting an innovation incubator for ventures
- Delivering support to industry to assist them in taking their innovations to market
- Using DHS/NATO procurements and contracts to 'pull' innovative solutions from the market
- Running demonstrations for innovative research and technologies
- Running prize competitions or 'grand challenges' to stimulate research solutions to challenges
- Delivering training on research and innovation for DHS/NATO officials
- Other: [*Please describe*]

Interview Close

- We have now covered the questions we wanted to ask you. Do you have any further comments or observations?
- Can you recommend any relevant literature sources that we should consult as part of this study?
- If we have further questions, can we get back to you?

Box B.3 outlines the interview protocol that was used to guide the WP3 interview discussions.

Box B.3 **List of interview questions: Case studies**

Introduction

- Research team introduction and study context
- Do you have any questions about the study before we begin?
- Please could you tell us briefly about your current role and responsibilities?

Interview Questions

This interview will focus on Centers of Excellence (COE), Small Business Innovation Research (SBIR), Apex Programmes and Technology Engines, Homeland Security Innovation Programs (HSIP) and other US/NATO models of potential relevance to Frontex. For each model:

1. Please describe the model and how it works in practice.
2. Who is responsible for its implementation?
3. What are the model's main functions? [***Prompts:*** *use checklist in Box 1*]
4. What are the key challenges faced by DHS/NATO in delivering these functions?
5. How far does this model help integrate research into operational practice? Please elaborate, providing examples where possible.
6. How effective do you consider this model in fostering research and innovation? What are its main advantages? [***Prompts:*** *bringing actors together, sharing information, providing access to DHS funding, funding innovative R&D*]
7. If you had the opportunity to set up a new research and innovation platform, which elements of this model would you replicate, and what would you do differently?

Checklist (see Q3)

- Sharing information on R&D opportunities
- Facilitating access to DHS/NATO funding instruments
- Bringing government, industry, academia and other actors together
- Conducting in-house R&D
- Providing debt and risk sharing schemes
- Hosting an innovation incubator for ventures
- Delivering support to industry to assist them in taking their innovations to market
- Using DHS/NATO procurements and contracts to 'pull' innovative solutions from the market
- Running demonstrations for innovative research and technologies
- Running prize competitions or 'grand challenges' to stimulate research solutions to challenges
- Delivering training on research and innovation for DHS/NATO officials
- Other: [*Please describe*]

Interview Close

- We have now covered the questions we wanted to ask you. Do you have any further comments or observations?
- Can you recommend any relevant literature sources that we should consult as part of this study?
- If we have further questions, can we get back to you?
- Thank you very much.

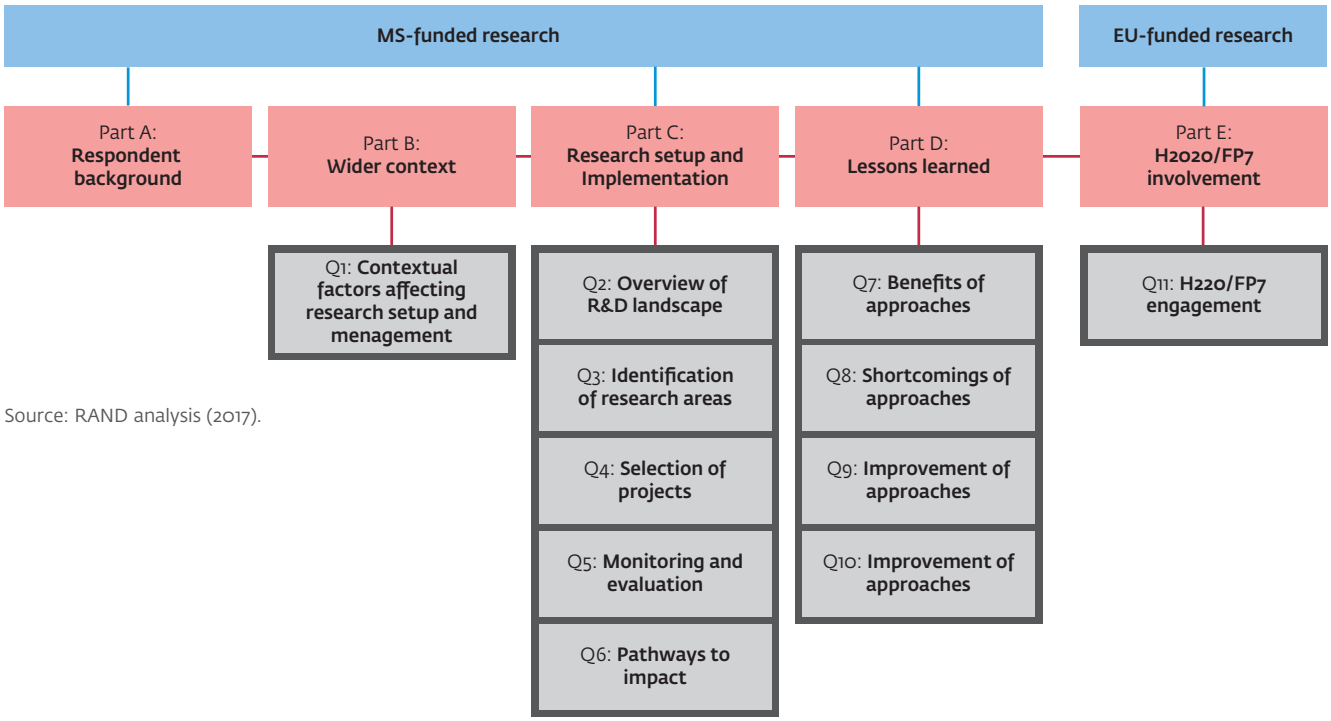
Appendix C: Survey outlines

This appendix presents the outlines of the surveys sent to EU MS and to industry and academic representatives.

EU MS survey

As illustrated in Figure C.1, this survey was designed to consider all of the steps of the research pathway. Parts A to D focus on research funded and conducted at the national level, and Part E focuses on the involvement of the respondent country in EU-funded research.

Figure C.1 **EU MS survey outline**



Source: RAND analysis (2017).

Part A: Respondent Background

Name	[*Please enter text here*]
Organisational affiliation	[*Please enter text here*]
Country	[*Please enter text here*]
Contact details ***(email and telephone)***	[*Please enter text here. Please note that these contact details will only be used for any points of clarification regarding your completed survey.*]
Attribution preference	[*Please could you confirm your preference regarding how your data is attributed in the report and any resulting publications:* ***Option 1:*** *'Full attribution': being named and quoted;* ***Option 2:*** *'Partial anonymity': only your organisational affiliation (role, organisation – please specify) being associated with your quotes;* ***Option 3:*** *'Full anonymity': your data being used without reference to your name or organisational affiliation.*]

Part B: Wider Context for Border Security Research Management

Question 1 asks you to describe the contextual factors affecting how border security research is set up and managed in your country.

1. Contextual Factors

1.1. How much strategic importance is assigned to 'border security' in your country?

☐ High (*i.e. in the top 3 policy priorities*)

☐ Medium (*i.e. in the top 3–10 policy priorities*)

☐ Low (*i.e. not in the top 10 policy priorities*)

[Further comments: please elaborate on how 'border security' is ranked among your country's policy priorities.]

1.2. What are the main border security challenges facing your country (e.g. illegal border crossings, cross-border crime)?

[*Please enter text here*]

1.3. Who are the main actors (types of organisation) involved in commissioning border security research?

☐ National border guard agency

☐ Wider government

☐ Industry/SMEs

☐ Academia

☐ Other (please specify below)

[*Further comments: Please enter text here*]

1.4. Are there any contextual factors (e.g. economic, political or legal factors) that affect the way that border security research is set up, delivered and integrated into operational practice?

[*Please enter text here*]

1.5. What are the main challenges affecting the conduct and management of border security research in your country (e.g. interruptions to funding streams, poor access to research findings, inadequate research management)?

[*Please enter text here*]

1.6. Other comments:

[*Please enter text here*]

Part C: Research Setup and Implementation

Question 2 asks you to outline how research topics are identified and prioritised in your country.

2. Identification and Prioritisation of Research Topics

2.1. Who are the main stakeholders involved in the identification and prioritisation of border security research topics, and what are their roles and responsibilities?

[*Please enter text here*]

2.2. How are research topics relating to border security selected and prioritised, and what are the associated timelines?

[*Please enter text here*]

2.3. Are these research topics clustered into themes (e.g. by institutions, by threat, by technology)? If 'yes', what are they?

☐ Yes

☐ No

[*Further explanation: please enter text here*]

2.4. How would you estimate the balance of high-tech, low-tech, and non-technological & social sciences research commissioned in your country?

☐ Mostly high-tech (i.e. complex technology applied and demonstrated in its final form)

☐ Mostly low-tech (i.e. low complexity technology where scientific research begins to be translated into applied research and development)

☐ Mostly non-technological (e.g. social sciences)

☐ Even distribution across the three areas

[*Further explanation including estimated proportion of each type of research: please enter text here*]

2.5. Is the 'impact potential' of border security research considered when identifying and prioritising research topics?

☐ Always

☐ Mostly

☐ Sometimes

☐ Rarely

☐ Never

[*Further explanation: please enter text here*]

2.6. How (if at all) is 'impact potential' measured?

[*Please enter text here*]

2.7. Other comments

[*Please enter text here*]

Question 3 asks you to describe how specific research projects within each overarching research topic are selected and awarded in your country.

3. Selection of Border Security Research Projects (Specification and Award)

3.1. Who are the main stakeholders involved in the selection of border security research projects, and what are their roles and responsibilities?

[*Please enter text here*]

3.2. What is the process for awarding border security contracts in your country, and what are the associated timelines?

[*Please enter text here*]

3.3. Please give examples of the kinds of assessment criteria used to evaluate research proposals.

[*Please enter text here*]

3.4. How much importance (if any) is assigned to the 'impact potential' of research proposals when evaluating proposals?

[*Please enter text here*]

3.5. In general, how are technical vs. financial offerings weighted when assessing research proposals?

[*Please enter text here*]

3.6. Other comments:

[*Please enter text here*]

Question 4 asks you to provide an overview of the main elements of border security research in terms of funding, personnel and research requirements.

4. Elements of Border Security Research

4.1. Terms of Reference (TOR): Who are the main stakeholders involved in turning technical requirement into TORs in your country, and what are their roles and responsibilities?

[*Please enter text here*]

4.2. TOR: What processes are in place for turning technical requirements into TORs, and what are the associated timelines and costs?

[*Please enter text here*]

4.3. Key actors: Who are the main actors involved in setting up, contributing to and delivering border security research projects, and what are their roles and responsibilities (e.g. project management, monitoring and evaluation (M&E), etc.)?

[*Please enter text here*]

4.4. Key actors: How do these different actors (e.g. researchers, external stakeholders, sponsors) contribute to research? What processes are in place to help them fulfil their roles and responsibilities (project management, M&E, etc.)?

[*Please enter text here*]

4.5. Budget management: Who are the main stakeholders involved in the management of border security research funding, and what are their roles and responsibilities?

[*Please enter text here*]

4.6. Budget management: How is border security research funding managed in your country, and what are the associated timelines and costs?

[*Please enter text here*]

4.7. Other comments

[*Please enter text here*]

Question 5 asks you to describe how the progress of border security research projects is monitored and evaluated.

5. Monitoring and Evaluating the Progress of Border Security Research Projects

5.1. Who are the main stakeholders involved in monitoring and evaluating the progress of border security research projects, and what are their roles and responsibilities?

[*Please enter text here*]

5.2. How are border security projects monitored and evaluated in your country, and what are the associated timelines and costs?

[*Please enter text here*]

5.3. Which indicators are used to monitor and evaluate project progress? How is 'research impact' measured?

[*Please enter text here*]

5.4. Other comments

[*Please enter text here*]

Question 6 asks you to explain how border security research findings are integrated into operational practice in order to achieve impact.

6. Practical Implementation of the Findings of Border Security Research

6.1. Who are the main stakeholders involved in the practical implementation of the findings of border security research, and what are their roles and responsibilities?

[*Please enter text here*]

6.2. What processes are in place to help border security research achieve impact?

[*Please enter text here*]

6.3. Other comments

[*Please enter text here*]

Part D: Lessons Learned and Way Forward

Question 7 asks you to assess how effective you consider border security research management to be in your country.

7. Perceived Overall Effectiveness of Border Security Research Management

7.1. In general, how effective do you consider border security research management in your country (in terms of how well research findings are integrated into operational practice)?

☐ Very effective

☐ Effective

☐ Ineffective

☐ Very ineffective

[*Further explanation: please enter text here*]

7.2. Why do you consider these approaches effective/ineffective (as applicable)?

[*Please enter text here*]

7.3. Other comments

[*Please enter text here*]

Question 8 asks you about what works well in the management of border security research.

8. Benefits of Border Security Research Management

8.1. In your view, what works well in the setup and management of border security research in your country?

[*Please enter text here*]

8.2. Why does this work well?

[*Please enter text here*]

8.3. Other comments

[*Please enter text here*]

Question 9 asks you about what works less well in the management of border security research.

9. Shortcomings of Border Security Research Management
9.1. In your view, what works less well in the setup and management of border security research in your country?
[*Please enter text here*]
9.2. Why does this work less well?
[*Please enter text here*]
9.3. Other comments
[*Please enter text here*]

Question 10 asks you to suggest how the management of border security research in your country could be improved.

10. Lessons Learned
10.1. How can the ways in which border security research is managed be improved?
[*Please enter text here*]
10.2. Are you aware of 'good practices' applied in other countries, sectors or organisations that could help improve approaches in your country?
[*Please enter text here*]
10.3. Other comments
[*Please enter text here*]

Part E: Involvement in EU-Funded Research

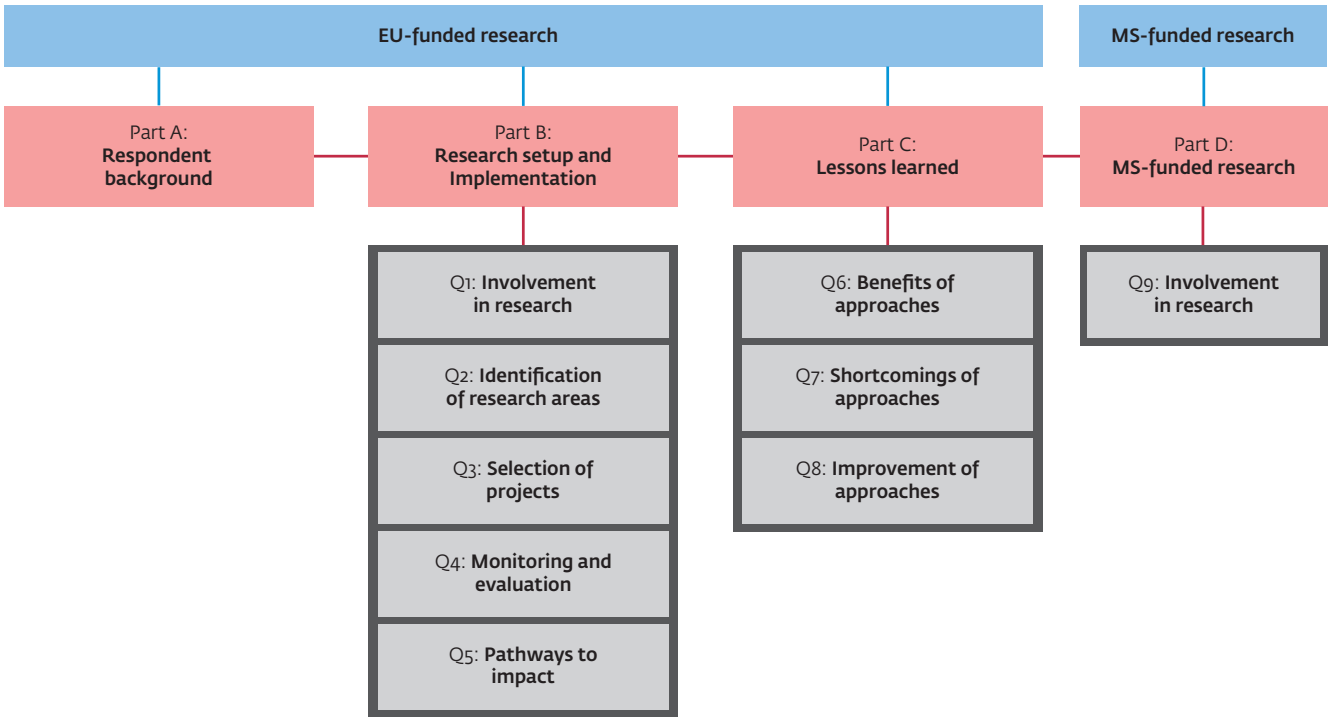
Question 11 asks you to describe your engagement with Horizon 2020 (H2020) and/or FP7 research projects.

11. H2020/FP7 Engagement
11.1. Please describe your country's involvement in H2020 and/or FP7 border security research projects.
[*Please enter text here*]
11.2. How (if at all) are H2020/FP7 research findings integrated into operational practice in your country? Please provide an example.
[*Please enter text here*]
11.3. How could H2020/FP7 research findings be operationalised more effectively in your country in the future?
[*Please enter text here*]
11.4. Other comments
[*Please enter text here*]

Industry and academia survey

As illustrated in Figure C.2, this survey's design was similar to that of the EU MS survey, and considered all steps of the research pathway. Parts A to C focus on research funded and conducted at the EU level, and Part D focuses on the involvement of the respondent in MS-funded research.

Figure C.2 **Industry and academic survey outline**



Part A: Respondent Background

Name	[*Please enter text here*]
Organisational affiliation	[*Please enter text here*]
Country	[*Please enter text here*]
Contact details ***(email and telephone)***	[*Please enter text here. Please note that these contact details will only be used for any points of clarification regarding your completed survey.*]
Attribution preference	[*Please could you confirm your preference regarding how your data is attributed in the report and any resulting publications:* ***Option 1****: 'Full attribution': being named and quoted* ***Option 2****: 'Partial anonymity': only your organisational affiliation (role, organisation – please specify) being associated with your quotes;* ***Option 3****: 'Full anonymity': your data being used without reference to your name or organisational affiliation.*]

Part B: Research Setup and Implementation

Question 1 asks you to describe your organisation's involvement in EU-funded research.

1. Involvement in Border Security Research

1.1. Please describe your organisation's involvement in H2020, FP7 and/or other EU-funded border security research projects.

[*Please enter text here*]

Question 2 asks you to outline how 'areas' of border security research (e.g. maritime security, border crossing points, etc.) are selected and prioritised in the EU.

2. Identification and Prioritisation of Research Areas

2.1. Are you aware of how research topics are identified in the EU, and is it always clear why particular areas have been prioritised?

[*Please enter text here*]

2.2. To what extent are industry, academia and 'end users' (i.e. border guards) consulted regarding their needs and priorities in order to inform the selection of research areas?

[*Please enter text here*]

2.3. In your view, how should border security research areas be identified and prioritised? Are there selection criteria that you think could be helpful?

[*Please enter text here*]

2.4. Are existing border security research areas clustered into themes (e.g. by institutions, by threat, by technology)? If 'yes', what are they?

☐ Yes

☐ No

[*Further explanation: please enter text here*]

2.5. How would you estimate the balance of high-tech, low-tech, and non-technological & social sciences research commissioned in the EU?

☐ Mostly high-tech (i.e. complex technology applied and demonstrated in its final form)

☐ Mostly low-tech (i.e. low complexity technology where scientific research begins to be translated into applied research and development)

☐ Mostly non-technological (e.g. social sciences)

☐ Even distribution across the three areas

[*Further explanation including estimated proportion of each type of research: please enter text here*]

Question 3 asks you to describe how specific projects within these overarching research areas are selected and awarded in the EU.

3. Selection of Border Security Research Projects

3.1. Which stakeholders are responsible for the selection of border security research projects, and what are their roles and responsibilities?

[*Please enter text here*]

3.2. What is the process for being awarded border security contracts in the EU, and what are the associated timelines?

[*Please enter text here*]

3.3. Please give examples of the kinds of assessment criteria used to evaluate research proposals.

[*Please enter text here*]

3.4. How much importance (if any) is assigned to the 'impact potential' of research proposals when these are being evaluated?

[*Please enter text here*]

3.5. In general, how are technical vs. financial offerings weighted when research proposals are being assessed?

[*Please enter text here*]

Question 4 asks you to describe how the progress of border security research projects is monitored and evaluated in the EU.

4. Monitoring and Evaluation (M&E) of Project Progress

4.1. Who is responsible for monitoring and evaluating the progress of border security research projects in the EU?

☐ The research provider (*please elaborate below*)

☐ The sponsor organisation (*please elaborate below*)

☐ Independent evaluation (*please elaborate below*)

☐ N/A – no M&E

[*Please enter text here*]

4.2. Please describe the M&E activities conducted by these stakeholders.

[*Please enter text here*]

Question 5 asks you to explain how border security research findings are integrated into operational practice in order to achieve impact.

5. Pathways to Impact

5.1. How (if at all) are the findings of EU-funded research projects put into operational practice? Please provide examples.

[*Please enter text here*]

5.2. Are there any processes in place to help border security research funded in the EU achieve impact?

[*Please enter text here*]

Part C: Lessons Learned and Way Forward

Question 6 asks you about what works well in the setup and management of border security research.

6. Benefits of Border Security Research Setup and Management
6.1. In your view, what works well in the setup and management of border security research in the EU?
[*Please enter text here*]
6.2. Why does this work well?
[*Please enter text here*]

Question 7 asks you about what works less well in the setup and management of border security research.

7. Shortcomings of Border Security Research Management
7.1. In your view, what works less well in the setup and management of border security research in the EU?
[*Please enter text here*]
7.2. Why does this work less well?
[*Please enter text here*]

Question 8 asks you to suggest how the setup and management of border security research in the EU could be improved.

8. Lessons Learned
8.1. How can the ways in which border security research is set up and managed be improved?
[*Please enter text here*]
8.2. Are you aware of 'good practices' applied in other countries, sectors or organisations that could help improve approaches in the EU?
[*Please enter text here*]

Part D: MS-Funded Research (if applicable)

Question 9 asks you about your organisation's involvement in MS-funded research and about the main types of organisation involved in funding research at the national level.

9. Involvement in Border Security Research

9.1. Please describe your organisation's involvement in MS-funded border security research projects.

[*Please enter text here*]

9.2. What are the main types of organisation involved in commissioning border security research at the national level?

☐ National border guard agency

☐ Wider government

☐ Industry/SMEs

☐ Academia

☐ Other (please specify below)

[*Please enter text here*]

9.3. How (if at all) are the findings of MS-funded research integrated into operational practice? Please provide examples.

[*Please enter text here*]

Appendix D: Frontex workshop supporting materials

This appendix presents the materials used as a basis for discussion at the stakeholder workshop held at Frontex on 5 September 2017, which was part of WP3's data collection methodology. This workshop aimed to assess various options for the establishment of a Frontex-led R&I platform. The overall objective of the workshop was to support an improved understanding of the benefits and limitations of different models ('functional roles') that Frontex may decide to implement.

The research team developed the supporting materials ahead of the workshop, which include an overview of functional roles for a Frontex-led R&I platform (Table D.1). This table corresponds to the functional roles included in Chapter 4 of the main report. Other supporting material includes an expanded table with descriptions and examples of functional roles (Table D.2), the assessment criteria and scoring guidance used by workshop participants (Table D.3 and Table D.4), and the participant worksheet for answering the mission statement question (Box D.1). It should be noted that the functional roles have been updated throughout the main report and in this technical annex following the stakeholder workshop at Frontex, and in response to feedback from the RAND expert group.

Table D.1 **Overview of functional roles**

Theme	Functional role	Name of functional role
Coordinating requirement identification and setting	1.1	Performing horizon scanning to identify security threats and innovation opportunities
	1.2	Analysing the operational needs of end users
	1.3	Other (please specify)
Providing thought leadership	2.1	Conducting research in-house
	2.2	Influencing policy developments
	2.3	Other (please specify)
Facilitating information provision and knowledge transfer	3.1	Centralising information on R&I opportunities
	3.2	Sharing information on operational impacts of research
	3.3	Facilitating knowledge transfer
	3.4	Delivering training and education for MS border guards
	3.5	Other (please specify)
Provide an 'honest broker' function	4.1	Facilitating coordination and cooperation between industry, academia, policy officials and practitioners
	4.2	
	4.3	Supporting coordination and cooperation between industry, academia, nations and investors (e.g. venture capitalists)
		Other (please specify)
Hosting innovation	5.1	Running technology demonstrations
	5.2	Running prize competitions or 'grand challenges'
	5.3	Launching an innovation incubator
	5.4	Other (please specify)
Facilitating access to funding	6.1	Providing direct R&I funding
	6.2	Facilitating access to available funding instruments
	6.3	Using Frontex procurements to 'pull' innovative solutions from the market
	6.4	Other (please specify)

Table D.2 **Descriptions and examples of functional roles**

Theme	Functional role	Name	Description of functional role	Example(s) of relevant innovation model(s) (*Source: RAND Research for Frontex and EDA, 2017*)
Coordinating requirement identification and setting	**1.1**	**Performing horizon scanning to identify security threats and innovation opportunities**	Systematically examining information in order to identify innovation opportunities and potential risks and threats relating to security, the environment and the political climate, which allows for better preparedness and decision making.	**US: DHS S&T**. S&T provides analysis and recommendations on viable technologies, products and services to advance homeland security capabilities. To do this, DHS draws on horizon-scanning activities and a 'technology scouting'[664] process to research and evaluate specific technology landscapes by sifting through global data on technology and market environments.
	1.2	**Analysing the operational needs of end users**	Engaging end users in research planning in order to help ensure that priorities are set and funds allocated in a way that takes operational requirements into consideration. This input can be captured through various mechanisms, including meetings and an analysis of capability gaps.	**US: Science and Technology Resource Allocation Strategy (STRAS)**. This Strategy facilitates cooperation between S&T and end users through quarterly meetings focused on ensuring that R&D efforts remain focused on operational requirements. **US: R&D Integrated Product Teams (IPTs)**. Within DHS, IPTs are tasked with identifying and coordinating DHS R&D efforts in priority mission areas, linking R&D activities with the work of the DHS Joint Requirements Council to close existing technology capability gaps. **US: USCG Idea Submission Review (ISR)**. The ISR process allows for project ideas to be submitted by USCG member and is used to ensure that USCG research, development, test and evaluation programme (RDT&E) efforts are aligned with operational needs and existing technological gaps. **Canada**: annual meetings between Public Safety Canada and operational agencies (Canada Border Services Agency, Royal Canadian Mounted Police and Immigration, Refugees and Citizenship Canada)
Providing thought leadership	**1.3**	**Other (please specify)**	E.g. harmonising border guard and market requirements.	N/A
	2.1	**Conducting research in-house**	Participating in research and innovation, whether through actively leading research projects or contributing to research activities in a more secondary, supportive capacity.	**US: DHS Science and Technology Directorate (S&T)**. S&T is the primary organisation for R&D within DHS, with responsibility for the RD&I programme that involves conducting basic and applied research (among other activities, e.g. testing and evaluation). 'Border security' is one of its areas of focus. **EU: Frontex**. Frontex is tasked to contribute to R&I activities relevant for border control. However, research projects are mainly outsourced and coordinated by its Research and Development Unit (RDU).
	2.2	**Influencing policy developments**	Providing independent advice and recommendations to key decision makers on innovative means to address future security challenges.	**US Defense Innovation Board**. Set up in 2016, the Board[665] is a 15-member panel introduced in order to 'inject a culture of innovation into the Pentagon'. The mission of the DIB[666] is to provide the Secretary of Defense with independent advice and recommendations on innovative means to address future challenges. Proposals put forward include the appointment of a Chief Innovation Officer to serve as a POC for innovation efforts across the DoD, and the creation of a COE for Artificial Intelligence and Machine Learning.
	2.3	**Other (please specify)**	N/A	N/A
Facilitating information provision and knowledge transfer	**3.1**	**Centralising information on R&I opportunities**	Presenting information regarding R&I funding in a consolidated and easily accessible way, e.g. on a single webpage or on an openly accessible database. This can help raise awareness regarding R&I opportunities among research stakeholders, industry representatives and end users, both at the EU and MS levels.	**Gap identified by Frontex study interviewees.** Study interviewees found that more could be done to facilitate information exchange across MS and organisations involved in border security research, particularly given that there is currently no centralised website or database with information about all border security research activities across the EU and its MS.
	3.2	**Sharing information on operational impacts of research**	Systematically communicating information on how research results have been integrated into operational practice after the end of each project, e.g. through press releases, briefings and other communications activities. This is aimed at increasing awareness among end users of the operational benefits of EU-funded research.	**Gap identified by Frontex study interviewees.** While MS participation in EU-funded research remains high, EU MS survey respondents reported that MS often lack access to information regarding project results that could help national border guards integrate these lessons into operational practice.

664 DHS (2016e).
665 Mehta (2016).
666 United States Federal Register (2017).

Theme	Functional role	Name	Description of functional role	Example(s) of relevant innovation model(s) (*Source: RAND Research for Frontex and EDA, 2017*)
Facilitating information provision and knowledge transfer (cont.)	3.3	**Facilitating knowledge transfer**	Systematically capturing lessons learned during project implementation and after project completion to build a repository of good practices, as well as inefficiencies, with a view to supporting MS and other relevant authorities in the setup and management of future research and innovation.	**Frontex**. Through projects, workshops and conferences, the RDU aims to facilitate engagement and exchange of information between border management authorities and providers of research, including research institutes, universities and industry. **NATO**. NATO has set up a Joint Analysis and Lessons Learned Centre aimed at capturing lessons in a systematic way and, among other activities, manages the NATO Lessons Learnt Portal (NLLP).
	3.4	**Delivering training and education for end users**	Delivering training for end users on the use of newly developed technologies to support the uptake and operationalisation of tools, technologies and other solutions developed through R&I.	**US: DHS COE**. COEs are a network of universities conducting research to address homeland security challenges. Among other functions, COEs deliver training, knowledge products and expertise for the homeland security enterprise. **ESA**. In the EU, the ESA provides education and training for astronauts through its European Astronaut Centre (EAC).
	3.5	**Other (please specify)**	N/A	N/A
Providing an 'honest broker' function	4.1	**Facilitating coordination and cooperation between industry, academia, policy officials and practitioners**	Cultivating relationships between research, industry, policy officials and end users in order to help develop greater cross-sector partnerships. This involves moving away from more contractual customer/supplier relationships to an increased focus on innovation in partnership towards a shared endeavour. These relationships would be encouraged by an 'honest broker' organisation, which would also identify opportunities for these partnerships.	**EU: Frontex**. Through projects, workshops and conferences, the RDU aims to facilitate engagement and exchange of information between border management authorities and providers of research, including research institutes, universities and industry. **US: DHS COEs**. Funding opportunities for COEs are open to US universities and colleges (encouraged to partner with industry) and are designed to support DHS-specified homeland security requirements.
	4.2	**Supporting coordination and cooperation between industry, academia, nations and investors (e.g. venture capitalists)**	Supporting innovation by coordinating the actions of third parties, rather than by directly funding or performing the work. For example, facilitating regular interactions among the members of the private venture capital community, small innovative companies and end users.	**US: Defense Venture Catalyst Initiative (DeVenCI)**. DeVenCI supports R&D by coordinating the actions of third parties, rather than by directly funding or performing the work. DeVenCI facilitates regular interactions among the members of the private venture capital community, small innovative companies. DeVenCI has focused on facilitating the purchase of field-ready products and services by DoD, rather than on the discovery and development of new capabilities.
	4.3	**Other (please specify)**	E.g. delivering support to industry to assist them in taking their innovations to market.	N/A
Hosting innovation	5.1	**Running technology demonstrations**	Presenting a prototype or incomplete version of a future system, put together as proof of concept with the purpose of showcasing the possible applications, feasibility, performance and method of a new technology. Demonstrations can be run for potential investors, researchers or end users in order to test the technology and convince these stakeholders of the viability of the chosen approach. It also presents an opportunity to gather end user feedback and make adjustments to the prototype or concept to better deliver value to end users and increase the probability of successful commercialisation.	**EU: H2020**. The *Treaty on the Functioning of the European Union* (TFEU) states that implementing research and technological demonstrations should be conducted in order 'to achieve a European research area'. Demonstration of research products often takes place at the end of H2020 (and FP7) projects. **Canada: Technology Demonstration Program** (TDP).[667] Launched in 2013 and managed by Innovation, Science and Economic Development, the TDP funds 1+ large-scale R&D projects per year, with a focus on conducting industrial research and technology demonstration.
	5.2	**Running prize competitions or 'grand challenges'**	Running innovation competitions to encourage industry experts to attempt to solve innovation challenges. By offering financial or other incentives ('prizes'), these initiatives can help entrepreneurs grow their business ideas, connect them to investors and global markets, and strengthen their innovative capabilities for the benefit of industry, end users and wider society.	**US: DARPA Grand Challenges**: a cash prize competition for US autonomous vehicles, funded in 2004 and 2005 by the Defense Advanced Research Projects Agency – the most prominent research organisation of the US DoD. Other DARPA prize challenges include: Urban Challenge (2007), Network Challenge (2009), Chikungunya Challenge (2014–15) and Robotics Challenge (2012–15).

667 Government of Canada (2017).

Theme	Functional role	Name	Description of functional role	Example(s) of relevant innovation model(s) (*Source: RAND Research for Frontex and EDA, 2017*)
Hosting innovation (cont.)	5.3	**Launching an innovation incubator**	Hosting an innovation 'incubator' or 'hub' on an organisation's premises, which can strengthen innovative capacity by bringing together key stakeholders from academia, industry and end users and by offering skills training and key infrastructure (e.g. labs, IT tools). An incubator can also be virtual (i.e. run online).	**NATO Cyber Incubator**. Launched in 2015, this 'incubator' is a pilot project to test ways of strengthening pre-competition cooperation between industry (including SME), academia and NATO's technical community into defining challenges and investigating innovative solutions for cyber defence. Activities include demonstration projects, discussion forums and interactive workshops.
	5.4	**Other (please specify)**	E.g. a science park (also called a 'university research park' or 'science and technology park'), which is located in close physical proximity to universities, government and private research bodies in order to share knowledge and promote innovation.	N/A
Facilitating access to funding	6.1	**Providing direct R&I funding**	Providing grants, subsidies, subsidised loans and equity financing for R&D, often (although not always) offered on a competitive basis. Non-competitive funding can also be offered through, for example, sole source mechanisms where the funding is intended for a unique technology or where it has to be allocated within a short timeframe.	**EU: Horizon 2020 (H2020):** the largest EU R&I programme, with around €80bn of funding available over seven years (2014–2020), with €73m available for border security research projects in 2014–2015 under 'Secure Societies'. **EU: Frontex-funded research**. Frontex has funded research projects since 2009, with annual funding increasing from 2009 to 2015. These projects are mainly outsourced and coordinated by Frontex's Research and Development Unit (RDU). **US: Department of Homeland Security (DHS) Centers of Excellence (COE)**. COEs are a network of universities conducting research to address homeland security challenges. Among other functions, COEs award research funding (e.g. recent funding opportunity[668] announced by the Borders, Trade and Immigration Institute (BTI)). There are currently 12 centres, 10 of which are active, with each focused on a unique homeland security need.
	6.2	**Facilitating access to available funding instruments**	Raising awareness on how to access EU funding opportunities. For each funding programme, this involves providing details regarding its purpose, activities, timeframe, budget, eligibility, and application process.	**European Defence Agency** (EDA)[669]. The EDA aims at raising awareness across the European Defence Technological and Industrial Base on how to access EU funding opportunities, with a particular focus on European Structural and Investment Funds, the new EU COSME (Competitiveness of Enterprises and SMEs) Programme and H2020.
	6.3	**Using procurements to 'pull' innovative solutions from the market**	Providing funding for R&I projects designed to address short-term, high-priority end user requirements that need to be addressed quickly.	**US: Rapid Innovation Fund (RIF)**. Provides a collaborative vehicle for small businesses to provide DoD with innovative technologies that can be rapidly inserted into acquisition programs that meet specific defence needs. Administered by the Office of the Secretary of Defense (OSD) Assistant Secretary of Defense for Research and Engineering (ASD R&E) and Office of Small Business Programs (OSBP).
	6.4	**Other (please specify)**	E.g. debt-sharing schemes (which encourage innovation by reducing the risk to lenders and investors, e.g. through partial cover of losses).	N/A

Table D.3 **Qualitative assessment criteria**

Criterion	Definition
Feasibility	The ease with which Frontex can implement each option[670] in practice
Impact	How far each option will increase the likelihood of research and innovation improving operational practices
Stakeholder appeal	The attractiveness of each option to key stakeholders with decision-making power and access to resources

668 DHS (2017).
669 EDA (2017).
670 At the external stakeholder workshop, 'functional roles' were referred to as 'options'. In Appendices D and E, the use of the term 'option' refers to the functional roles described throughout the main report and elsewhere in this Technical Annex.

Table D.4 **Quantitative scoring metrics**

	1	2	3	4
General definition	**Very low**	**Quite low**	**Quite high**	**Very high**
Feasibility	Very low feasibility, i.e. it would be almost impossible to implement the option.	Quite low feasibility, i.e. the option would require major changes for it to be implemented.	Quite high feasibility, i.e. the option would require minor changes for it to be implemented.	Very high feasibility, i.e. the option is readily implementable.
Impact	Very low impact, i.e. the option will not increase the likelihood of research and innovation improving operational practices.	Quite low impact, i.e. the option is fairly unlikely to increase the likelihood of research and innovation improving operational practices.	Quite high impact, i.e. the option is likely to increase the likelihood of research and innovation bringing minor improvements in operational practices.	Very high impact, i.e. the option is likely to increase the likelihood of research and innovation bringing major improvements in operational practices.
Stakeholder appeal	Very low stakeholder appeal, i.e. the option is highly unlikely to attract the support of key stakeholders.	Quite low stakeholder appeal, i.e. the option is quite unlikely to attract the support of key stakeholders.	Quite high stakeholder appeal, i.e. the option is quite likely to attract the support of key stakeholders.	Very high stakeholder appeal, i.e. the option is very likely to attract the support of key stakeholders.

Box D.1 **Frontex's mission statement**

What role should Frontex be playing in the field of research, development and innovation for border security? What do you see as being the added value of Frontex in this field?

In answering the first part of the question, please consider what Frontex should (1) continue to do, (2) stop doing, (3) start doing, or (4) do differently in the context of research, development and innovation.

Appendix E: Frontex workshop summary

This appendix provides an overview of the stakeholder workshop held on 5 September 2017, before summarising the discussions that took place. Relevant reference materials, including the tables of functional roles and a description of the scoring approach applied at the workshop, are presented in Appendix D.

Workshop overview

On Tuesday 5 September 2017, RAND Europe organised a workshop at Frontex to assess various options[671] for the establishment of a Frontex-led R&I platform. There were approximately 28 participants in attendance throughout the day. The majority of the participants were MS representatives from border guard agencies. Other participants included representatives from Frontex and the European Commission.

The workshop opened with a brief overview of the study and workshop objectives. Participants were then divided into three groups for sessions one and two. Session one, 'Functional options for a Frontex-led R&I platform' involved participants developing a mission statement for a Frontex-led R&I platform and assessing a set of functional roles through qualitative discussion.[672] In session two, 'Ranking of functional options', participants were asked to rank the functional roles according to their 'feasibility'[673] and 'impact'.[674] Session three, 'Challenges, opportunities and practical considerations', summarised the main discussion points and the preferred functional roles of each group.

671 Functional roles are also referred to as 'options' in Appendices D and E (see previous footnote).

672 Functional roles are outlined in Table 1.

673 'Feasibility' was defined as 'the ease with which Frontex can implement each option in practice'.

674 'Impact' was defined as 'how far each option will increase the likelihood of research and innovation improving operational practices'.

Summary of discussion

While functional roles scored highly across the board, some roles scored more favourably than others. However, it should be noted that participants tended to conflate 'familiarity' with 'feasibility', in that they often gave high feasibility scores to those roles that they were particularly familiar with.[675]

The first theme, requirements and identification setting, and its two functional roles, 'perform horizon scanning to identify security threats and innovation opportunities' (1.1) and 'analyse the operational needs of border guards' (1.2), were highly rated. Regarding thought leadership, there was divergence in opinion between participants. Role 2.1, 'conducting research in-house', was poorly received by participants. They agreed that Frontex should not develop tools or technologies, but instead it should leverage its existing knowledge from external research outputs. Based on this, participants said that Frontex could create knowledge, risk analyses and overviews of past and current work. However, participants found the 'influencing policy developments' role (2.2) feasible and impactful, stating that by having an influence on policy developments, Frontex could better help connect operational needs with the European Commission policy context. Participants also said that having Frontex in that role would help Frontex spend money more effectively as they have an in-depth understanding of border security research.

Under information sharing, participants stated that convening expertise and disseminating findings is very important for Frontex and can help avoid duplication of project work. They also said that it was good for Frontex to know experts in MS conducting these projects, and to continue to build relationships with them. Participants also felt that Frontex could offer help with procurement procedures, for example by providing a checklist. Role 3.1, 'centralise information on R&I opportunities', was highly rated – particularly on feasibility – as participants felt that if this entailed the creation of a database it would not be too difficult to implement. Regarding role 3.2, 'share information on the operational impacts of research', opinion was divided. While impact was highly rated, feasibility scores ranged between 2 and 4.

'Deliver training and education for MS border guards' (role 3.4) was highly rated overall. While some participants stated that industry should be undertaking product training and education as they develop the technology, the participants suggested that Frontex should also provide baseline training. Other participants said that Frontex could help MS with the testing of border security technologies and also help ensure that the output meets end user needs. Participants said training is already being delivered and its impact is high. Role 3.3, 'facilitate knowledge transfer', received mixed scores: while feasibility was high, views on impact varied, as participants stated that this depended on MS knowledge and priorities.

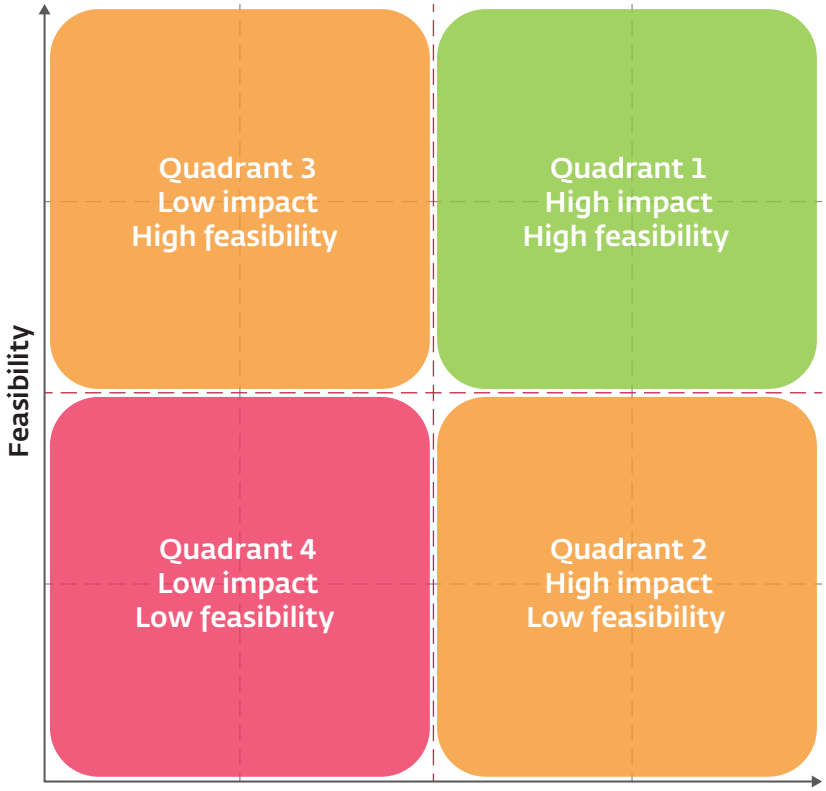
Under the honest broker theme, participants gave high ratings to the two functional roles, 'support coordination and cooperation between industry, academia, nations and investors (e.g. venture capitalists)' (4.2), and 'faciliate coordination and cooperation between industry, researchers, policy officials and practitioners' (4.1). Participants agreed that Frontex needs to play the role of a convenor and communicator. The groups said that while Frontex fulfils this requirement already, there is a risk of Frontex being solicited directly by industry and becoming disconnected from the needs of MS.

675 It should be noted that the numbers in this appendix correspond to the updated numbering of functional roles, as presented in Appendix D.

Participants noted that hosting innovation should be focused on the specific needs of MS and end users. While role 5.1, 'run technology demonstrations', scored highly on feasibility and impact, roles 5.2 and 5.3, 'host prize competitions' and 'launch an innovation incubator', scored poorly in comparison. One reason given by participants was that 'prize competitions' and 'innovation incubators' are not Frontex's core business. Another reason related to logistical issues, or example the possibility that a jury would need to be set up to assess the competition, and that MS may not want to share new developments more widely.

Regarding funding, participants broadly saw Frontex as a coordinator and facilitator to help MS find new funding. Participants rated role 6.1, 'provide direct R&D funding', quite highly. Role 6.2, 'facilitate access to available funding instruments' was also seen as important, with suggested ways of improving this including the creation of a website and more proactive dissemination of information to MS (e.g. through newsletters). Participants noted that to deliver these tasks, Frontex would need to invest in human resources to identify and disseminate information, and also to work closely with the European Commission to obtain information early on. They also pointed out that not all MS would be eager to share the results of their projects. Regarding role 6.3, 'use Frontex procurements to 'pull' innovative solutions from the market', some participants felt that this overlooked the fact that MS need tailor-made solutions to respond to their unique context and border challenges.

Figure E.1 **Matrix of functional roles**



Overall, the matrix (see Figure E.1) showed that participants saw most functional roles as having high impact and high feasibility for a Frontex-led R&I platform. In particular, information sharing, influencing policy developments, being an honest broker, providing training and education, and requirements identification and setting all were ranked highly by participants. Participants appeared to place less importance on Frontex being directly involved in conducting in-house research; rather, they felt that Frontex should focus its efforts in this area on leveraging research conducted externally.

Questions and comments

According to one participant, the reason why grand challenges scored more poorly than other functional roles could be due to a lack of familiarity. This participant observed that grand challenges can be very impactful, can incentivise the involvement of small- and medium-sized enterprises, and can be an indirect way of stimulating the market and creating new ideas. According to the participant, grand challenges can also help to develop certain products and technologies faster and with lower budgets, as well as setting a baseline for future research.

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