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D1.2 - FLEXI-cross Use case definition

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Glossary of terms and abbreviations used

Terminology/Acronym	Description
AI/ML	Artificial Intelligence/Machine Learning
AR	Augmented reality
BCP	Border Check Points
DoA	Description of Action
EC	European Commission
EU	European Union
GA	Grant Agreement to the project
HW	Hardware
ISAR	Interactive Streaming for Augmented Reality
INUS-CBA	INtelligentUxV Surveillance-Crowd Behaviour Analysis
IoT	Internet of Things
KPI	Key Performance Indicator
LEA	Law Enforcement Agency
MD	Moldova
OBU	On-Board Unit
RO	Romania
RT-PCR	Reverse transcription polymerase chain reaction
SW	Software
TEN-T	Trans-European Transport Network
WP	Work Package
UC (#)	Use Case (1, 2, 3)

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Executive Summary

This D1.2 deliverable reports on the results of T1.2 “Use case target KPI co-design". This document provides a detailed description of the three use cases of the FLEXI-cross project, each of which serves as a platform to validate the solutions produced during the project. The individual use cases here target specific border crossing situations at three specific geographic sites: 1) port-based crossing at the Romanian Port of Galati, 2) vehicular road-based crossing at the Greek-Bulgarian border and 3) rail-based crossing at the Romanian-Moldovan border. Each use case will leverage the toolkit developed by FLEXI-cross to enhance border control processes, resulting in more secure, efficient, and expedited border crossing experiences for local authorities and involved passengers. This deliverable will provide information on each of the use cases through identification of the involved stakeholders and end-user groups, along with the specific facilities and equipment to be used during pilot deployments. The specific scenarios and user-journeys will be detailed, along with the intended measurable results and key performance indicators required to substantiate the FLEXI-cross toolkit. This document will further outline potential barriers and operational risks for each pilot which will be considered during subsequent use case planning and executions. The design of these use cases was a collaborative effort between FLEXI-cross partners based on the current needs of relevant border authorities and will therefore serve as substrate for establishing and subsequently validating the FLEXI-cross toolkit functionalities.

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1 Introduction

1.1.1 FLEXI-cross concept and approach

FLEXI-cross is an innovative project which aims at producing a technological toolkit/platform which will be leveraged to enhance border-checking solutions. These solutions aim to augment the security, reliability, and robustness of operational measures during border checking procedures for various end-users and stakeholders. The results of this project aim to improve border management capabilities while simultaneously maintaining high degrees of protection for personal privacy and individual rights of civilians. The former is to be accomplished by providing more effective and cost-efficient solutions for border checks. To deliver such results, this flexible toolkit is designed based on the direct needs of European Union (EU) border authorities and passengers. These analyzed requirements have previously been reported in detail in deliverable D1.1 ("Report on EU border authorities & passenger requirements for border-crossing procedures"). The needs of these stakeholders were investigated from three specific border-crossing locations in Europe and were therefore instrumental in defining the deployment sites and scenarios with which this project will use to validate the results produced here. These use-cases will be described in this current deliverable, with emphasis on their role in assessing the performance of the toolkit developed in this project. In addition to defining these use cases, this deliverable will provide an overview of the key performance indicators and measurable impact categories which will be used to provide quantitative scientific measurement of the efficacy of the tools produced in this FLEXI-cross project. Overall, the applied use of the FLEXI-cross toolkit in these use cases aims to deliver the following core functional impacts for border control processes (Figure 1):

- Predictive risk assessments of people and vehicles, which allow detection of abnormal behavior and will provide anti-trafficking and anti-smuggling protection.
- Portable biometric-based identity checks will allow efficient and secure person verifications.
- Portable ad-hoc Border Check Points resulting from mobile / easily transported solutions.
- Blockchain enabled data exchange and processing frameworks to ensure private, secure, and traceable data exchanges.
- Cost- and time-efficient border checking procedures resulting from data-driven optimization of existing operational practices.
- Better experiences and increased safety for border-personnel through human-machine-interfaces which will provide enhanced situational awareness via Augmented Reality.

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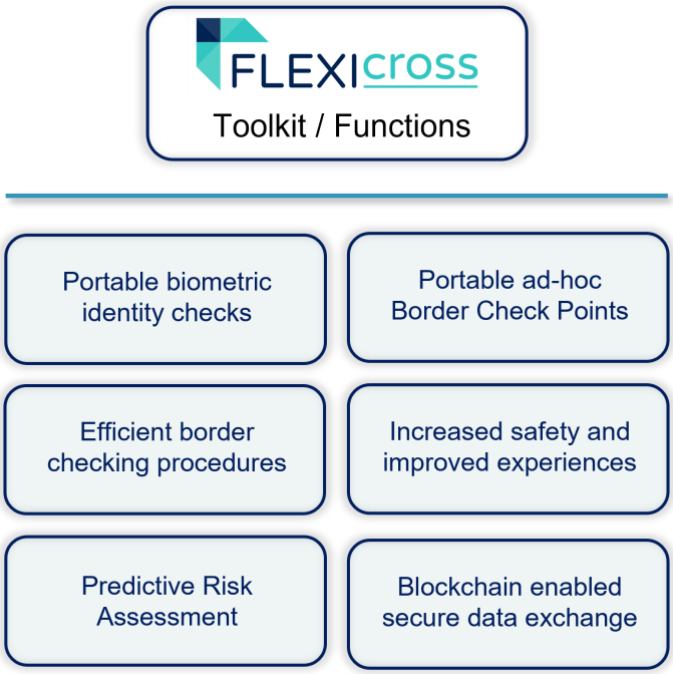

Figure 1 – FLEXI-Cross Concept & Methodologies

1.1.2 Purpose of this deliverable

The purpose of this deliverable is to provide a non-technical report which details the use cases of this FLEXI-cross project and their corresponding key performance indicators. This document will outline each use case and their specific attributes, along with providing information on how the use cases will be integrated with the proposed tools of this FLEXI-cross project. The information provided in this deliverable will play an important role in future tasks of this project which will build upon the use case definitions which are critical for development of the project architecture and subsequent implementation of their functionalities in live pilot showcase demonstrations. This deliverable also provides a tentative timeline for when relevant technical workshops, training, and demonstrations are intended to occur over the course of this project duration.

1.1.3 Intended Audience

This deliverable possesses a dissemination level of Public. As a result, the intended audience includes members of the FLEXI-cross consortium, relevant European Commission personnel, and the public. Audience members will find this deliverable as a source of information for different purposes depending on their background, expertise, and interest. For technical consortium partners, this document provides an overview of the implementation scenarios with which their tools will be utilized for the purpose of the end-user. For end-user partners, this document will provide an overview of how the FLEXI-cross solutions will be leveraged in their respective use case environments and act as substrate for development of the tool functionalities. The public can find benefit from this document as it provides information on the research scope and intended deployment of the results derived from this EU funded research project, particularly one aimed at enhancing border crossing experiences for EU member states and civilians alike.

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1.1.4 Structure

The pages of this document consist of an introduction (**I**), followed by (**II-IV**) detailed descriptions of each use case and their corresponding details. The technical modules intended to be utilized in each use case along with deployment timelines and impact considerations are presented **(V)**, and this deliverable ends with a (**VI**) conclusions and future directions section. This deliverable includes an annex of a table which reports on the use case key performance indicators and impact categories (**VIII**).

1.1.5 Border Crossing Situations – Use Case Definition & KPI co-design

Border crossing demands in Europe have been experiencing an increase in recent years. Indeed, merchandise trade in Europe in 2021 increased by 8.2% in volume and 22.5% in value alone [1], with Europe contributing to 35% of world exports of intermediate goods [1]. European merchandise export and import volumes also exhibited an increase as assessed in early 2022 [1]. Additionally, passenger transport growth rates have been shown to steadily increase in prior years [2]. These increasing demands provide ongoing challenges for border control processes which must accommodate the operational needs associated with such increasing metrics. Attempting to meet these needs, however, can be costly with respect to resources, infrastructure, and time; as a result, both commercial freight and passenger-based border crossing stakeholders could be impacted significantly. Beyond economic costs, considerations toward safety, privacy, and protection are critically important, particularly given the prevalence of illegal crossing activities at European borders. Indeed, the EU reported an increase in irregular external border crossings by 64% from 2021 [3], a time when it was already at its highest since prior to the covid-19 pandemic [4]. Recognition of these border control trends, needs, and resulting demands is evident in the measures the European Union has implemented which aim to assist border control centers/institutions. A variety of the resulting innovations, such as e.g., the Entry/Exit System [5] and European Travel and Authorization System [6], seek to enhance border control practices and procedures, which lead to more effective and cost-efficient crossing measures while also contributing toward maintaining privacy and security of passengers and travelers. The goal of this FLEXI-cross project aims to produce an innovative technological toolkit to enhance border crossing measures. The functionalities of this toolkit will be designed for three specific instances of border crossing modalities with corresponding different locations (Figure 2):

- Port-based crossing at the **Romanian Port of Galati (RO Platform)**
- Vehicular road-based crossing at the **Greek-Bulgarian border (GR-BG Platform)**
- Rail-based crossing at the **Romanian-Moldovan border (RO-MD Platform)**

Each one of these use cases has unique needs and challenges for their modality-specific border crossing procedures. As such, the toolkit developed in this FLEXI-cross project will accommodate these needs with a combination of individually tailored and mutually beneficial functionalities. As graphically visualized in Figure 2, the regional locations of each use case and the envisioned toolkit functionalities to be utilized are shown. Given the diverse transit modality of each use case, each provide a unique framework to influence the development of, and subsequently validate, the toolkit functionalities of this project.

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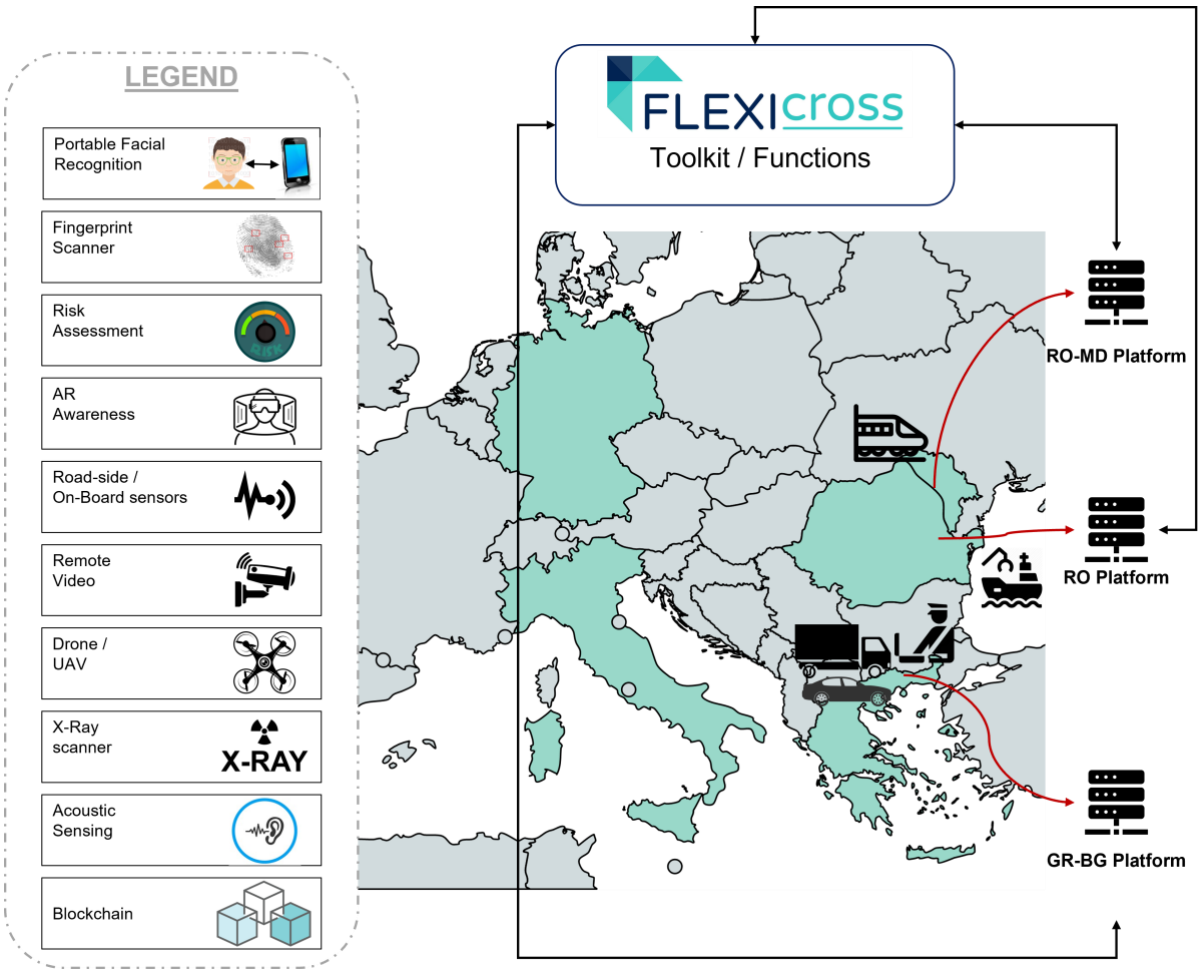

Figure 2 – FLEXI-Cross Use Case & Technologies Overview

1.1.5.1 Use Case Definition Methodologies

The definition of the three use cases here is the result of extensive research and analysis of current border crossing practices and end-user requirements at the three sites described above. The results of such research have previously been summarized in deliverable D1.1 and will not be discussed here beyond mentioning that the processes used to define user requirements were instrumental in formulating specific attributes of the use cases. The research conducted in these studies was led by end-user consortium members who play an active role in border crossing experiences with active collaboration from technical partners. Such perspectives allow the FLEXI-cross use cases to reflect accurate representations of border crossing scenarios and their current needs. In addition to this research, continued multilateral discussions between partners of this consortium served to refine and parse out specific features of the individual trials. The following sections will provide information on each of the three use cases of this FLEXI-cross project. The descriptions here reflect the pilot deployments for each use case as they are currently envisioned at this current state of the project.

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2 Use Case #1 – Port border-check (Romania/Galati Port)

2.1.1 Use Case motivation and specific aims

The eastern border of Romania is currently one of the most important border locations worldwide. The importance of this border is clear in its position as the eastern border of Europe, which has become critical in the ongoing war in Ukraine. The objective of the Romanian border use case is to digitize border control systems by implementing high-performance mobile solutions integrated into the already existing systems. The border location of this use case is the Port of Galati. The Port of Galati ensures the connection between the European Union (EU) and the Commonwealth of Independent States and attracts goods and passengers from neighbouring countries as a triple-modal port. A triple-modal port is one which includes three modes of transport - rail, road, and water. In addition, the port is important for two types of rail transport (European and Russian standard) and two types of water transport (maritime and fluvial) and is strategically positioned on the Central Rhine-Danube Trans-European Transport Network (TEN-T) Corridor. The strategic importance and complexity of this European border crossing point requires increasing the level of security beyond existing measures by implementing the latest generation of technologies. Additionally, the specific control operations should be enhanced to become more efficient and less time-consuming. Emphasis in this use case will be placed on the mobility of the implemented control tools, on their interconnection with the shore systems, and on the integration of information coming from different systems or verification tools in a centralized system. Reaching these aims is the ambition of the FLEXI-cross technological toolkit and will be the focus of this first use case (UC1).

2.1.2 Description of the Use Case

As a result of the conflict between Russia and Ukraine, a large part of civilians chose to withdraw from the war path, with many of them seeking refuge in the territories of EU member states and neighbouring countries. Thus, starting from 24.02.2022, at the border crossing points with Ukraine and the Republic of Moldova, significant increases in passenger traffic into the country were recorded. Along with the intensification of traffic, the number of incidents also increased. Most acts of a criminal nature were detected at the border with Ukraine. At the same time, the highest increase was recorded here – with a large increase in 2022 compared to 2021, according to the Report on the evaluation of the activity of the Border Police in 2022 [7]. The Port of Galati thus became a main gateway to Europe, being the largest river and maritime port on the Danube and the second largest Romanian port. In these conditions, it is urgently necessary to increase the level of security at Romania's borders by implementing technical solutions that allow faster and more accurate detection of high-risk persons and types of goods considered dangerous (e.g., waste, weapons, drugs, etc.) by using the latest generation of technological solutions. Moreover, the consolidated integration of information from a variety of different systems/sensors/devices will provide a more accurate assessment of the threat level for each ship arriving in Galati Port.

Given these critical needs, this FLEXI-cross project intends to utilize its innovative technological platform to enhance border checking procedures at the Port of Galati. By enhancing these processes, this use case will also validate the efficacy of the toolkit provided here. The specific details of UC1 will be provided below, but in general consist of applying the FLEXI-cross toolkit toward border checking procedures at this port location. This use case, as mentioned above, will be located at the Danube based port of Galati in Romania. The intended length of this UC1 pilot is 2-3 months, with at least 1 month for organizational activities (i.e., approvals from the IGPF and relevant end-users). Five specific scenarios are proposed in this use case, which constitute individual steps of border control processes. These five scenarios consist of the following:

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Description of the scenarios:

1. Identification of a mismatch between the documents presented for border control and the person;
2. Fraudulent abandonment of a ship by a crew member during border control;
3. Boarding the ship during the mooring for border control of a foreign person;
4. During border control, materials suspected of being dangerous, e.g., illegal waste, are detected;
5. During border control, an illegal person is detected on board.

These scenarios are further described below in section 2.1.4 User Journey / Pilot Deployment Steps.

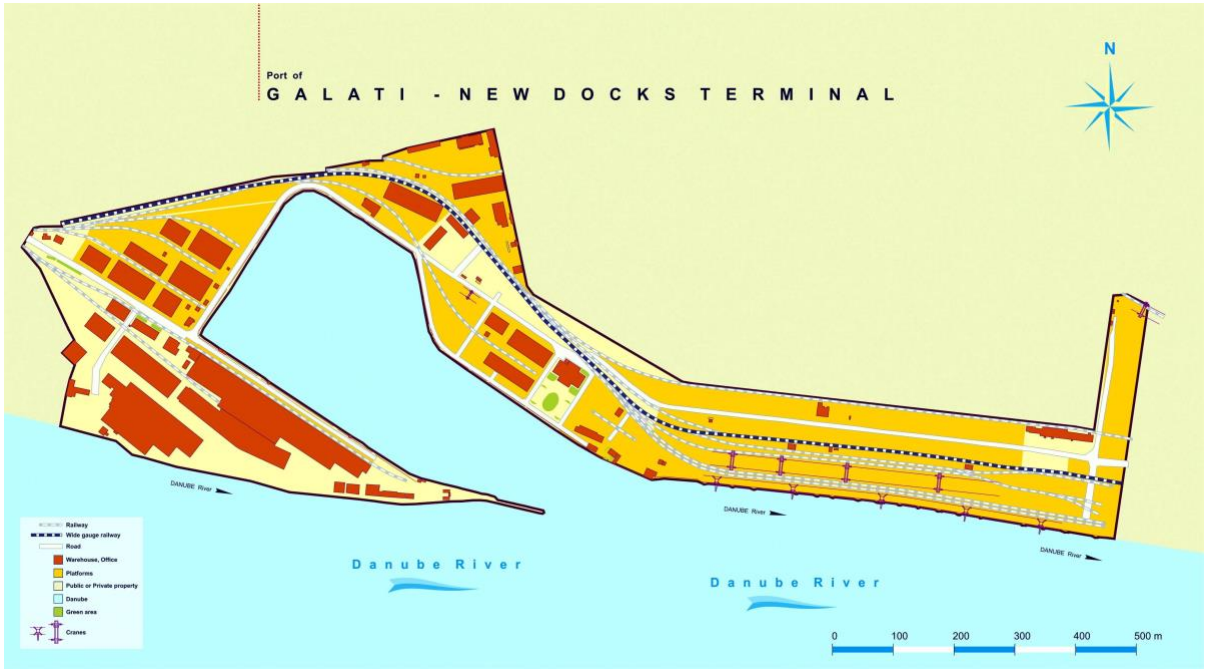

Figure 3 – UC1 Port of Galati Location (source: https://apdmgalati.ro/en/galatis-port/bazinul-nous-port/)

2.1.2.1 Participants, End Users, and Stakeholders

The follow section describes the participants, end users, and relevant stakeholders for UC1. These use case stakeholders consist of the consortium partners within this project who are involved in this use case. Additionally, their intended individual contributions are summarized.

Table 1 – UC1 Participants & Stakeholders

Partner	Role	Contribution
ATG	Consortium Partner/ End-User Support	Support to the end-user providing the challenges, solution requirements, personnel for trials and solution validation

GIBP	Consortium Partner / End-User	End-user providing challenges, solution requirements, personnel for trials and solution validation.
IGPF	Consortium Partner / End-User	End-user providing challenges, solution requirements, personnel for trials and solution validation.
ENG	Consortium Partner / Technical Partner	Integrator/technology developer providing data processing and Artificial Intelligence/Machine Learning (AI/ML) tools and integration services.
BEIA	Consortium Partner / Technical Partner	Software (SW) developer providing AI/ML based risk assessment based on acoustic sensor input.
HOLO	Consortium Partner / Technical Partner	SW/Hardware (HW) provider providing advanced situational awareness based in Augmented Reality (AR).
ICCS	Consortium Partner / Technical Partner	Technology provider for crowd behavior analysis/abnormal behaviour detection based on a tethered UAV system, as well as for face verification/identification via a mobile app.

2.1.2.2 Components of the Use Case

In this UC1, a variety of components will be utilized. The following new equipment/devices and systems are aimed to be incorporated.

- Internet of Things (IoT) components, connected via the test-bed management tools of the VITAL5G project. The VITAL5G-derived testing and experimentation services will be used for the purposes of interconnecting these IoT devices within a 5G connectivity network.
- Novel high-power acoustic through-the-wall sensor using broad bands of ultrasound signals, capable to detect boxes or small containers hidden in bulk cargo will be researched and tested in this project.
- AI/ML tools for risk assessment based on acoustic sensor input provided by BEIA. The acoustic sensing will identify suspicious sounds by using high power acoustic waves and analyzing the back – scattered acoustic signal.
- 3D AR Situational Awareness will be provided with augmented reality visualization software and hardware provided by HOLO. The FLEXI-cross AR visualization application will incorporate an Interactive Streaming for Augmented Reality (ISAR) plugin and associated AR visualization client smart glasses. AR smart glasses will be used to assist border control personnel with the identification of people that have been detected and identified as suspicious or warranting attention through the INUS-CBA platform from video feed processing (see below).
- MUSCA software for 2D monitor based situational awareness, data processing and AI/ML tools and integration services provided by ENG.
- INUS-CBA platform (INtelligentUxV Surveillance-Crowd Behaviour Analysis) and FACE-VI mobile app (Face Verification Identification mobile application) provided by ICCS.

2.1.3 Integration with FLEXI-cross platform – Modules & Connectivity

This use case will focus on the enhancement of the port security and control procedures for passengers and their luggage by using the innovative FLEXI-cross toolkit components. This will occur through the adoption of state-of-the-art technologies that will improve the operational capability of port authorities and customs agencies, to validate passengers' IDs and to detect, identify, and prevent smuggling and trafficking attempts via water. Advanced and portable biometric technology will be used by port authorities and local police to quickly, safely, and securely validate the identification (IDs) of the passengers/crew of berthed ships, before disembarkation, providing extremely high levels of data privacy. The technology will be integrated with agents/officers' mobile devices for portability and (re)configurability, while it will also provide instructions for the faster and more efficient deployment of the agents across the port (hence improving the end-to-end operation, the process flow, and the usability of the available resources), based on the available personnel, the incoming ships, and their respective risk assessment. Additional portable equipment may be deployed to assist with luggage scanning and the detection of potential smuggling attempts. Augmented Reality smart glasses will be deployed in this use case which will assist in providing situational awareness and information delivery during passenger/personnel identification and detection.

2.1.4 User Journey / Pilot Deployment Steps

Table 2 details a first description of the pilot operational steps per scenario that will be followed during the execution of the UC1 Galati Port border control trial. These operational steps might be adapted based on the outcomes of WP2 (FLEXI-cross Toolkit Development, Integration and Testing) and reported in D3.1 "Trial planning and experimentation methodology".

Table 2 – UC1 User Journey / Planned Scenarios

Scenario #	Step #	Pilot operational steps
Scenario 1 Mismatch between the documents and the person presented at the control	1	A cruise ship carrying passengers docks in Galati Port
	2	During the border control, the operator utilizes a smartphone with the FACE-VI mobile app i.e., captures the face portrait on-the-spot picture of an individual and one photograph of its travel document/passport's face photo) for person verification/identification
	3	The FACE-VI mobile app displays the identification and verification results (mis-verification/mis-identification)
	4	The system receives a mis-verification/mis-identification event
	5	The operator in the control room who receives the event, escorts the person to a different location to carry out a thorough check
	6	The operator on site receives coordinates and images of people being identified by the FACE-VI app which are displayed to the operator as holographic content in three dimensions while wearing AR smart glasses

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Scenario 2 One of the crew members leaves the berthed ship, evading the control by bypassing the control team	1	A commercial vessel docks in Galati Port
	2	During the border control, one of the crew members leaves the berthed ship, evading the control by bypassing the control team
	3	The evading crew member is being detected via the INUS-CBA platform in a restricted area
	4	The system receives an abnormal behavior detection event and a video stream
	5	The intervention team of the border police is informed to take action
	6	The intervention team intercepts, detains, and escorts the person for additional checks. Interception of the person is mediated by 3D visualization of the suspect on AR glasses worm by the on site operator. Information about their location will be provided to the operator wearing the AR glasses
	7	The border police carry out a thorough check on the apprehended person by utilizing a smartphone with the FACE-VI mobile app (i.e., captures the face portrait on-the-spot picture of the individual and one photograph of its travel document/passport's face photo) for person verification/identification
	8	The FACE-VI mobile app displays the identification and verification results (mis-verification/mis-identification)
	9	The system receives a mis-verification/mis-identification event
	10	The border police carry out a thorough check on the apprehended person which is augmented by three-dimensional information delivery provided to the AR glasses worn by the on site operator, derived from images/information of the person
Scenario 3 A person attempts to board the ship clandestinely	1	A commercial vessel docks in Galati Port
	2	During the border control, a person from the port perimeter increases the speed of movement to board the ship clandestinely and acoustic sensors will be used to detect unusual noises
	3	The person's speed of movement is identified as abnormal
	4	The system receives an abnormal behavior detection event and a video stream
	5	The control team on board the ship is informed

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	6	The control team intercepts and apprehends the person, the person is then escorted for checks. Interception of the person is mediated by 3D visualization of the suspect on AR glasses worm by the on site operator. Information about their location will be provided to the operator wearing the AR glasses
	7	The border police carry out a thorough check on the detained person by utilizing a smartphone with the FACE-VI mobile app (i.e., captures the face portrait on-the-spot picture of the individual and one photograph of its travel document/passport's face photo) for person verification/identification
	8	The FACE-VI mobile app displays the identification and verification results (mis-verification/mis-identification)
	9	The system receives a mis-verification/mis-identification event
	10	The border police carry out a thorough check on the detained person which is augmented by three-dimensional information delivery provided to the AR glasses worn by the on site operator, derived from images/information of the person
Scenario 4 Detection of suspected dangerous material	1	A commercial vessel docks in Galati Port
	2	The risk analysis is carried out based on the statements of the ship's captain and the alert is generated
	3	During border control, the end user detects suspected dangerous materials, i.e., illegal waste (batteries and metal components) with the help of XRay/Radiation devices and acoustic sensors and VITAL-5G Testbed. Information delivery to on site operators regarding the suspected dangerous materials (e.g., location, details, etc.) will be provided to AR glasses and displayed to the operator
Scenario 5 Detection of illegal person on board	1	A commercial vessel docks in Galati Port
	2	The risk analysis is carried out based on the statements of the ship's captain and the alert is generated
	3	During border control, the end user detects illegal person on board with the help of X-ray devices and acoustic sensors
	4	The control team on board the ship is informed
	5	The operator escorts the person to a different location to carry out a thorough check by utilizing a smartphone with the FACE-VI mobile app (i.e., captures the face portrait on-the-spot picture of the individual and one photograph of its travel document/passport's face photo) for person verification/identification

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	6	The FACE-VI mobile app displays the identification and verification results (mis-verification/mis-identification)
	7	The system receives a mis-verification/mis-identification event
	8	The operator who receives the alert escorts the person to a different location to carry out a thorough check which is augmented by three-dimensional information delivery provided to the AR glasses worn by the on site operator, derived from images/information of the person.

2.1.5 Expected Measurable Results & KPIs

The following key performance indicators (KPIs) represent measurable result categories which are aimed to be profiled following the successful completion of UC1.

1. Detection rate of high-risk individuals
2. Identification rate of people
3. Biometric based false negative rate

Further and more detailed information on the impact and measurable KPIs across the three use cases, including UC1, can be found in Annex 1 (section 8) of this deliverable and section 5.1.3.

2.1.6 Potential pitfalls and risks

In the design of this use case, considerations were made toward potential risks and pitfalls which might arise during or prior to the execution of the use case. These risks are described here with emphasis on their impact and predicted probability.

Table 3 – UC1 Risk Assessment

Risk Name	Severity	Likelihood	Description
Limited or no access to legacy systems	Medium	Medium	Limited or no access to certain IGPF databases or data frame formats due to privacy issues.
Needed Technology readiness levels.	Medium	Low	Solution components will not reach the required maturity to be tested.
Interoperability issues	Low	Low	Lack of interoperability between the central platform and the trial site border check.
Unforeseen events (e.g., escalation of the military conflict in Ukraine)	High	Medium	Unforeseen events such as e.g., an escalation of the military conflict in Ukraine, or another possible pandemic outbreak, will impose to postpone the testing or relocate the location for the tests.

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3 Use Case #2 – Road border-check (Greece-Bulgaria border)

3.1.1 Use Case motivation and specific aims

Use Case 2 of this FLEXI-cross project involves another border crossing location which will be provided with the innovative technological toolkit developed here. The Greece-Bulgaria Border Crossing Point in this use case serves as a customs and passport control point on the road border between Greece and Bulgaria. At this location, the corresponding border control center houses a Passport Control Department and a Customs office unit. As for traffic from this border crossing point, passenger (cars), tourist (buses), and commercial traffic (trucks) are allowed to cross. With respect to infrastructure, this location is designed to have separate exits and entrances for vehicles. Each section includes three traffic lanes (passenger, bus, and truck) and one backup lane. However, only one specific section of the facilities is active for vehicle entry and exit, which includes an exit lane (formerly the passenger entrance lane), one main entrance lane (formerly the bus entrance lane), and two backup traffic lanes (formerly the truck entrance lane and backup lane). Passport control for entry and exit is carried out adjacent to the main exit traffic lane. In addition, there is another site suitable for conducting checks between the main entrance lane and the two backup traffic lanes. A separate section of the facility is inactive.

The massive numbers of vehicles passing through the BCP daily as well as the time-consuming process followed at the BCP, result in long queues of vehicles and passengers (could reach 5km) awaiting to cross the border and thus long delays (up to 24h) which may occur.

3.1.2 Description of the Use Case

The objective of the Greek-Bulgarian use case is to demonstrate the capabilities of an integrated system (used by operators and travelers) that merges legacy border control systems involved in the day-to-day tasks of the border authorities with state-of-the-art deployable and mobile checking technologies. In doing this, Border Control operations will become less time-consuming, as well as more efficient and effective. In this frame, the FLEXI-cross toolkit will be integrated with existing devices and systems used by the Hellenic Police at the BCP site in this use case and new devices/systems delivered by the FLEXI-cross partners, to upgrade the offered level of security and to enable new, innovative, border-control functions, such as FLEXI-cross platform, Machine Vision analytics via infrastructure cameras or fixed cameras in tethered drones, on-board unity (OBU), vehicle plate recognition system, mobile control applications for police operator and passengers, etc. A complete list of the systems and devices to be used in this use case is provided in Section 3.1.2.2.

Part of the new equipment to be deployed will be mobile and deployable systems that can be utilized prior to the BCP either by performing checks at the waiting queues of vehicles and passengers or by setting up pre-control point that can perform an initial check before reaching the BCP or by the passengers themselves (pre-registration process). An infrastructure camera or camera fixed on tethered drone deployed in order to observe through the whole length of the queue and provide real time streaming for machine vision analytics on plates' number recognition, vehicles' queuing number, passengers' suspicious behaviour (e.g., U-turn deviating from the queue). On board sensors and remote connectivity to vehicles' OBU (e.g., for trucks) can provide additional information on the vehicles' travel history, stops, engine and cargo status, potential contraband and/or smuggling attempts and more. A Pre-registration mobile application used by passengers and vehicles can be used, to minimize waiting times at the actual borders. Specifically, the scenarios that will be covered during the trial demonstration are the following and further detailed in operational steps in Section 3.1.4.:

- Truck carrying hidden illegal material;
- Truck carrying hidden migrants;
- Rented car tries to cross the BCP (criminal activity);

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- Driver/passenger attempts to cross with false documents;
- Addressing sudden surge in incoming vehicles via a dynamic deployment of additional resources.

3.1.2.1 Participants, End Users, and Stakeholders

The following are the involved actors for UC2. Actors constitute participants, end-users, and relevant stakeholders who will be engaged with this use case and its deployment on-site. Each actor and their responsibility within UC2 are indicated.

Table 4 – UC2 Participants & Stakeholders

Partner	Role	Contribution
HPOL	Consortium Partner/ End-User / Trial Leader	Support to the end-user providing the challenges, solution requirements, personnel for trials and solution validation
KEMEA	Consortium Partner / End-User Support/ Task Leader	Support to the end-user providing challenges, solution requirements, personnel for trials and solution validation.
WINGS	Consortium Partner / Technical Partner / Technical Trial Leader	Technology developer providing AI/ML based data ingestion and processing offering predictive risk assessment and remote vehicle monitoring functionality

3.1.2.2 Components of the Use Case

In UC2, several components will be utilized to enhance the border control processes at the Greek-Bulgarian border. The following will detail the new equipment/devices and systems aimed to be incorporated.

The novel systems that will be added to the BCP operations, consist of the following:

- Mobile control application (police & passengers' version) which occur in-advance
- WINGS Chariot and WINGSPARK systems, with various backend (data ingestion, processing, event triggering, etc.), as well as UI capabilities (dashboards, analytics, etc.)
- WINGS fixed (Roadside Unit/RSU) Infrastructure Camera deployed on BCP Infrastructure (optional also tethered drone camera) and visual analytics, for context/vehicle risk assessment, vehicle queue and type classification, as well as plate recognition capabilities
- WINGS On-board Unit (OBU) and On- board sensors (location, velocity, acceleration, temperature, light, humidity, BLE sensor, etc.) with remote 4G/5G connectivity
- Mobile control application (police & passengers' version) for in-advance, remote passenger/driver passport/fingerprint scanning information notification to authorities for border crossing time minimization

3.1.3 Integration with FLEXI-cross platform – Modules & Connectivity

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The Greek-Bulgarian border UC will rely on a number of static and mobile assets, as part of the data ingestion, data processing, service, and user interface layers, related to camera-based real-time video streams, fingerprint/passport scanning, remote and vehicle on-board unit-based sensing, AI/ML (such as computer vision), diagnostics and cross-referencing modules for offering end-to-end risk assessment, smuggling, and trafficking services to the authorities. The abovementioned components will be offered as part of the FLEXI-cross architecture layers, while connectivity will be realized leveraging various technologies, such as 4G/5G, Wi-Fi, as well as fixed broadband connectivity.

3.1.4 User Journey / Pilot Deployment Steps

Table 5 details a first description of the pilot operational steps per scenario that will be followed during the execution of the Greek-Bulgaria border control trial. These operational steps might be adapted based on the outcomes of WP2 (FLEXI-cross Toolkit Development, Integration and Testing) and reported in D3.1 "Trial planning and experimentation methodology".

Table 5 – UC2 User Journey / Planned Scenarios

Scenario #	Step #	Pilot operational steps
Scenario 1 Truck carrying hidden illegal material	1	A truck arrives at passport control to enter the country.
	2	During passport control, the command-and-control system alerts the end user that the vehicle is overloaded, which is not justified by the waybills presented by the driver of the vehicle.
	3	The end user deploys the OBU-based information/digital tachometer and the mobile x-ray device to check the vehicle, where illegal materials are detected inside it.
Scenario 2 Truck carrying hidden migrants	1	A truck arrives at passport control to enter the country.
	2	The driver of the vehicle, seeing border control officers checking inside the vehicles, deviates from the queue, makes a U-turn and parks his vehicle in the customs parking lot. In addition, the operator is notified by the command-and-control system that the vehicle is overloaded.
	3	An alert is generated, through the command-and-control system, notifying the operator of the abnormal behavior.
	4	The operator assigns the incident to the border control officer who conducts checks inside the vehicles.
	5	During the control of the vehicle and the driver, the weight of the vehicle is not justified, based on the waybills.
	6	The border control officer notifies the operator of the result of the check, and the operator deploys the mobile X-ray device to check the vehicle, where illegal migrants are detected inside it.
Scenario 3 Rented car tries to cross the BCP (criminal activity)	1	A rental car arrives at passport control to enter the country.
	2	The system targets the vehicle before it reaches the inspection line, through license plate number recognition, for thorough inspection and alerts the operator.
	3	The operator assigns a border control officer to check the driver of the car and the documents of the car, with mobile control devices.

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Scenario #	Step #	Pilot operational steps
	4	The border control officer checks the documents of the driver and the car with the mobile control devices and after the check refuses entry to the driver as he cannot justify the purpose of his trip.
	5	The border control officer informs the operator about the outcome of the control.
Scenario 4 Driver/passenger attempts to cross with false documents	1	A car with two passengers arrives at passport control to enter the country.
	2	During the passport and biometric control one passenger of the vehicle presents a false travel document.
	3	The system generates an alert to the operator about the existence of a false travel document and the need to carry out a thorough control.
	4	During the thorough control, the false travel document is established, and the passenger of the vehicle is arrested.
Scenario 5 Addressing sudden surge in incoming vehicles via a dynamic deployment of additional resources	1	Detection of 15 vehicles via live feed from tethered drone or infrastructure camera.
	2	The system defines that as an incident of sudden increase in incoming flow.
	3	An alert is created for assets' deployment.
	4	The operator assigns the available personnel to the incident and deploys the mobile assets.
	5	During document control, passengers who have used pre-registration are directed to another traffic lane for faster processing.

3.1.5 Expected Measurable Results & KPIs

The following KPIs highlight the measurable result categories which are aimed to be profiled following the successful completion of UC2.

1. Waiting + processing times
2. Depth of checks
3. Deployment times for ad-hoc BCP
4. Resources optimization
5. Freight mass estimation, Declination from declared mass on the waybills.
6. Number of contraband/smuggling incidents
7. Number of abnormal behavior incidents/month
8. Weight declination from waybill
9. Number of contraband/smuggling incidents
10. Number of rented-vehicle crossing incidents/month
11. Number of incoming vehicles

Further and more detailed information on the impact and measurable KPIs across the three use cases, including UC2, can be found in Annex 1 (section 8) and section 5.1.3 of this deliverable.

3.1.6 Potential pitfalls and risks

To ensure an optimal trial performance, a first risk assessment is performed and reported in Table 6. These risks and their associated severity levels along with probability of occurrence are described.

Table 6 – UC2 Risk Assessment

Risk Name	Severity	Likelihood	Description
COVID-19 outbreak and personnel from trial partners is diagnosed with COVID-19 symptoms.	High	Medium	The consortium will act proactively and establish backup plans to ensure the realization of the trial upon agreement with the European Commission (EC), such as to potentially shift the period of execution or run the trial considering all necessary sanitary controls. The project will be followed by more than one person per trial partner to ensure its smooth transition in case of confirmed COVID-19 cases.
Tense political situation in EU external borders.	High	Low	The participation of the Border Guard Authorities guarantees that the trial areas can be seamlessly accessed by their local personnel. Dedicated teleconferences with HPOL will be scheduled in order to discuss on time technical details for the interconnection of their legacy systems with FLEXI-cross.
Lack of confidence and/or expertise from the stakeholders/ operators for handing the FLEXI-cross solutions.	High	Low	Have as many stakeholders as possible trained and comfortable with using the new FLEXI-cross technologies integrated with their legacy systems. The overall training of the operators is of great importance to take place a sufficient period of time before the execution of the trial.
FLEXI-cross solutions will be only tested on a theoretical/ simulated basis and not in real time operations	Medium	Low	Technical partners' innovative solutions have been scheduled to be tested under real operational conditions and assets to test the effectiveness of the FLEXI-cross solutions in the field. Rehearsal(s) of the trial will be scheduled in proper period of time.
FLEXI-cross results are not satisfactory for end-users reducing the possibilities of exploitation.	High	Low	The project will follow a methodology based on continual improvement reviewing and revising approaches with respect the quality and relevance. The priority of the trial will be to ensure that the project's results meet the expectations of the end-users.
The expected alert(s) will not emerge when we refer to real time incidents.	Medium	Low	Make sure that the duration and actions of a specific abnormal activity are enough for activating the alert of interest.

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4 Use Case #3 – Intelligent, secure and portable border checking system, for the facilitation of rail travel - RO-MD border (Romania-Moldova border)

4.1.1 Use Case motivation and specific aims

Romania's eastern border is currently one of the most important borders. This is largely due because it is the Eastern border, as mentioned in UC1, and due to the ongoing war in Ukraine which has influenced crossing events substantially at this border. This third use case of the FLEXI-cross project will focus on rail-based border crossing at the Romanian-Moldova border with a main target that border inspections are frequently delayed due to the examination of COVID-19 symptoms and epidemiologic documents (RT-PCR, vaccination). The main routes in Europe for child trafficking originate in Eastern and Central Europe, Africa, or Asia and lead to Western Europe. According to Europol data, the most involved EU Member States are Romania, Moldova, Bulgaria, the Netherlands, Hungary, and Poland, with Nigeria, China, Albania, Vietnam, and Morocco being the most involved third nations.

The objective of the Romanian-Moldova usage case is an enhanced and faster system of border checks when it comes stopping children trafficking. The RO-MD border ensures the connection rail (two types of rail transport - European and Russian standard) between the European Union and Ukraine (via Moldova) and attracts goods and passengers from neighboring countries. BCP serves train passengers. The strategic importance and complexity of this European border crossing point requires increasing the level of security at the border by implementing the latest generation of technologies which will enable the specific control operations performed there to become more efficient and less time-consuming.

4.1.2 Description of the Use Case

The use case aims to digitize the border control systems at the Romanian-Moldova border by leveraging high-performance mobile solutions which will be integrated into the existing legacy systems. As mentioned above, these goals are driven by the strategic importance of the border as the eastern border of Europe and the ongoing war in Ukraine. The overall objective of this use case is to enhance security, improve efficiency, and streamline control operations at the border. The Romanian-Moldova border serves as a crucial connection point for rail transportation between the European Union and Ukraine via Moldova. It attracts goods and passengers from neighboring countries and requires increased security measures due to its strategic significance mentioned previously. By implementing the latest generation technologies and mobile solutions, border control operations can become more efficient and less time-consuming.

Expected Scenario and Basic Steps:
This use case will target the following functionalities in order to address the issues highlighted above:

- Use case objectives
  - o Create a software platform that allows relevant authorities to link parents' and their children's biometric identification data (including multimodal biometry using face/voice) and travel documents, also usable by border control authorities and featuring delegation of custody rights using blockchain
- Targeted functions to overcome limitations of current practice
- Novelty of the FLEXI-cross approach

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o Using portable devices connected using 5G for multimodal biometry allows Law Enforcement Agencies (LEA)s to check in real time any person in their territory against various databases. Blockchain enables data authenticity checks for documents of passengers and goods arriving at external EU borders.

4.1.2.1 Participants, End Users, and Stakeholders

The follow section describes the participants, end users, and relevant stakeholders for UC3. These use case stakeholders consist of the consortium partners within this project who are involved in this use case. Additionally, their intended individual contributions are summarized.

Table 7 – UC3 Participants & Stakeholders

Partner	Role	Contribution
GIBP	Consortium Partner / End-User	End-user providing challenges, solution requirements, personnel for trials and solution validation.
IGPF	Consortium Partner / End-User	End-user providing challenges, solution requirements, personnel for trials and solution validation. Access to legacy systems will also be provided.
BEIA	Consortium Partner / Technical Partner	Integrator / technology developer providing the biometric and AI/ML based functionalities as well as the integration of all devices and services into one platform for this use case.
TCCFR	Consortium Partner / End-User	End-user providing challenges and solution requirements from rail operator's perspective, providing access to legacy devices and systems, and participating in the execution and validation of trials/solutions

4.1.2.2 Components of the Use Case

In UC3, several components will be used to enhance legacy systems in the Romanian-Moldovan border crossing in order to augment border control processes. The following will detail the new equipment/devices and systems are aimed to be incorporated:

Used Facilities:
BEIA: VITAL-5G Testbed as previously described in UC1 at the Port of Galati; S2P Testbed for speech biometry; STAMINA Testbed for pandemics; PAPUDTestbed for Profiling using deep learning.

Equipment / Components:

- Biometric sensors, Document readers
- 5G Communication infrastructure
- Applications for authorities installed in relevant devices (smartphones)
- Train wagons
- Video cameras

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- Acoustic sensors
- 5G smartphones

4.1.3 Integration with FLEXI-cross platform – Modules & Connectivity

The aim of this particular use case centers on the deployment of an application that utilizes an Internet-of-Things (IoT) detection system and video cameras situated at the border crossing point to identify individuals (minors/immigrants) who trespass the border and to make the checking of legal documents faster. The toolkit of this platform aims at efficiently arranging streams of information for transmission to the directions center utilizing 5G network variables. The wireless transmission of video streams and data from diverse sensors, including GPS and biometrics, can be facilitated through an internal 5G network that is linked to the transmission center. The aforementioned feature facilitates the establishment of internet connectivity for the sensor suite, enabling it to react to specific protocols, such as scanning and identification, aimed at impeding the transit of individuals with criminal records or contraband items.

The demonstration will begin with the registration and linking of biometric data of volunteering passengers (50-100) by authorities (3-5). A border-checking application will be installed on appropriate devices (smartphones with multimodal biometric sensors). Custody delegation and the entry of information about an unaccompanied minor into the system will take place. Biographic information, biometrics, and any other information provided by the minor are included in the registered information. Authorities control the amount of trust in the input information.

The implementation of communication and monitoring technologies is deemed necessary for both travelers and as a means of identifying and addressing areas of vulnerability. The integration of sensors and cameras will facilitate the implementation of compatible wireless communication standards across a dedicated 5G network, thereby enabling the expansion of internet connectivity for the detection system. This section will detail the installation of various sensors at border crossing points, including GPS, biometric, and engine power sensors situated within the machine room. The sensors furnish pertinent data, including individual-specific traits, automobile registration numbers, and features of potential baggage/cargo, which will be conveyed to the monitoring equipment at the nearby border checkpoint enabling the authorities to make suitable determinations. The team will be able to utilize live video feeds from their environment through high-definition video cameras to attain the high-resolution, high-connectivity, and low-latency video streams that are exclusively provided by 5G.

The physical layer of the toolkit is responsible for the transmission of data from sensors and video streams. The stratum in question comprises a diverse array of sensors, devices, and client agents that are responsible for the acquisition and transmission of data to the designated repositories. The heterogeneity of technologies, networks, and protocols is expected to be significant in this layer, owing to the distinct nature of the sensors and the diverse UC sites. To achieve uniformity in the integration of contextual data, a shared data model will be followed.

The middleware layer of the repository provides suitable facilitators for every use case requirement, ranging from the integration of devices to intricate event processing. The fundamental element of the middleware is the data ingestion and integration module, which establishes a connection between the physical layer and the output layer through a data bus. The core layer of the repository is responsible for converting raw data into valuable insights, which enhances the decision-making capabilities of the advanced support services. The Decision support mediator facilitates the flow of information from the core layer to the output layer, which is situated above it. The mediator furnishes information and materials to facilitate the results for stakeholders in the context of unified communications. The FLEXI-cross platform will be enhanced by the FLEXI-cross applications, which will

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facilitate user engagement with the platform's repositories. The security components are designed to cover all layers and enable effective and secure communication between on-site and off-site infrastructure.

4.1.4 User Journey / Pilot Deployment Steps

Table 8 details a first description of the pilot operational steps per scenario that will be followed during the execution of the Romania-Moldova border control trial. As in the previous user journeys, these operational steps have potential be modified based on the outcomes of WP2 (FLEXI-cross Toolkit Development, Integration and Testing) which will reported in D3.1 "Trial planning and experimentation methodology".

Table 7 – UC3 User Journey / Planned Scenarios

Scenario #	Step #	Pilot Operational Steps
Scenario 1 Mismatch between the documents and the minor person/or adult between 18-21 years presented at the control	1	A train carrying passengers stops for the border checks in Rail way Border Point
	2	During the border control, the border police utilize a mobile device with multimodal biometry verification, captures the face portrait on-the-spot picture of an unaccompanied minor individual/ or adult between 18-21 and one photograph of its travel document/passport's face photo, his fingerprint and also records the voice for person verification/identification.
	3	The software displays the identification and verification results (mis-verification/mis-identification)
	4	The system receives a mis-verification/mis-identification event for face, fingerprint, and voice
	5	The operator in the control room who receives the event, escorts the person to a different location to carry out a thorough check pending the presence of the competent national child authority
Scenario 2 Detection of cargo incoming from a country with pandemic disease outbreak	1	A train carrying cargo stops for the border checks in Rail way Border Point
	2	During the border control, the documents for the cargo is crosschecked with the databases/blockchain
	3	The border police officer in the control room is informed via the command and control screen that part of the merchandise departed from a country where a disease outbreak has a potential pandemic threat

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	4	The operator in the control room contacts the competent national health authority to conduct specific checks
Scenario 3 Detection of illegal person on board	1	A train carrying cargo stops for the border checks in Rail way Border Point
	2	During the border control, the documents for the cargo is crosschecked with the databases and AI profiling is done
	3	The border police officer in the control room is informed via the command and control screen that part of the cargo departed from a country with a high risk of migration
	4	The operator in the control room contacts the officers in the second line to conduct a thorough check of the wagons
	5	Border Police Officers detect (with the use of x ray devices/acoustic sensors/ other devices) 2 people being clandestine on board of the wagon hidden in the merchandise
	6	The persons identified are escorted for further investigations.

4.1.5 Expected Measurable Results & KPIs

The following KPIs highlight the measurable result categories which are aimed to be profiled following the successful completion of UC3:

- Optimization on the border waiting times
- Detection rate on foul play and alerts raising on the borders
- Users' satisfaction rates with respect to existing procedures
- Decrease of costs

Further and more detailed information on the impact and measurable KPIs across the three use cases, including UC3, can be found in Annex 1 (section 8) and section 5.1.3. of this deliverable.

4.1.6 Potential pitfalls and risks

The first risk assessment has been performed for this use case and reported in the following table. These risks and their associated severity levels along with probability of occurrence are described.

Table 8 – UC3 Risk Assessment

Risk Name	Severity	Likelihood	Description
Limited or no access to legacy systems	Medium	Medium	Limited or no access to certain IGPF databases or data frame formats due to privacy issues.
Needed Technology readiness levels.	Medium	Low	Solution components will not reach the required maturity to be tested.

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Interoperability issues	Low	Low	Lack of interoperability between the central platform and the trial site border check.
Unforeseen events (e.g., escalation of the military conflict in Ukraine)	High	Medium	Unforeseen events such as e.g., an escalation of the military conflict in Ukraine, or another possible pandemic outbreak, will impose to postpone the testing or relocate the location for the tests.

5 Cross Use Case Overview, Deployment Roadmap and Impact

Having described the individual use cases in detail, this section will provide information relevant to all three. The envisioned technical modules and their applicability along with the deployment roadmaps will be presented. Additionally, key performance indicators and information regarding their impact will be described.

5.1.1 Architectural Modules & Use Case Applicability

In order to meet the needs of the end-user in the use cases described here, this FLEX-Cross project will utilize a diverse set of innovative technical tools. These components will provide a comprehensive toolkit which will be used across the three use cases. Each of the tools envisioned to bring functionalities to the FLEXI-Cross border crossing solutions are listed below along with an index of which use case they are intended to be used in. Further information on the tools themselves and the architecture overall will be provided in deliverable D1.3 “Initial FLEXI-cross solution architecture & testing methodologies”.

Table 9 – Cross Use Case Technical Modules

Module Name	Module Owner	UC1*	UC2*	UC3*
3D AR Situational awareness	HOLO	X		
2D Situational awareness	ENG	X		
2D Situational awareness	WINGS		X	
2D Situational awareness	BEIA	X		
Role based Access & Control	ENG	X	X	X
Data Export	ENG	X	X	X
Visual Analytics Dashboard	eBOS	X	X	X
Risk assessment	eBOS	X		
Vehicle risk assessment	WINGS		X	
Face image capture (related to FACE-VI app)	ICCS	X		

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Face feature extraction (related to FACE-VI app)	ICCS	X		
Face verification and identification (related to FACE-VI app)	ICCS	X		
UAV video (related to the INUS-CBA platform)	ICCS	X		
Crowd behavior analysis (related to the INUS-CBA platform)	ICCS	X		
Abnormal Behaviour detection (related to the INUS-CBA platform)	ICCS	X		
Human trafficking detection	WINGS/BEIA		X	
Contraband/smuggling detection	WINGS/BEIA		X	
Entities classification	WINGS		X	
Computer vision processing	BEIA/WINGS		X	
Positioning prediction	BEIA	X		
Identities processing	WINGS		X	
Cargo content identification	BEIA			X
Diagnostics	WINGS		X	
Cross-referencing	WINGS		X	
Tethered camera	WINGS		X	
Fixed camera	WINGS		X	
Fingerprint scan	WINGS		X	

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Passport Scan	WINGS		X	
Remote and onboard sensing	WINGS		X	
Acoustic sensing	BEIA	X		
Vehicle weight scale	BEIA			X
X-Ray/Radiation Scanning	BEIA	X		

*Modules indexed to individual use cases are only envisioned and planned. Cross use case indices are subject to change depending on future architecture and use case discussion which will evolve during the progression of the project.

5.1.2 Use Case Deployment Timeline and Roadmap

Applied use of the FLEXI-cross toolkit, as highlighted through the above technical modules, is the aim of this project. Each of the three use cases will have their associated toolkit components deployed on-site as envisioned in the above use case journey descriptions. Future steps in this project will utilize the technical modules above in order to meet the use case needs presented here. Technical workshops are currently planned which will allow the technical partners opportunities to develop, integrate, and execute deployment tests prior to the use case pilot showcase demonstrations. The final showcase demonstrations are currently planned to be held in April 2025 (±2-3 months), which will occur following toolkit installation on the use case site premises the month prior. Prior to these individual showcase demonstrations, internal technical demonstrations will be conducted, which aim to prepare for the final showcase pilots. Preparations for the internal demonstrations will be preceded by an initial simplified integration in September 2024 (± 2-3 months). Internal technical demonstrations are currently planned for October 2024 (± 2-3 months). In addition to demonstrations and workshops, physical training exercises are planned throughout the duration of the project which will allow all use case stakeholders to be provided with necessary skills and information for pilot deployments to be run smoothly.

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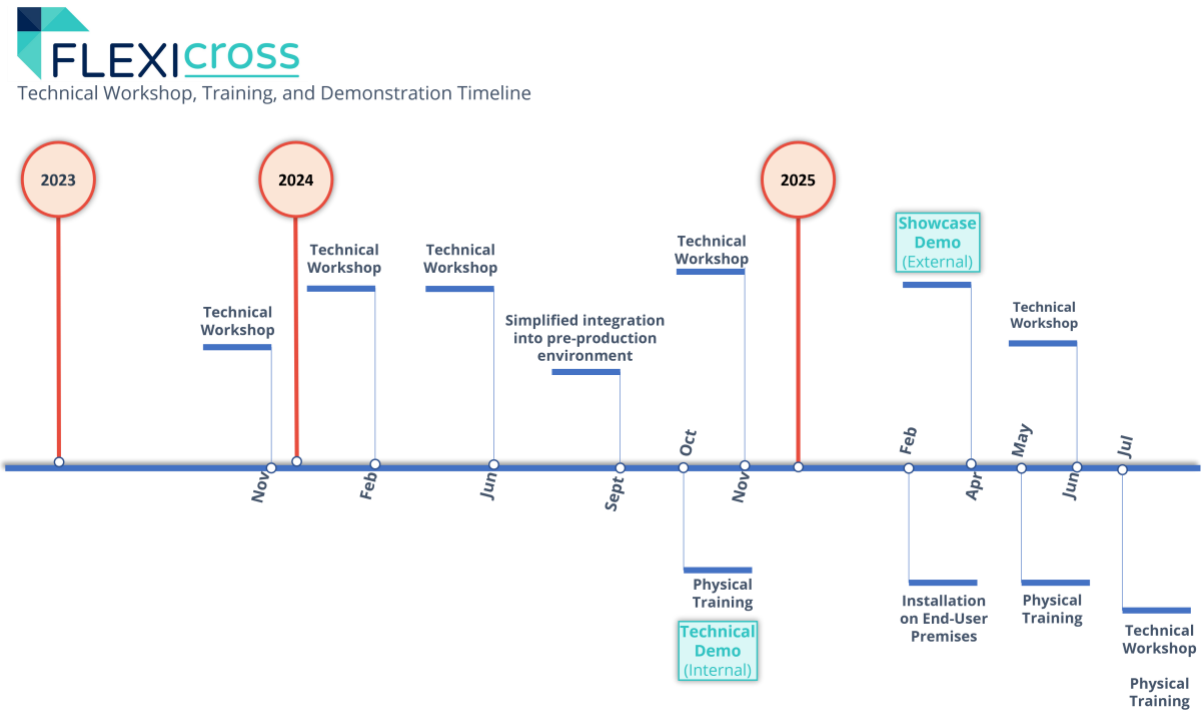

Figure 4 – FLEXI-Cross Use Case, Training, and Technical Workshop Timeline

5.1.3 Use Case KPI and Impact Categories

The impact that the FLEXI-cross project aims to achieve span over three different phases: Medium, Long, and Wider impact.

On the Medium term, FLEXI-cross intends to contribute significantly to three specific outcomes and make a difference beyond the immediate scope of the project. These outcomes consist of the following:

1. **Implementation of a seamless border crossing experience for travelers, operators, and border authority staff:** the FLEXI-cross solution aims to enhance border-checking operations by providing efficient, secure, and flexible processes, resulting in a better travel experience with reduced waiting times. This is achieved through various measures, including traveler pre-registration, targeted searches, increased detection rates, predictive risk assessment, and optimized resource utilization based on real-time data.

2. **Increase security, reliability, and privacy during cross border checks for both passengers and cargo**: the FLEXI-cross solution offers secure and dependable transmission, processing, and storage of data while prioritizing privacy protection for EU border authorities. The solution address day-to-day issues such as trafficking, smuggling, document falsification, and access of flagged individuals, leading to a significant increase in border-checking procedures' scrutiny, security, and success rate.

3. **Improve organization, flexibility, and planning of border checking points:** the FLEXI-cross trials are expected to significantly improve the end-to-end border checking process's overall efficiency. The project aims to use prior knowledge and real-time information to make real-time adjustments to equipment/device usage, border personnel placement, and vehicle/drone deployment to better match real-life conditions at various checkpoints. In addition, new processes will be introduced to either increase a certain BCP's capacity or establish a new ad-hoc BCP to manage traffic peaks.

On the Long term, the FLEXI-cross project aims to attain the below three impacts:

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1. Improve the security of EU land, air, and sea borders against accidents, natural disasters, and security breaches.
2. Improve border crossing experience for travelers and border authorities' staff, while maintaining security and monitoring of movements across air, land, and sea borders.
3. Improve customs and supply chain security through better prevention, detection, and fighting illegal activities across EU border crossing points.

On the Wider range, the FLEXI-cross project aims for improving all European citizens lives on three different scales:

1. **Societal**: the FLEXI-cross project, through the dynamic, effective, and cost-efficient services that it aims to deliver, is looking to improve the safety of European citizens, to contribute toward the protection of their lives, and finally to encourage and engage public and private sectors in the process of finding new innovative ideas which will open a new horizon for new technologies and solutions.
2. **Economic**: transport of humans and goods between European countries is increasing year to year and is expected to increase exponentially with the new route planning that is ongoing between many European countries [8, 9]. In addition, Europe is witnessing an increase in level of employment within the EU area, which will put more stress on the different border check points. Therefore, the FLEXI-cross project will deliver a solution to facilitate smooth and efficient transportation between the countries which will result in an increase in economic activities and opportunities.
3. **Scientific**: the FLEXI-cross project, through the different research areas that are planned to take place, and though the expected impact on the regulations, and standardization, will secure huge material for academic and professional industries.

Throughout the project implementation, many Key Performance Indicators will be used to measure either the intended results or the impact that the consortium is aiming to achieve with this FLEXI-cross project. The following figure graphically demonstrates the different KPIs with respect to the respective levels of impact.

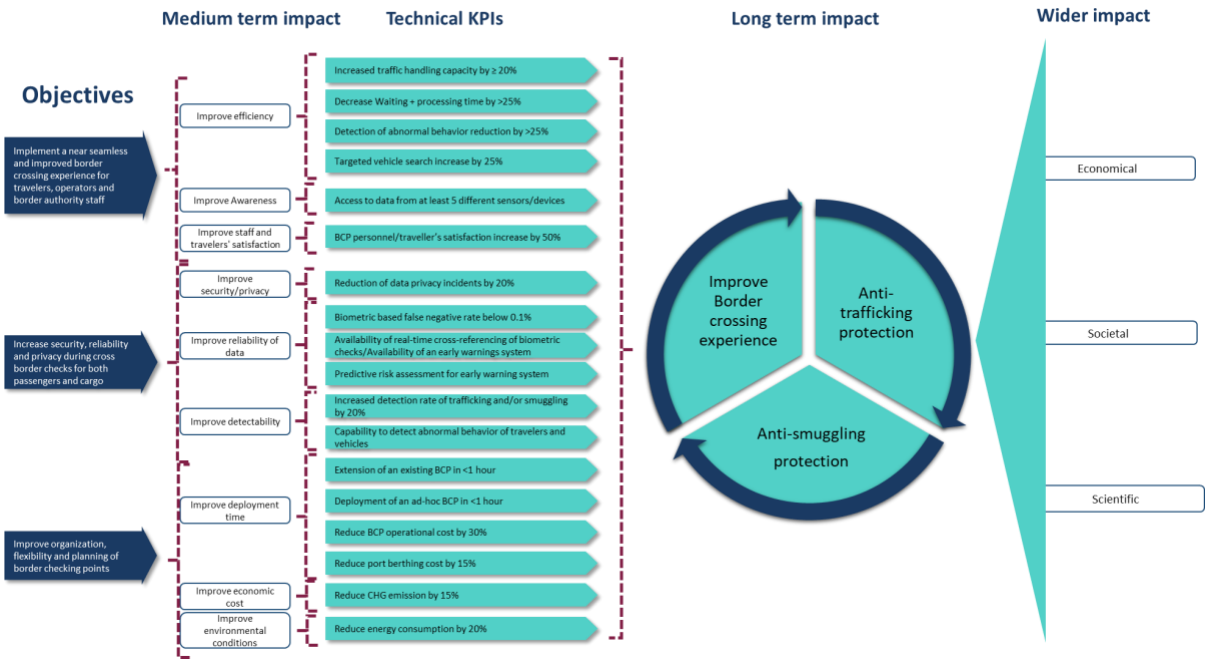

Figure 5 – Use Case Impact and KPI Categories

As mentioned above, the FLEXI-cross toolkit will be demonstrated through three different use cases and in each use case, the solution will provide many benefits and added value which will be demonstrated and shown through many target KPIs. Annex 1 of this deliverable details the mapping of these KPIs and the added values on the three mentioned levels of Medium, Long, and Wider term.

6 Conclusion and Future Directions

This deliverable D1.2 has provided a report of the work resulting from T1.2 “Use case target KPI co-design”. This document provided the initial descriptions of the three specific use cases of this project, which originated from multilateral discussions between relevant stakeholders of this project, with extensive cooperation between border control authorities and FLEXI-cross technical partners. Each of the use cases presented here represents a unique environment to assess and validate the effectiveness of the tailored FLEXI-cross innovative technical toolkit which will be developed and deployed in the duration of this project. Three use cases were described: 1) port-based crossing at the Romanian Port of Galati, 2) vehicular road-based crossing at the Greek-Bulgarian border and 3) rail-based crossing at the Romanian-Moldovan border. Each use case was described with respect to the motivation and aims which drive the need for the innovative technical solutions which will be produced in this project. The relevant stakeholders, end-users, and actors for each use case were introduced, along with the functional components that are intended to be utilized in each use case. A tentative user journey/pilot scenario timeline and accompanying expected measurable results were described along with predictive risks and potential pitfalls which will be monitored leading to the future toolkit development steps and deployments of these pilots. In this deliverable, the technical modules which are being developed for this project have been indicated along with their respective sites of deployment per use case. A tentative timeline with use case relevant events (e.g., technical workshops, physical training, and deployments) was presented. Finally, key performance indicators and impact category analyzes were introduced which cover the medium and long term with consideration toward wider impact. Collectively this deliverable has provided an overview of the use case of this FLEXI-cross project. Future work will consist of continued discussion and granular planning for each use case to ensure that deployment of these trials is reached successfully, and to accommodate any needed modifications resulting from changes which arise during the continued research practices of the project. More immediate steps consist of further defining the architecture of the FLEXI-cross platform given the use case specifications described above along with its future integration and testing phases.

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8 Annex I: Use Case KPI and Impact Categories

Annex 1 of this deliverable details the mapping of these KPIs and the added values on the three mentioned levels of Medium, Long, and Wider term. These impact and KPI categories refer to the text presented in section 5.1.3. The mapping of these KPIs is separated by use case (1-3).

Please note that the Wider Impact categories listed below (Figures 8, 11, 14) are merely descriptive in potential and will be assessed for success of impact at a later period in this project.

Use Case 1, for the Romania/Galati port: which aims to enhance the protection and biometric checks for European ports.

		Medium Term impact																	
		Improve efficiency				Improve awareness	Improve staff and traverlers' satisfaction	Improve security/ privacy	Improve reliability of data			Improve detectability		Improve deployment time				Improce economic cost	Improve environmental conditions
	Added value of the Flexicross solution	Increased traffic handling capacity by ≥ 20%	Decrease Waiting + processing time by >25%	Detection of abnormal behavior reduction by >25%	Targeted vehicle search increase by 25%	Access to data from at least 5 different sensors/ devices	BCP personnel/traveller's satisfaction increase by 50%	Reduction of data privacy incidents by 20%	Biometric based false negative rate below 0.1%	Availability of real-time cross-referencing of biometric checks/ Availability of an early warning system	Predictive risk assessment for early warning system	Increased detection rate of trafficking and/or smuggling by 20%	Capability to detect abnormal behavior of travelers and vehicles	Extension of an existing BCP in <1 hour	Deployment of an ad-hoc BCP in <1 hour	Reduce BCP operational cost by 30%	Reduce port berthing cost by 15%	Reduce CHG emission by 15%	Reduce energy consumption by 20%
UC1: Romania/ Galati port: Enhanced protection and biometric checks for European ports	Modularity, flexibility and portability of the checks	x	x	x	x		x				x	x	x			x		x	
	easy and rapid deployement of tethered UAV					x	x					x	x	x	x				
	expoitation of AI/ML algorithms			x	x		x				x	x	x						
	AR visualization					x	x					x	x						
	seamless integration of different data sources					x		x		x	x	x	x						
	easy transportation of equipment with the BCP													x	x				
	intelligent evaluation of data acoustic signatures			x	x						x	x	x						

Figure 6 – UC1: Medium Term Impact Categories

		Long Term impact		
		Improve border crossing experience	Anti-trafficing protection	Anti-smuggling protection
	Added value of the Flexicross solution	travelers' and end users' satisfaction score >=70% (2030)	reduction of trafficking attempts at EU land, rail and sea borders of about 30% (2030)	reduction of smuggling attempts at EU land, rail and sea borders of about 30% (2030)
UC1: Romania/ Galati port: Enhanced protection and biometric checks for European ports	Modularity, flexibility and portability of the checks	x	x	x
	easy and rapid deployement of tethered UAV		x	x
	expoitation of AI/ML algorithms	x	x	x
	AR visualization	x	x	x
	seamless integration of different data sources		x	x
	easy transportation of equipment with the BCP			
	intelligent evaluation of data acoustic signatures		x	x

Figure 7 – UC1: Long Term Impact Categories

	Added value of the Flexi cross solution	Wider impact		
		Economical	Societal	Scientific
UC1: Romania/ Galati port: Enhanced protection and biometric checks for European ports	Modularity, flexibility and portability of the checks			
	easy and rapid deployement of tethered UAV			
	expoitation of AI/ML algorithms			
	AR visualization			
	seamless integration of different data sources			
	easy transportation of equipment with the BCP			
	intelligent evaluation of data acoustic signatures			

Figure 8 – UC1: Wider Impact Categories

Use Case 2, for Greece-Bulgaria borders: for Intelligent and dynamic customs procedures for improved border crossing experience on the road.

		Medium Term impact																	
		Improve efficiency				Improve awareness	Improve staff and travelers' satisfaction	Improve security/ privacy	Improve reliability of data			Improve detectability		Improve deployment time				Improce economic cost	Improve environmental conditions
	Added value of the Flexi cross solution	Increased traffic handling capacity by ≥ 20%	Decrease Waiting + processing time by >25%	Detection of abnormal behavior reduction by >25%	Targeted vehicle search increase by 25%	Access to data from at least 5 different sensors/ devices	BCP personnel/traveller's satisfaction increase by 50%	Reduction of data privacy incidents by 20%	Biometric based false negative rate below 0.1%	Availability of real-time cross-referencing of biometric checks/ Availability of an early warning s system	Predictive risk assessment for early warning system	Increased detection rate of trafficking and/or smuggling by 20%	Capability to detect abnormal behavior of travelers and vehicles	Extension of an existing BCP in <1 hour	Deployment of an ad-hoc BCP in <1 hour	Reduce BCP operational cost by 30%	Reduce port berthing cost by 15%	Reduce CHG emission by 15%	Reduce energy consumption by 20%
UC2: Greece-Bulgaria borders: Intelligent and dynamic customs procedures for improved border-crossing experience on the road	early checking technologies	x	x		x		x											x	
	integrated information from various systems, sensors/devices				x	x				x	x	x	x						
	early warning system			x	x		x				x	x	x						
	remote monitoring and control of the end to end process						x						x						

Figure 9 – UC2: Medium Term Impact Categories

	Added value of the Flexi cross solution	Long Term impact		
		Improve border crossing experience	Anti-trafficing protection	Anti-smuggling protection
		travelers' and end users' satisfaction score >=70% (2030)	reduction of trafficking attempts at EU land, rail and sea borders of about 30% (2030)	reduction of smuggling attempts at EU land, rail and sea borders of about 30% (2030)
UC2: Greece-Bulgaria borders: Intelligent and dynamic customs procedures for improved border-crossing experience on the road	early checking technologies	x		
	integrated information from various systems, sensors/devices		x	x
	early warning system		x	x
	remote monitoring and control of the end to end process		x	x

Figure 10 – UC2: Long Term Impact Categories

	Added value of the Flexi cross solution	Wider impact		
		Economical	Societal	Scientific
UC2: Greece-Bulgaria borders: Intelligent and dynamic customs procedures for improved border-crossing experience on the road	early checking technologies			
	integrated information from various systems, sensors/devices			
	early warning system			
	remote monitoring and control of the end to end process			

Figure 11 – UC2: Wider Impact Categories

Use Case 3, for Romania-Moldova borders: for Intelligent, secure and portable border checking system, for the facilitation of rail travel.

		Medium Term impact																	
		Improve efficiency				Improve awareness	Improve staff and traverler's' satisfaction	Improve security/ privacy	Improve reliability of data			Improve detectability		Improve deployment time				Improce economic cost	Improve environmental conditions
	Added value of the Flexicross solution	Increased traffic handling capacity by ≥ 20%	Decrease Waiting + processing time by >25%	Detection of abnormal behavior reduction by >25%	Targeted vehicle search increase by 25%	Access to data from at least 5 different sensors/ devices	BCP personnel/traveller's satisfaction increase by 50%	Reduction of data privacy incidents by 20%	Biometric based false negative rate below 0.1%	Availability of real-time cross-referencing of biometric checks/ Availability of an early warnings system	Predictive risk assessment for early warning system	Increased detection rate of trafficking and/or smuggling by 20%	Capability to detect abnormal behavior of travelers and vehicles	Extension of an existing BCP in <1 hour	Deployment of an ad-hoc BCP in <1 hour	Reduce BCP operational cost by 30%	Reduce port berthing cost by 15%	Reduce CHG emission by 15%	Reduce energy consumption by 20%
UC3: Romania-Moldova borders: Intelligent, secure and portable border checking system, for the facilitation of rail travel - RO-MD border	border checking is done seamlessly using light equipment (smartphones)		x				x												
	data is unified and standardised																		
	interoperability with other systems					x		x		x		x				x	x		

Figure 12 – UC3: Medium Term Impact Categories

	Added value of the Flexi cross solution	Long Term impact		
		Improve border crossing experience	Anti-trafficing protection	Anti-smuggling protection
		travelers' and end users' satisfaction score >=70% (2030)	reduction of trafficking attempts at EU land, rail and sea borders of about 30% (2030)	reduction of smuggling attempts at EU land, rail and sea borders of about 30% (2030)
UC3: Romania-Moldova borders: Intelligent, secure and portable border checking system, for the facilitation of rail travel - RO-MD border	border checking is done seamlessly using light equipment (smartphones)			
	data is unified and standardised			
	interoperability with other systems		x	

Figure 13 – UC3: Long Term Impact Categories

	Added value of the Flexi cross solution	Wider impact		
		Economical	Societal	Scientific
UC3: Romania-Moldova borders: Intelligent, secure and portable border checking system, for the facilitation of rail travel - RO-MD border	border checking is done seamlessly using light equipment (smartphones)			
	data is unified and standardised			
	interoperability with other systems			

Figure 14 – UC3: Wider Impact Categories