PEN-CP
Pan-European Network of Customs Practitioners

Customs Innovations Resulting from EU Projects

Game Changers or Forgotten Ideas?

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Credits

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1 Introduction

As global trade grows and security threats evolve, customs administrations face mounting pressure to adopt innovative solutions to effectively fulfill their border control duties. However, limited resources, weak connections with innovators, and risk-averse mindsets often hinder the adoption of new technologies within customs organizations. EU-funded research and development projects tackle these challenges by offering a platform to customs to drive innovation[1] in collaboration with industry and academic partners.

1.1 Customs innovation under EU research and innovation programmes

The EU Framework Programme for Research and Innovation is the EU's primary funding mechanism for advancing research and innovation. The current programme, Horizon Europe (2021–2027), builds on its predecessors—Horizon 2020 (2014–2020), Framework Programme 7 (2007–2013), and earlier initiatives. Projects funded under these programmes have played a valuable role in driving technological advancements and innovative solutions across various scientific disciplines, policy areas, industries, and government functions (DG RTD 2020).

The European Union has long recognized the importance of research and innovation in strengthening border security, enhancing customs operations, and ensuring the smooth and secure flow of goods across EU borders. EU-funded customs-focused projects have primarily been funded under the Civil Security umbrella of the EU Framework Programmes. Since 2007, the start of the Framework Programme 7, more than 800 projects have been launched under the Civil Security theme, covering areas such as fighting crime and terrorism, border management, resilient infrastructure, disaster resilience, security research and innovation, cybersecurity, and secure online environments[2].

Customs authorities have become increasingly engaged in these research and innovation projects. Over the years, their involvement has evolved from being passive recipients of technological advancements to becoming key contributors in shaping research agendas, defining operational needs, and testing emerging solutions. Through partnerships with research institutions and industry stakeholders, customs administrations have provided invaluable insights to ensure that technological developments align with real-world enforcement challenges and operational requirements.

Among these EU projects, several have directly contributed to innovation in customs enforcement, spanning areas such as data and analytics, non-intrusive inspection, and laboratory technologies. Customs agencies have not only benefited from technological advancements but have also actively participated in pilot projects, testbeds, and collaborative research efforts to refine and deploy new solutions in border environments. Their growing engagement reflects a broader trend in which customs administrations are embracing innovation-driven approaches to enhance security, facilitate trade, and adapt to evolving threats and global trade dynamics.

[1] According to Eurostat (2025), "innovation is the use of new ideas, products, or methods where they have not been used before." It arises from technological advancements, novel combinations of existing technologies, or the application of newly acquired knowledge within an enterprise.

[2] These initiatives have been supported with €3.9 billion in EU funds (Mancini and Manchon 2025).

1.2 Why customs need EU research and innovation projects

Over the years, more and more customs administrations have joined EU-funded research and innovation projects as active partners[3]. They have also come to recognize the benefits of EU projects—particularly in fostering cooperation with academic and technology partners. After decades of participation, it has become increasingly clear why customs benefit from EU research and development projects: they help address four common innovations management challenges customs authorities face:

- **Priority on daily operations over strategic innovation.** Customs agencies often lack the expertise, time, and funding needed to explore, develop, and adopt promising innovations. This is largely because their focus on daily operations consumes the limited resources that could otherwise be allocated to long-term capability building and innovation activities. EU project funding helps address this challenge by enabling customs to hire dedicated personnel to track and drive the progress and impact of customs-related innovations, as well as actively participate in research and development activities.
- **Inefficient markets for customs innovations.** The market for customs solutions suffers from both fragmented demand and limited supply. Each country has a single customs administration that follows national rules and procurement priorities, resulting in a small and divided customer base. At the same time, few suppliers can provide innovative solutions for the fragmented customs clientele at scale and competitive prices. EU projects help invigorate the market by connecting customs administrations with security innovators—including multinationals, small and medium enterprises, research institutes, and academia. These projects create a platform for customs to articulate their shared needs and plan for joint procurement activities, forming a more unified customer base. In turn, this enables the innovation industry to develop solutions that better align with customs requirements.
- **Lack of cooperation with security innovators.** Customs could greatly benefit from closer collaboration with security innovators in industry, academia, and the broader law enforcement community, where fresh ideas and cutting-edge technologies emerge. However, integrating small and medium enterprises, start-ups, and scale-ups into larger innovation ecosystems remains a challenge. Especially that smaller entities often lack the resources and networks needed to engage with customs authorities and access growth opportunities. EU project consortia help bridge this gap by bringing customs and security innovators together to tackle customs-defined challenges.
- **Risk-averse organizational culture:** Customs administrations often have a conservative stance to change, making the adoption of new innovations challenging. While innovation inherently involves a risk of failure, the risk-averse nature of customs organizations can slow progress. EU projects help mitigate this problem by providing a conducive environment for customs to experiment with innovative ideas and engage in high-risk, high-reward ventures that drive meaningful change.

[3] This shift has been reinforced by recent project calls that include eligibility criteria requiring the active involvement of customs authorities in EU-funded projects. This ensures the participation of key end-user groups, strengthening the relevance and impact of these initiatives for customs and other security practitioners.

Overall, it is evident that EU projects can offer significant benefits for customs by driving innovation through stronger partnerships, enhanced resources, and improved coordination. However, a crucial practical question remains: What lasting impact have innovations from these projects had on the customs community? In other words, have EU-funded projects led to transformative, game-changing solutions that reshape customs operations? Or have the project innovations quickly faded into obscurity, forgotten once project funding ends? Answering this question is essential—not only to assess the impact of past EU projects but also to shape the future of customs innovation in Europe.

1.3 Research approach and methodology of this study

This study aims to assess the impact of EU-funded innovation projects on customs and collect evidence of the upscaling and sustained adoption of project outcomes beyond EU funding. This investigation began with the identification of a shortlist of 20 EU research and innovation projects from the Framework Programme 7 and Horizon 2020 funding cycles, covering a broad range of technologies relevant to customs security. From this initial list, twelve projects were selected based on the availability of key project contributors for interviews.

Data collection involved semi-structured interviews with project coordinators, customs partners, and key technology partners. The interview questions focused on evaluating post-project impact and the continuity of outcomes, covering topics such as immediate actions after project completion, commercialization of technologies, adoption by customs, further research initiatives, contributions to broader technology development, ongoing partnerships, untapped opportunities, integration into products or services, and plans for continued development. The complete set of interview questions is provided in Annex A of this report.

In addition to interviews, a comprehensive review of project materials archived on the EU's CORDIS online platform was conducted. This included an analysis of project deliverables, result summaries, leaflets, and promotional materials to gather further insights into EU-supported customs-related projects and their lasting contributions.

2 Customs innovations from twelve EU projects

EU-funded projects have driven significant advancements in customs enforcement operations, improving data-driven risk management, non-intrusive inspection, and laboratory capabilities. Many of the innovations have continued to evolve beyond their original projects, either through adoption by customs authorities, integration into commercial solutions, or further refinement in new research initiatives.

2.1 DIRAC: Advanced technologies for detecting illicit drugs

The DIRAC project was a pioneering initiative focused on developing advanced technologies for detecting illegal drugs. Through research and engineering, the project successfully produced three groundbreaking prototypes designed to enhance drug detection capabilities in various operational scenarios.

The first prototype, the Identification Unit, employed infrared absorption spectroscopy to identify drug traces on surfaces or in liquids. Its primary advantage was its ability to deliver rapid on-site analysis, making it an invaluable tool for frontline customs officers at borders. The second prototype, the Vapor Detection Unit, incorporated gas chromatography to detect drug vapors in the air. This device proved particularly effective in screening packages and luggage for concealed drugs. Lastly, the Salt Detection prototype made use of a specialized technique to identify drug salts, even at low concentrations, adding another layer of precision to illicit substance detection.

These prototypes underwent rigorous laboratory and field testing, demonstrating high levels of effectiveness in real-world conditions. However, despite their success, the DIRAC project's technological advancements did not translate into a commercial product. The primary obstacles included funding constraints and a series of technical challenges that needed to be addressed before the prototypes could become viable for widespread use. Among these challenges were the need for miniaturization to enhance portability, integration of all three functionalities into a single, versatile unit, development of an intuitive user interface, increased robustness to ensure durability in various environmental conditions, and compliance with certification and regulatory standards for commercial and legal acceptance.

Following the conclusion of the DIRAC project, researchers and developers continued working on refining detection methods and addressing the identified limitations. One of the key areas of focus was improving sensitivity and detection limits, particularly concerning semi-volatile substances. This led to modifications in the analyzer configuration used during the project.

Further projects built upon the foundation laid by DIRAC, though with different focuses. The RISEN project concentrated on crime scene analysis, leveraging detection technologies to enhance forensic investigations. Meanwhile, the ROCSAFE project explored the application of similar technologies in the context of CBRN (chemical, biological, radiological, and nuclear) threats, moving beyond the scope of drug detection for customs enforcement.

An important insight gained from the DIRAC project was that customs authorities prioritized the detection of significant quantities of illicit drugs over trace elements. This understanding informed subsequent research and development efforts, guiding the refinement of detection technologies to

better align with operational needs. As a result, ongoing proposals were being prepared to integrate DIRAC's technological advancements into customs and border management frameworks, signaling a continued commitment to applying and improving these innovative detection methods in practical, high-impact scenarios.

Table 1 DIRAC project overview

DIRAC	
Technology focus	Drug detection technologies using infrared absorption spectroscopy, gas chromatography, and specialized salt detection techniques to enhance the identification of illicit substances in various operational settings.
Customs partners	No customs partners in the project[4]
Targeted threats	Illicit drugs
Project timeline	2010-2014
Follow-up developments	Further development in ROCSAFE and RISEN projects.

2.2 MODES_SNM: Modular detection system for special nuclear material

The MODES_SNM project was launched to develop a modular, mobile detection system capable of identifying radioactive and special nuclear materials[5] with improved accuracy. This system incorporated high-pressure scintillation detectors using noble gases like helium and xenon to detect gamma rays, fast neutrons, and thermal neutrons. By improving the sensitivity of radiation detection, MODES_SNM aimed to identify weak or shielded radioactive sources while providing spectroscopic analysis to determine gamma-ray emitters. The project ran from January 2012 to June 2014, and the Irish customs actively participated as a key partner.

The MODES_SNM prototype underwent extensive real-world testing under customs supervision at Rotterdam Port, Heathrow Airport, Dublin Port, and a Swiss land border crossing. These trials included scanning commercial traffic and detecting radioactive test sources provided by customs agencies for demonstration purposes. Notably, the system successfully identified a neutron source in Dublin, demonstrating its capability to detect shielded materials effectively. Customs officers from all test locations contributed test sources and scenarios, ensuring a comprehensive evaluation. The results highlighted the system's high accuracy and sensitivity, with an acceptable false alarm rate while remaining fully mobile and rapidly deployable. The prototype functioned effectively in both stationary and mobile modes, validating its usability for customs agencies.

The project successfully delivered a van-mounted modular radiation detection system equipped with specialized gas scintillators. The system met the International Atomic Energy Agency (IAEA) standards for portable radiation scanners, making it a practical solution for field deployment by

[4] Belgian customs provided strong support during field trials even if they were not funded partners in the project.

[5] Special nuclear materials refer to fissile materials such as uranium-233, uranium-235, and plutonium, which can sustain a nuclear chain reaction and are primarily used in nuclear reactors and weapons (USNRC 2023).

emergency responders. The user-friendly interface further enhanced its operational efficiency. The technology proved capable of detecting shielded special nuclear material, confirming its effectiveness for border security applications. As a result, one patent was filed to protect the innovative detector design.

By the end of the project, the MODES_SNM system had reached a high technology readiness level[6], leading to its commercialization. Several enforcement agencies, including customs authorities, adopted the system, and an updated version remains in production today. Additionally, some of the detection techniques developed during the project have been integrated into fixed radiation portal monitors currently in use by customs agencies. Building on the success of MODES_SNM, the ENTRANCE project was launched to further develop a modular, portable radiation detection system, incorporating lessons and technology from the MODES_SNM project.

The MODES_SNM project demonstrated significant advancements in radiation detection technology, delivering an effective, mobile, and adaptable solution for detecting nuclear threats. With its successful commercialization and integration into enforcement operations, the project has made a lasting impact on nuclear security and radiation monitoring at borders.

Table 2 MODES_SNM project overview

MODES_SNM	
Technology focus	A mobile, modular detection system for radioactive and special nuclear materials by advancing high-pressure scintillation cell technology using noble gases like helium-4 and xenon, integrating fast and thermal neutron detectors alongside gamma-ray spectroscopy to enhance detection accuracy, assess shielding effects, and provide real-time analysis through an advanced information system.
Customs partners	Ireland
Targeted threats	Shielded and weak radioactive sources, including special nuclear materials.
Project timeline	2012-2014
Follow-up developments	Commercialization, adoption by several enforcement agencies, and integration of its detection techniques into existing radiation portal monitors.

2.3 HANDHOLD: Mobile detection and sensor technology

The HANDHOLD project aimed to develop a portable sensor system for detecting concealed threats such as drugs, tobacco, explosives, biological hazards, and radioactive materials. Designed to complement detection dogs, the system leveraged advanced olfactory detection technology, sensor

[6] See Annex B for the descriptions of technology readiness levels.

integration, and low-power embedded computing to enhance customs and law enforcement capabilities. The project involved the Irish customs and ran from April 2012 to March 2016.

A major outcome of HANDHOLD was the development of a handheld detection device incorporating novel airflow mechanisms and real-time data analysis. The project produced two prototype versions equipped with four new sensors utilizing mid-Infrared spectroscopy and fluorescence quenching techniques. A geographical mapping tool was also developed to assist mission commanders in visualizing detection data. Laboratory tests confirmed the system's ability to detect cocaine and tobacco, while a radioactive material sensor was successfully field-tested in a postal facility. A user interface was designed to support operational use, but the requirement to integrate multiple sensors into a single platform impacted individual sensor performance, particularly in comparison to specialized radiation detection devices available at the time.

Following the project's conclusion, additional research was conducted in collaboration with Irish customs, where a drug detection sensor analyzed vapors extracted from a maritime container with a small amount of cocaine. The results were promising, but no further studies were pursued. Some sensory techniques from HANDHOLD were later adapted in the ROCSAFE project, though without a customs-specific focus. Despite its technological advancements, no further commercialization efforts were undertaken, limiting the broader adoption of the HANDHOLD system.

Table 3 HANDHOLD project overview

HANDHOLD	
Technology focus	A cost-effective, portable, and sensor-based detection platform to complement detection dogs in identifying illicit substances, leveraging advanced airflow mechanisms, real-time data analytics, and low-power embedded computing for enhanced border security operations.
Customs partners	Ireland
Targeted threats	Illicit drugs, explosives, chemical, biological, radiological, and nuclear (CBRNE) substances, as well as other contraband smuggled across borders.
Project timeline	2012-2016
Follow-up developments	Further advancements in the ROCSAFE project with a renewed focus beyond border security, aimed at ensuring the safety of crime scene investigators.

2.4 ACXIS: Automated comparison of X-ray images for cargo scanning

The ACXIS project aimed to enhance cargo scanning capabilities by developing a manufacturer-independent reference database for X-ray images. Running from September 2013 to May 2017, it involved customs administrations from Switzerland and the Netherlands, alongside research centers and industry partners. The project sought to standardize X-ray images from scanners from different

manufacturers, develop algorithms for automated threat detection, and create a training simulator to improve inspection officer capabilities.

A major outcome of ACXIS was the development of the first algorithm specifically designed for interpreting container X-ray images. By integrating historic detection images, mock-ups of illegal cargo, and legitimate cargo into a comprehensive database, the system enabled automated comparisons to enhance threat recognition. The algorithm was successfully integrated into a commercial environment, allowing real-time analysis by both machine learning models and human screeners. A demonstration in Rotterdam validated the system's effectiveness, receiving positive feedback from customs officials. Additionally, the project contributed to scientific research, leading to several academic publications that remain a key resource in X-ray image interpretation.

Despite its technical success, the full adoption of ACXIS technology faced challenges. While major X-ray technology developers began incorporating algorithm-based image interpretation into their commercial offerings, Dutch Customs struggled to integrate the system due to IT infrastructure limitations. These challenges reflected broader difficulties in implementing AI-driven solutions within tightly regulated government functions.

Over time, the principles developed in ACXIS influenced the industry, with many European customs administrations piloting the technology. The widespread adoption of automated image recognition in cargo screening took years, as infrastructure and processes had to evolve to support the new approach. The project also introduced the concept of generating synthetic X-ray images to train machine learning models, addressing data scarcity—a method that has since become an industry standard. ACXIS laid the groundwork for commercial X-ray interpretation algorithms, shaping the future of automated cargo screening and AI-powered non-intrusive inspection systems.

Table 4 ACXIS project overview

ACXIS	
Technology focus	A manufacturer-independent reference database for X-ray cargo images, standardizing scanner outputs across systems from different manufacturers, and implementing automated algorithms to identify potentially illegal cargo using historical and simulated images.
Customs partners	The Netherlands and Switzerland
Targeted threats	Illicit cargo of all kinds.
Project timeline	2013-2017
Follow-up developments	Pilot implementation by customs and contributions to the advancement of automated and AI-driven non-intrusive inspection solutions, as well as the use of synthetic X-ray images for training detection models. Major X-ray technology manufacturers began working on building and commercializing their own algorithms.

2.5 CRIM-TRACK: Sensors for detecting of illegal chemical substances

The CRIM-TRACK project aimed to develop a portable, rapid, and low-cost detector using a disposable micro-colorimetric chip for detecting illegal drugs, drug precursors, and homemade explosives. Envisioned as a "mechanical sniffer dog," the system sought to enhance customs administrations' ability to identify threat materials in closed consignments by analyzing emitted vapors. Running from January 2014 to April 2017, the project involved Dutch Customs in testing and development.

The project successfully produced three laboratory prototypes—Wellington, White Horse, and Warden—each progressively smaller to move towards a fully portable border inspection toolkit. While the prototypes demonstrated the technology's potential in controlled environments, they were not yet suitable for field deployment and required further refinement. Despite plans for commercialization by 2020, no direct commercial product emerged from CRIM-TRACK.

Although the project's specific prototypes were not brought to market, the core principle of colorimetric detection has been applied in commercial products developed independently, based on different chemical foundations. Dutch customs used a commercial detection device leveraging similar technology until recently, indicating that CRIM-TRACK's research contributed to advancements in operational tools. While not a direct outcome of the project, colorimetric detection has continued to evolve in various applications.

The project leader remained active in the field of contact chemistry, shifting focus towards food safety sensor development—an area considered less complex than customs threat detection. Some insights from CRIM-TRACK may have influenced this work, though no direct commercialization has taken place. Multiple patents were filed as a result of the project, with the possibility that the technology's principles have contributed to broader sensor research and development.

Table 5 CRIM-TRACK project overview

CRIM-TRACK	
Technology focus	A portable, rapid, and low-cost colorimetric detection system capable of identifying illegal substances by analyzing emitted vapors, aiming to enhance customs inspections with a "mechanical sniffer dog" approach.
Customs partners	The Netherlands
Targeted threats	Illicit drugs, their precursor chemicals, and homemade explosives with potential expansion to nuclear materials, nerve agents, and other illegal substances.
Project timeline	2014-2017
Follow-up developments	Colorimetric detection technology principles serve as a foundation for scientific research and may have been integrated into various commercial products and applications.

2.6 CORE: Border security through end-to-end supply chain visibility

The CORE project aimed to strengthen security and resilience in global supply chains while ensuring efficiency in cross-border trade and logistics. Running from May 2014 to June 2018, CORE brought together key stakeholders, including customs authorities, law enforcement, shippers, and logistics providers. Customs agencies from Belgium, the Netherlands, and the UK actively participated in large-scale technology demonstrations, testing solutions to enhance supply chain transparency and customs risk management. CORE was the largest customs-related EU project under the Horizon Programme, both in terms of the number of partners and the amount of funding.

After the CORE project ended, its impact continued across multiple sectors, driving advancements in supply chain data sharing, customs processes, policy reform, and sustainability. One of its most visible outcomes was the development of TradeLens, a commercial platform by IBM and Maersk that digitized supply chain data, enabling real-time information exchange among customs, businesses, and logistics providers across international trade lanes. Despite its eventual discontinuation, TradeLens demonstrated the potential of digital platforms in global trade.

CORE also influenced customs risk management by proving the value of business data in enhancing risk assessment. Dutch customs integrated this concept into their Customs Risk Information System, which consolidates real-time shipment data and uses artificial intelligence for more precise risk evaluations. At the EU level, the project helped shape policy discussions, contributing to a proposed shift toward a "trust and check" customs model, allowing trusted traders to provide continuous data access for customs instead of filing declarations for each shipment.

Several spin-off projects extended CORE's principles into new areas. The PROFILE project explored the use of big data to enhance customs risk assessment, improving accuracy and efficiency. The 'Data Pipeline for Circular Economy Monitoring' applied CORE's data-sharing framework to track materials throughout their lifecycle, from production to disposal, supporting sustainability initiatives. At the same time, emerging supply chain platforms, including airfreight solutions like ONE Record of the International Air Transport Association (IATA), built upon the CORE's data pipeline model, while third-party companies captured real-time data for logistics optimization, predictive analytics, and automated customs processing.

Table 6 CORE project overview

CORE	
Technology focus	Integration of connectivity and data analytics technologies into a scalable, cost-effective digital ecosystem that strengthens global supply chain security, enhances operational efficiency, and ensures regulatory compliance.
Customs partners	Belgium, Netherlands, and the UK
Targeted threats	A wide range of threats to global supply chains, including terrorism, smuggling, counterfeiting, tax fraud and sabotage.
Project timeline	2014-2018

Follow-up developments	Piloting and operational integration of risk assessment solutions by a customs partner, contributing to the advancement of digital logistics platforms, and further developments in the PROFILE and Data Pipeline for Circular Economy Monitoring projects. Inspired the development of the Customs Risk Information System (CRIS) and the ONE record system of IATA. Lessons learnt integrated into the Customs Reform Package.

2.7 C-BORD: Multi-technology solutions for smarter container inspection

The C-BORD project enhanced container inspection at EU borders by developing a detection toolbox integrating five complementary technologies: improved X-rays, target neutron interrogation, photofission, sniffing[7], and passive radiation detection. These non-intrusive inspection methods targeted a wide range of contraband, including cigarettes, illicit drugs, misdeclared goods, as well as hazardous materials such as explosives, nuclear material, chemical and biological warfare agents, and radioactively contaminated goods. Running from June 2015 to November 2018, the project involved customs authorities from the Netherlands, Poland, and Hungary.

The project successfully developed and integrated advanced detection technologies into a single user interface, significantly improving customs screening capabilities. Passive radiation detection systems were enhanced with new threat lensing algorithms and machine learning models to detect special nuclear material with greater accuracy, reducing false alarms and improving threat classification. The system outperformed international standards, integrating radiation and X-ray data into a C-BORD multi-technology user interface for enhanced decision-making.

The Rapidly Relocatable Tagged Neutron Inspection System was a key trial technology in C-BORD, enabling the detection of explosives and contraband drugs through advanced material classification. By identifying elemental signatures such as nitrogen, carbon, and oxygen, the system improved accuracy over previous inspection methods. Advanced classification algorithms, including a fuzzy decision tree, helped differentiate between organic materials, drugs, explosives, and benign substances, providing customs officials with precise insights. Compared with conventional X-ray radiography, this C-BORD technology demonstrated superior 3D scanning and material detection capabilities, detecting even small amounts of explosives in cargo containers.

The project also made significant advancements in photofission technology, integrating a high-energy linear electron accelerator with specialized detection modules to identify fissile materials such as uranium and plutonium. Real-world testing at Rotterdam Port validated the system's ability to complement existing X-ray scanning processes, providing reliable Special Nuclear Material detection in diverse border environments. Additionally, a graphical user interface was developed to streamline operations, allowing efficient management of both active and passive detection modes.

To improve the detection of volatile substances, the project advanced evaporation-based detection systems, employing sensor arrays, biorecognition elements, and thermal desorption units for drug and explosives identification. A sniffer trolley and large-volume sampling system were developed and tested in major European ports, demonstrating a 63% success rate in identifying contaminated

[7] Refers to the detection of trace amounts of volatile compounds, including explosives, narcotics, and other illicit substances.

containers. Despite facing challenges in achieving technology readiness level 7 (system prototype demonstration in operational environment), improvements in pattern recognition software have paved the way for future commercialization of these technologies.

C-BORD also introduced enhanced X-ray technologies, improving image quality, material discrimination, and operational efficiency. Algorithms for de-overlapping materials and estimating material equivalency enhanced customs officers' ability to differentiate objects inside containers. These improvements led to two patents, with additional innovations planned for implementation in commercial High-energy Cargo and Vehicle Monitoring Tunnel systems.

Some project components, such as airborne detection, did not reach operational maturity, while others, such as high-intensity continuous X-ray radiation and neutron interrogation, faced limited adoption due to safety concerns and high costs. However, several C-BORD technologies have since been integrated into commercial screening solutions, with the multi-sensor software platform now a standard industry feature.

Following C-BORD's completion, passive detection advancements became widely adopted in customs operations, while high-intensity X-ray testing continued in overseas trials in the US. Although neutron interrogation has been commercialized, it remains underutilized by customs due to radiation safety concerns and comparatively lengthy scanning times. Inspired by C-BORD, the ENTRANCE project has since focused on adapting these technologies for rail wagon inspections, while commercial partners continue to refine multi-sensor integration software for broader security applications.

Table 7 C-BORD project overview

C-BORD	
Technology focus	A multi-technology detection toolbox integrating X-rays, neutron interrogation, photofission, trace detection, and passive radiation sensing to enhance non-intrusive container inspections at EU borders, improving the detection of contraband, hazardous materials, and special nuclear material while minimizing manual inspections.
Customs partners	The Netherlands, Poland and Hungary
Targeted threats	Contraband cigarettes, illicit drugs, misdeclared goods and dangerous illicit substances, including explosives, nuclear material, chemical and biological warfare agents and radioactively contaminated goods.
Project timeline	2015-2018
Follow-up developments	Several C-BORD technologies have since been integrated into commercial screening solutions (such as the New Threat Lensing), with the multi-sensor software platform now a standard industry feature. Further development in ENTRANCE.

2.8 MESMERISE: Next-generation screening with X-ray and infrasound

The MESMERISE project was designed to modernize customs and security screening by developing a high-resolution, non-intrusive scanner capable of detecting concealed items both inside and on the body. Unlike traditional scanners, the technology required no operator interpretation, making it a fully automated system. The project ran from May 2016 to July 2019 and involved customs partners from the UK and Norway. The project's goal was to enhance the detection of narcotics, explosives, and other contraband using a combination of ultra-low-dose multispectral X-ray transmission for internal inspection and infrasonic interrogation for external body screening. Importantly, MESMERISE placed strong emphasis on privacy and dignity, eliminating explicit imaging through automated detection.

Two key technologies emerged from the project. The first, X-MESMERISE, was a multi-energy X-ray system designed for detecting concealed substances inside the body. However, despite several design refinements, the system failed to meet the required image quality standards and was less effective than existing scanners. As a result, the technology development was halted before reaching a pilot stage. The second technology, Z-MESMERISE, was an infrasound-based device for external body inspection. Using low-frequency sound waves, it effectively detected anomalies on the body's surface and successfully progressed to the prototype stage, showing promise for further development.

After the project's completion, the X-MESMERISE technology was abandoned due to its inability to meet operational needs and a series of setbacks in follow-up testing. Efforts to pilot test the system at Barajas Airport in Madrid were disrupted by the COVID-19 pandemic and geopolitical challenges, including the war in Ukraine, which prevented hardware modifications by a Belarusian technology partner. Additionally, the closure of a key radiological facility led to the destruction of the prototype's X-ray tube, making further testing impossible.

In contrast, the infrasound-based Z-MESMERISE technology was deemed a success and laid the foundation for the MELCHIOR project. This follow-up project aims to refine the system for real-world applications, particularly for screening visitors at prisons and securing critical infrastructure such as airports, sports arenas and other public venues. The infrasound technology is now being scaled up for operational deployment and will be integrated with millimeter-wave and other non-ionizing radiation technologies to improve detection efficiency.

Table 8 MESMERISE project overview

MESMERISE	
Technology focus	A high-resolution, non-intrusive scanner using multispectral X-ray and infrasonic interrogation to autonomously detect and identify concealed commodities (internal and external) with automated algorithms and data fusion, eliminating reliance on human interpretation.
Customs partners	Norway and the UK
Targeted threats	Narcotics, explosives, weapons, and contraband concealed inside or on the body.
Project timeline	2016-2019

Follow-up development	Further development in MELCHIOR.

2.9 PROFILE: Data and analytics for customs risk assessment

The PROFILE project aimed to enhance European customs risk management by leveraging advanced data analytics and new data sources. By integrating machine learning, graph-based analytics, and natural language processing, PROFILE enabled customs officers to process large datasets more effectively. Running from August 2018 to February 2022, the project involved customs administrations from Norway, Estonia, the Netherlands, Sweden, and Belgium.

PROFILE produced advanced tools and methodologies for customs risk management. These innovations included a predictive model for commodity code classification, an autoencoder neural network for anomaly detection, and an interactive visual data analysis interface. The project also developed solutions for data feed from external commercial sources to customs, along with best practices for data cleansing and integration. Additionally, PROFILE created training modules for customs data analysts, which may later be commercialized as an e-learning course.

One of the project's key findings was that customs authorities had not fully utilized valuable external datasets, such as shipping instructions and company databases like Orbis and Dun & Bradstreet. It demonstrated that linking records across multiple datasets improved risk assessment capabilities, offering new insights into large-scale data mining. The project also highlighted the potential of advanced data analytics techniques, such as machine learning and graph-based analytics, in detecting new risk patterns and predicting illicit cross-border activities.

Following PROFILE's conclusion, customs administrations began integrating the most promising datasets into their systems, focusing on external sources like shipping instructions and company records. The project also influenced updates to operational risk management systems, particularly through the adoption of linked datasets for more effective risk analysis. Meanwhile, technology partner IBM explored ways to incorporate PROFILE's data analytics advancements into its cloud-based solutions, particularly within IBM Watson.

Table 9 PROFILE project overview

PROFILE	
Technology focus	The application of advanced data analytics, including machine learning, graph-based analytics, and natural language processing, to enhance customs risk management by improving data integration, anomaly detection, and predictive risk assessment.
Customs partners	Norway, Estonia, the Netherlands, Sweden, and Belgium.
Targeted threats	All types of contraband.
Project timeline	2018-2022
Follow-up developments	Further development of PROFILE data analytics tools as part of customs research and development, enhanced customs data accessibility via

	external data sources, and contributed to the integration of advanced data analytics capabilities into commercial toolkits.

2.10 COSMIC: CBRNE detection in shipping containers

The COSMIC project aimed to strengthen security at ports and borders by improving container and vehicle inspections against CBRNE (Chemical, Biological, Radiological, Nuclear, and Explosives) threats. Running from October 2018 to September 2021, the project introduced a three-stage detection system using advanced sensors for faster, more effective screening. The project focused on two key technologies: analyzing air from sealed consignments for hazardous materials and using muon interactions, a form of cosmic radiation, to scan shipping containers. Dutch Customs was among the project's key participants.

COSMIC developed eight advanced CBRNE sensors, introducing previously unavailable detection capabilities across chemical, biological, nuclear, radioactive, and explosive threats. Key innovations included NA-NOSE nano-technology sensors for rapid chemical and biological detection, a muon scanner for identifying shielded nuclear materials in dense cargo, and high-sensitivity DMA-MS vapor extraction for explosives, chemicals, and bacterial detection. Additional technologies, such as PDA bacterial sensors and DMA-CPC virus detection, enhanced manual inspection capabilities.

Despite significant progress, air-based threat detection remained in the laboratory stage, requiring further research. Muon imaging, tested in Israel, proved effective for high-density materials but required refinement for broader application. Trials at a simulated border crossing yielded promising results, though further improvements in image resolution and algorithm development are needed.

A data integration platform was successfully implemented, connecting air and muon detection systems to customs screening. However, AI functionalities remained underdeveloped due to limited operational data. While air detection did not advance beyond prototype, muon detection saw continued development and commercialization. Prototypes have been deployed in Singapore, Sri Lanka, and the US, though still in a testing phase. Companies like Decision Sciences focus on real-time container scanning using COSMIC technologies, while GScan adapts the capabilities for detecting contraband in Europe.

COSMIC's advancements have inspired further EU-funded projects, including SilentBorder, which aims to refine muon detection for palletized and truck-sized cargo. While muon technology has entered prototype deployment, further improvements are needed for full operational integration.

Table 10 COSMIC project overview

COSMIC

Technology focus	A multi-layered detection system integrating eight advanced CBRNE sensors and innovative analytics software to overcome challenges in detecting concealed threats in sealed shipping containers, enabling fast, accurate inspections at ports and borders without disrupting trade flow.
Customs partners	The Netherlands
Targeted threats	Chemical, Biological, Radiological, Nuclear and Explosives threats (CBRNE)
Project timeline	2018-2021
Follow-up developments	Commercialization of muon detectors and further development in the SilentBorder project. Application of the muon technology to detect structural failures in building

2.11 BorderSens: real-time detection of chemical substances at the border

The BorderSens project, titled "Nanotechnology-based sensors for real-time detection of chemical substances," aimed to enhance border security by developing a portable, cost-effective, and wireless device for detecting illicit drugs and their precursors. By integrating sensor technologies, nanotechnology, and advanced data analysis, the project sought to create a highly accurate and selective detection system. To validate its effectiveness, the technology was tested at multiple border sites in the EU.

Running from September 2019 to November 2023, the project brought together ten end-users, including customs administrations from the UK, Netherlands, Belgium, and Sweden. The need for improved drug detection was clear, as existing handheld devices, such as Raman systems, are still expensive technologies. Cheaper alternatives, like colorimetric test kits, suffer from accuracy limitations. BorderSens aimed to bridge this gap by developing smaller, more affordable, and user-friendly sensors, ensuring they met practical field requirements through close collaboration with customs and other law enforcement authorities.

Developing a single multi-sensor device proved challenging, leading to the creation of three distinct electrochemical sensors: the single sensor, the BorderSens array, and the nanoMIPs sensor. The single sensor is a compact handheld device that detects individual drugs, such as cocaine, heroin, ketamine, MDMA, or methamphetamine, by dissolving a sample in a solution and applying a droplet to an electrode. Results are obtained in under a minute. The BorderSens array expands capabilities by simultaneously testing for multiple drugs using six parallel tests. Meanwhile, the nanoMIPs sensors enable the detection of non-electroactive drugs, such as amphetamines, which traditional electrochemical sensors struggle to identify.

By the project's conclusion, these sensors had significantly lower costs than Raman devices, reducing prices to approximately €10,000–€12,000 per unit. However, portability remains an area for improvement. Despite this, the sensors demonstrated high sensitivity and specificity in detecting a wide range of substances. Customs laboratories in the Netherlands and Sweden played a key role in testing and validation, assessing the sensors in both laboratory and seaport environments.

Since the project's conclusion in 2023, the University of Antwerp, a key partner, has been seeking investors to advance development and commercialization. Former customs partners remain open to testing improved versions, but full adoption by customs and other end-users has yet to be realized. While BorderSens delivered promising prototypes, further refinement and investment are needed for operational deployment.

Table 11 BorderSense project overview

BorderSense	
Technology focus	Sensor technologies with electrochemical strategies, nano-molecularly imprinted polymers, and advanced data analysis to develop a highly accurate, portable, and wireless device for rapid on-site detection of illicit drugs and precursors at EU borders, addressing accuracy, cost, and portability challenges in current screening methods.
Customs partners	The UK, Netherlands, Belgium and Sweden
Targeted threats	Illicit drugs and their precursors.
Project timeline	2019-2023
Future developments	Investors or new project funding are being pursued to advance the technology toward commercialization.

2.12 ENTRANCE: multiple technologies for non-intrusive inspection

The ENTRANCE project aimed to develop an advanced, user-driven toolbox for risk-based non-intrusive inspection of cross-border freight, particularly at EU Customs Union borders. Running from October 2020 to November 2023, it sought to enhance border security while minimizing trade disruption and involved customs administrations from Slovakia, Croatia, Bulgaria, and Belgium.

A key ENTRANCE outcome was the Automated Risk Assessment Platform (ENARTIS), which centralized inspection results, enabling automated threat detection and historical X-ray image comparisons. Enhanced mobile X-ray scanners improved depth imaging and material discrimination, addressing challenges in container inspections. The project also introduced a non-intrusive detection system for high-speed cargo, integrating mobile radiation detection systems capable of detecting gamma and neutron radiation at speeds of 5–30 km/h. Another innovation was muon scattering imaging, which improved the detection of hidden objects in dense cargo with high precision.

Further advancements included photofission technology, utilizing a 7 MeV mobile X-ray system (instead of the fixed 9 MeV system used in C-BORD) to detect nuclear materials like uranium, making scanning equipment more compact and safer to use. ENTRANCE also established a Trans-European Radiation Portal Monitor network, enhancing passive detection of nuclear and radioactive materials across EU borders. Key technical contributions included high-speed nuclear detection, which improved passive radiation detection at higher transit speeds, depth imaging innovations, which enhanced the localization of threats within containers, and novel material discrimination techniques,

which improved X-ray analysis by separating organic and metallic materials, and container wall “removal”, leading to more accurate contraband detection.

Several technologies developed in ENTRANCE have since been commercialized. Smiths Detection has introduced enhanced X-ray detectors and algorithms that improve depth localization, material isolation, and discrimination, with at least one customs administration acquiring products based on this technology. Arktis’ portable radiation detection system is now available for purchase, though its adoption by customs administrations remains unclear. Meanwhile, photofission technology continues to advance under the MULTISCAN 3D project, which also explores innovative applications in 3D container imaging, utilizing a laser-plasma based source.

Table 12 ENTRANCE project overview

ENTRANCE	
Technology focus	An advanced toolbox integrating automated risk assessment, non-intrusive inspection technologies, and high-speed passive radiation detection to enhance EU Customs border security against illicit materials with minimal trade disruption.
Customs partners	Belgium, Bulgaria, Croatia and Slovakia
Targeted threats	Illicit cargo of all kinds.
Project timeline	2020-2023
Future developments	The X-ray system and radiation detection portals have been commercialized, with some adoption by customs administrations. Meanwhile, the photofission system is undergoing further development in the MULTISCAN 3D project, exploring advanced applications in 3D container imaging.

3 Driving customs innovation from research to implementation

This chapter discusses how innovations from customs-relevant EU projects are adopted, sustained, and scaled. It highlights customs' active role in innovation, identifies challenges in bridging research and practice, and offers recommendations to strengthen customs participation in future projects. The chapter concludes with suggestions for improving EU research and innovation programmes to better support long-term innovation in the customs sector.

3.1 What happens to customs innovations after the end of EU projects?

Ensuring the long-term impact of customs innovations developed in EU-funded projects is a critical challenge. Without clear pathways for further development, commercialization, and integration into operational systems, many promising innovations risk being overlooked or phased out. The continued advancement of customs innovations can take various forms, depending on the needs and priorities of stakeholders.

Customs in-house refinement and adoption of innovations

Customs are the primary end-users of EU-funded border security projects, which makes customs uptake of innovations a key measure of a project's success. Many projects aim for high technological readiness by completion, but most innovations still require final adjustments before they can be fully integrated into daily customs operations[8]. As a result, customs organizations often refine these innovations further in-house to bridge the final gap for operational implementation[9].

For example, after the CORE project ended, Dutch customs adopted the data pipeline concept and began integrating it into their processes. This led to the development of the Customs Risk Information System, which consolidates multiple data sources—including declarations, business data, and real-time shipment information. By combining artificial intelligence with traditional risk profiles, the system provides a more comprehensive, data-driven approach to customs risk management. In parallel, Dutch customs are piloting CORE-based technologies to support initiatives like digital product passports—digital records that track key product information throughout its lifecycle. These passports enhance transparency, compliance, and efficiency in supply chain management.

The ACXIS project pioneered advanced algorithms to automate the interpretation of container X-ray images. Following its completion, customs authorities, in collaboration with leading X-ray technology providers, continued refining and testing these algorithms. Their efforts have brought the technology to a level where it is now integrated into mainstream commercial solutions and actively deployed in daily enforcement operations at EU borders.

[8] Some customs experts have expressed concerns that EU projects end up with innovations that are not yet ready for immediate use in daily customs operations. However, these concerns are partly unjustified, as EU research projects typically aim for mid-to-high-level technology readiness, where innovations have been validated or demonstrated in customs environments. However, further effort is almost always needed for commercialization and large-scale deployment.

[9] It's important to note that certain customs innovations developed internally remain undisclosed to the public due to law enforcement sensitivity.

After the HANDHOLD project ended, Irish customs conducted in-house research to evaluate the project's drug detection technologies. A sensor was used to analyze vapors extracted from a maritime container carrying a small amount of cocaine. While the results were promising, no further studies were pursued due to competing research and development priorities. Some sensory techniques from HANDHOLD were later incorporated into the ROCSAFE project, though without a specific focus on customs applications.

The PROFILE project developed techniques for data linking between customs and external sources, applied Natural Language Processing and Random Forest machine learning methods to improve the accuracy of commodity code predictions, and introduced novel data cleansing practices, among other analytical tools. These tools have since been further refined within customs organizations to enhance risk assessment capabilities. The project also evaluated the value of external data for customs risk assessment, with customs partners determining that some datasets were not worth the cost and effort of integration, thereby directing future efforts toward more promising data sources.

Market deployment and commercialization

Some EU-funded technologies evolve into commercial products, but tracking their journey from early development to market adoption can be complex. Innovations are often rebranded, integrated into larger systems, or further refined. Additionally, corporate mergers and intellectual property licensing create further challenges in tracing their commercialization pathways. Despite these complexities, several high-profile examples demonstrate the eventual commercialization of innovations from EU projects.

A notable example is TradeLens, a blockchain-based logistics platform for end-to-end supply chain visibility provided by IBM and Maersk. The development of TradeLens's data pipeline concept across consecutive EU projects illustrates this transition. It began with early research and awareness-building, engaging the customs and business communities as part of the CASSANDRA project. It then progressed through pilot projects in different trade environments to establish a business case in CORE. Finally, it was adapted for specific customs applications, such as its implementation by the Dutch tyre importer Van den Ban as part of PROFILE. Although TradeLens was eventually discontinued, it demonstrated the transformative potential of digital platforms in global trade.

Enhanced X-ray detector functionalities, developed through EU-funded projects like ACXIS, CORE, and C-BORD, were integrated into Smiths Detection's commercial offerings soon after ENTRANCE. Likewise, Arktis' commercial offering for portable radiation detection system was upgraded soon after the project's completion. Similarly, Estonia-based GScan leveraged research from the COSMIC project to commercialize its proprietary muon screening technology for container inspection.

Many EU projects have led to patent filings, which play a crucial role in transferring innovation from research to industry and bringing new technologies to market. While patents do not guarantee commercial success, they provide intellectual property protection, enabling developers to secure and potentially monetize their inventions. Notably, the CRIM-TRACK, C-BORD, and MODES_SNM projects resulted in several patents, supporting the transition of their innovations into practical applications.

Commercialization does not always remain within the border security domain where the initial research and development took place. For example, the CRIM-TRACK prototype, originally designed for substance identification at borders, also has potential applications in food safety and public health monitoring. Similarly, advancements from the HANDHOLD project continued under ROCSAFE, shifting focus from border security to protecting crime scene investigators from CBRNE threats. Meanwhile, the non-ionizing detection technology developed in MESMERISE is being further refined in the ongoing MELCHIOR project, with applications extending to public venue protection and prison security. COSMIC's muon scanning technology has the potential for future commercialization in the construction sector, where it could be used to inspect structural damage in bridges and buildings.

Further research and development in subsequent EU projects

A key strategy for advancing innovations from EU research and development projects is to integrate them into successive EU-funded initiatives. Many emerging technologies begin at a low technology readiness level and require multiple funding cycles to achieve full deployment in border control operations. Securing additional research grants allows these innovations to be refined, validated, and adapted for practical use in customs applications.

Several examples highlight the impact of this approach. The ongoing MELCHIOR project, which develops non-ionizing technology to detect threats concealed within the human body, builds on advancements from its predecessor, MESMERISE. Similarly, the data pipeline concept that led to the TradeLens digital logistics platform originated in EU-funded projects such as CORE, and PROFILE, gradually evolving into a commercial solution.

The enhanced X-ray detector, together with more advanced software, commercialized shortly after the ENTRANCE project, exemplifies how long-term EU research funding drives innovation. In 2015, the ACXIS project achieved a breakthrough by demonstrating depth information in X-ray images at small angles through stereoscopic studies. This technology advanced further in 2016–2017 within the CORE project, where fast, high-resolution scanning and matrix detectors showed promise for depth analysis. By 2018, the C-BORD project validated the concept, leading to its transformation into an operational technology in 2023 through the ENTRANCE project.

Innovation beyond technology

While technological product innovation remains a key focus, EU research projects also drive process innovation through operational integration, knowledge sharing, and international collaboration[10]. Though harder to quantify, these process innovations are essential for strengthening customs capabilities in the long term.

Beyond technology, EU projects have guided customs enforcement and innovation strategies. For example, ENTRANCE and PROFILE explored data-sharing methods between customs and research partners to develop joint customs risk assessment systems and experiment with federated learning to train cargo targeting models. PROFILE also provided key lessons on overcoming security, data-sharing, and legislative challenges in collaborative customs risk management projects. Similarly, the

[10] Product innovation involves the market launch of a new or significantly improved good or service, while process innovation refers to adopting new or enhanced production, distribution, or support processes (Eurostat 2025).

ACXIS project pioneered customs X-ray image sharing, offering critical insights for later AI-driven threat detection models that require large datasets of reference images to work.

EU-funded projects have also contributed to international standardization and policy advancements. The ACXIS project likely helped lay the groundwork for the World Customs Organization's Unified File Format (UFF), now a global standard for customs X-ray image processing. CORE and PROFILE supported the development of UN/CEFACT and FEDeRATED semantic reference libraries for multimodal international logistics. COSMIC advanced CBRNE cargo screening standards and performance metrics at national, EU, and international levels.

EU projects have also influenced customs policy design. Insights from CORE have shaped the European Union's Customs Reform Package, which aims to replace traditional customs declarations with a "trust and check" trusted trade lane model. Additionally, projects like CORE and PROFILE have developed customs training materials, fostering long-term capability building and innovation scaling.

3.2 How can customs maximize their benefits from EU projects?

EU projects offer customs administrations capabilities to enhance innovation management through cooperation, additional resources, and technology demonstration opportunities. There are powerful strategies that the customs community employs to further strengthen its role in EU research and innovation projects to maximize its benefits.

Early involvement of customs at the project preparation stage

Project proposal writing typically begins shortly after the release of the new Work Programme, about eight months before the submission deadline. Involving customs practitioners early in the proposal design stage ensures projects address real-world innovation needs and can significantly help to shape the direction of project action plans.

However, customs administrations often join project consortia relatively late, limiting their ability to shape the project's scope and innovation agenda. One reason for this late entry is the overwhelming number of project invitations, which can lead to decision paralysis when selecting which proposals to join. Additionally, bureaucratic hurdles in obtaining approval from top management may further delay customs participation, making it difficult for customs experts to engage early and contribute effectively to the proposal-writing stage.

To address this issue, customs administrations should streamline proposal approval processes, set clear project selection criteria, and designate innovation officers to evaluate opportunities. Training on EU project funding can also support timely decision-making.

Focus on operational testing and demonstrations

Operational testing and integration remain significant challenges in advancing customs technology. EU projects can help address these challenges by incorporating real-world demonstrations and operational testing into their innovation agendas. Successful examples of this approach include the CORE and ENTRANCE projects, which have conducted multiple demonstrations at seaports and

land crossings. These hands-on tests provided valuable insights into practical implementation, performance validation, and stakeholder engagement, highlighting the importance of real-world evaluation before full-scale adoption and operational deployment.

To maximize the effectiveness of EU projects, customs partners should insist on dedicated demonstration activities as an integral part of project implementation. In exchange, customs authorities should be prepared to offer the necessary technical and logistical support to ensure demonstrations are successfully executed at border posts and other operational environments[11].

Creation of in-house innovation teams with risk-seeking attitude

Customs administrations would benefit from dedicated in-house teams focused on building networks, developing innovation expertise, and securing EU project funding. They could maintain close contact with their National Contact Points (NCPs), experts who provide comprehensive assistance on all aspects of participation in EU-funded projects. Applying for and managing research grants requires specialized skills that must be cultivated over time to achieve successful innovation outcomes. Additionally, customs would benefit from internal expertise to manage the financial and technical reporting of EU project funding effectively.

These innovation teams in customs should adopt a risk-taking, entrepreneurial mindset, which is essential for driving innovation. This means accepting that some projects will succeed while others may fail. However, learning from unsuccessful projects is valuable, as it helps avoid repeated mistakes and improves future initiatives. While this approach is not common in government administrations like customs, EU research and development projects offer a supportive environment where customs innovators can take calculated risks for the sake of creativity and progress.

Promotion of EU projects among customs experts

Many customs administrations are unaware of the benefits of EU projects for their innovation activities, and some might not even know they can apply for EU funding as part of a consortium. EU projects should be actively promoted to among customs experts, emphasizing their innovation benefits. Clear success stories and practical outcomes will encourage participation and adoption. Additionally, workshops, webinars, and direct engagement with customs experts can help clarify the application process and encourage greater involvement in EU-funded innovation initiatives. For example, the activities of the EU's Detection Technology Expert Group (DTEG) have enhanced customs engagement in EU research projects.

Importantly, project reports, particularly those showcasing the results of field demonstrations of new technologies, could serve as a valuable promotional tool[12]. While it is understandable that these reports are often not publicly available due to security and commercially sensitive information, their dissemination could be more open than it has traditionally been. A specific dissemination level could be established to grant all EU customs access to key materials, such as test sheets, demonstration results, and technical documentation of customs-relevant EU projects. This access would enable

[11] Demonstrations depend on active customs participation, as testing often requires access to customs expertise, facilities, and regulated threat material samples, such as cocaine or TNT.

[12] The availability of public reports ("deliverables") on CORDIS, the EU's platform for showcasing research and development projects, is remarkably low for most projects.

customs experts from around the EU to evaluate the performance and potential of innovative technologies, supporting informed decision-making and broader adoption.

Active exploring of post-project funding

EU research and development projects typically aim to achieve advanced technology readiness levels by their end. However, operational deployment by customs requires additional resources beyond the scope of EU project funding. To bridge this gap, customs and other project partners should explore alternative financing options to sustain technology development and ensure last-mile implementation.

Several post-project funding instruments are available to support authorities like customs administrations in advancing innovation. The Technical Support Instrument (TSI) offers additional resources to ensure continuity in innovation and implementation at the Member State level. Meanwhile, the EU's Internal Security Fund (ISF) supports initiatives such as the procurement of ICT systems, training programs, technology testing, and interoperability improvements, ensuring customs authorities have access to cutting-edge digital solutions. Additionally, the Union Anti-Fraud Programme (UAFP), including its Hercule component, provides financial support to EU member state authorities, helping them build operational and technical capacity to combat fraud.

Another key late-stage implementation support is the Customs Control Equipment Instrument (CCEI) under the EU's Integrated Border Management Fund (IBMF), which provides financial support for the purchase, maintenance, and upgrade of customs control equipment. This includes advanced detection technologies for border crossings, inland customs offices, and mobile units, such as X-ray scanners and laboratory equipment for goods analysis. The CCEI also funds operational testing of new and innovative technologies, staff training, and essential software updates.

For private sector innovators, the EIC Fund, the venture investment arm of the European Innovation Council (EIC), provides €3.5 billion in capital to support start-ups and small and medium size enterprises. Additionally, private sector funding—through venture capital, corporate investment, and strategic acquisitions by larger companies—can further drive the scaling of promising technologies beyond the research phase.

3.3 How can the EU research programme better serve customs?

The previous section explored ways for the customs community to foster deeper and more productive participation in EU projects. This concluding section focuses on how the design of EU research programmes can improve the accessibility and attractiveness of EU research and development projects for customs administrations.

Enhancing innovation through open topic project calls

Open-topic research calls play a crucial role in fostering innovation by addressing urgent customs challenges and enabling a rapid response to emerging needs. Maintaining or expanding funding for these flexible calls should remain a priority in future EU programs, as demonstrated in recent Horizon Europe Civil Security for Society initiatives.

These open-ended funding opportunities allow for customs-specific and adaptable solutions, providing the flexibility needed to tackle specialized issues. For example, project proposals for open topic calls could focus on improving CITES[13] enforcement by enhancing detection methods for the illegal trade of endangered plant and animal species. Another area of focus could be the development of advanced cargo screening solutions for break bulk shipments on river barges. Expanding these research opportunities would empower both researchers and industry partners to develop tailored, high-impact solutions that align with evolving customs and security demands.

Introducing competitive continuity between innovations

The concept of competitive continuity could be introduced as a cost-effective strategy to support the transition of customs innovations from research to commercialization. This approach would follow a multi-phase funding model, supporting multiple early-stage projects in parallel. As projects advance, follow-up funding would be allocated only to the most promising solutions, creating a structured innovation pipeline. By systematically filtering out weaker concepts and refining successful ones, this model ensures that the most viable technologies progress efficiently toward commercialization and operational deployment by customs.

Competitive continuity can also be applied within a single project. For example, in the MESMERISE project, two technological approaches were initially explored. However, after early-stage testing, one was found to be underperforming. The project team made a strategic decision to discontinue the weaker approach and reallocate resources to the more promising technology. While abandoning an idea requires courage, effective innovation management is not just about developing new solutions—it also involves identifying and eliminating less viable ones. Encouraging this selective approach within EU-funded projects can streamline development cycles, optimize resource use, and lead to higher-quality outcomes for customs and other end-users.

Requiring stronger customs involvement in EU projects

To maximize the practical impact of EU research projects, customs and other end-users should play a more defined and influential role in project development. EU projects should require the active participation of a broad and relevant group of end-users—those who will directly benefit from the innovations being developed. This can be reinforced by increasing the number of end-users within project consortia as a prerequisite for EU funding eligibility.

In addition, customs partners should have a decisive role in shaping technology choices within EU-funded projects. Their influence should be secured through formal integration into project governance structures, either by being included in the project steering group, where they can contribute to strategic decision-making, or by holding key leadership positions such as work package and task leaders, overseeing critical aspects of project implementation. By embedding customs experts in these leadership roles, EU projects can more effectively align technological innovations with real-world operational requirements.

[13] The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) provides the framework for governing international wildlife trade.

Enabling small-scale innovation ventures within a project

A powerful way to drive rapid and targeted innovation is to allow EU projects to tender sub-projects for small-scale developments by external innovators outside the project consortium. This approach allows fresh expertise to contribute to prototyping and refining customs-related technologies, resulting in incremental improvements that enhance operational performance.

Existing EU initiatives highlight the effectiveness of this approach. The Horizon 2020-funded Pan-European Network of Customs Practitioners (PEN-CP) has successfully supported small-scale product development through Innovation Grants. Similarly, Frontex, the European Border and Coast Guard Agency, has introduced grants for "Novel Technologies for Futureproofing the EU External Borders" (Frontex 2024). Both programs offer approximately €60,000 per grant, enabling the incremental refinement of promising technologies to ensure they are field-ready for frontline border enforcement. By integrating similar funding mechanisms into broader EU research programs, the EU can accelerate the transition from prototypes to fully deployable technologies.

Simplifying EU project administration

To encourage greater customs participation in EU research projects, funding instruments should continue to reduce administrative burdens and simplify bureaucratic processes. Excessive red tape can discourage customs authorities from engaging in research initiatives, particularly those with limited prior experience in EU projects. Many customs practitioners, especially first-time participants, struggle to navigate the complexities of grant agreements, consortium agreements, technical reporting, and financial reporting. These challenges create barriers to entry, limiting customs' access to EU funding and concentrating project funds among a small group of experienced beneficiaries.

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Annex A: Interview questions

- What happened right after the project concluded?
- Have any technologies been commercially developed following the project?
- Have customs purchased any such technologies?
- Have any project results lead to further research projects?
- Have any project results lead to technology developments in any field?
- Has there been any follow-up with any partner after the project?
- Do you see any potential for further advancements or applications of the outcomes of the project that currently is not being considered?
- Have any project results been included, in any way, in your products or services portfolio?
- Are there any plans to continue working on or developing the outcomes from the project?

Annex B: Technology readiness levels

Technology readiness levels (TRL) based on Horizon 2020 Work Programme 2018-2020 General Annex G:

- 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 (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified
- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

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