D3.1 - Trial planning and experimentation methodology

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Glossary of terms and abbreviations used

Terminology/Acronym	Description
AI	Artificial Intelligence
BCP	Border Check Point
DoA	Description of Action
EC	European Commission
FACE - Verification/Identification mobile app	Face-VI mobile app
GA	Grant Agreement of the project
GHG	Green House Gases
HMI	Human machine interface
INUS-UPE	INtelligent UxV surveillance - Unusual Pattern Extraction INUS-UPE platform
KPA	Key Performance Area
KPI	Key Performance Indicator
ML	Machine Learning
NFU	Non Functional
OBU	On Board Unit
RSU	Road Side Unit
UAV	Unmanned Aerial Vehicle
UC	Use case
WP	Work Package

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Executive Summary

WP3 plays a pivotal role in ensuring the success of the project by **facilitating the seamless execution and fulfilment of planned trials** at the border/entry-point facilities, specifically, the main objectives of WP3 are as follows:

1. **Definition of trial preparation methodology and trial execution guidelines:** Establishing clear methodologies and guidelines is crucial for the effective preparation and execution of trials.

2. **Trial coordination, interworking, and progress monitoring:** WP3 oversees the coordination of trials, ensuring smooth collaboration between stakeholders and monitoring the progress of each trial.

3. **Trial configuration and calibration:** Proper configuration and calibration of trial setups are essential for accurate and reliable results.

4. **Conducting extensive field trials according to plan:** WP3 ensures that trials are conducted rigorously according to predefined plans, maximising the reliability of the data collected.

5. **Generating useful output per trial site:** The outcomes of trials are meticulously analysed and synthesised into valuable insights and outputs for each trial site.

6. **Comprehensive technical and operational KPI analysis and validation:** WP3 conducts thorough analysis and validation of technical and operational Key Performance Indicators (KPIs) to assess the effectiveness of border control operations.

D3.1 marks a pivotal milestone for WP3 due to its significance in laying the groundwork for the successful execution of trials. D3.1 contains information about several key elements that are essential for the smooth implementation of trials. Below, the key points for the successful execution are summarised:

1. **Trial Planning:** It provides detailed plans for conducting trials at each facility, including the related operational scenarios.
2. **Used Tools:** The report specifies the tools and technologies to be utilised during the trials. This includes hardware, software, and any other equipment (e.g., Legacy systems) necessary for data collection, analysis, and validation.
3. **Experimentation Methodology:** It outlines the methodology to be followed by FLEXI-Cross experimenters/users during the trials. This includes the tools which are going to be employed for each operational scenario and details the metrics for assessing the effectiveness of these scenarios.
4. **An Integrated Approach to Trial Validation Planning:** This phase focuses on establishing a comprehensive validation framework that ensures the alignment of solutions with the project's objectives and ethical standards. The framework will not only emphasise the coherence between solutions and project goals but also define stringent performance criteria for evaluating the functionality of various modules.

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1 Introduction

In D3.1, a validation strategy is presented, encompassing various facets of the FLEXI-cross project, including the validation pillars, trial planning, and early drop results. This holistic approach ensures a thorough examination of the project's objectives and methodologies, while also adhering to the ethical guidelines outlined in D6.1. The validation pillars of FLEXI-cross are systematically assessed to gauge their alignment with project goals and user requirements. Through careful planning and execution, the UCs aim to provide robust validation of these pillars, ensuring their effectiveness in achieving project objectives.

Furthermore, the trial validation, planning, and approach are meticulously crafted to simulate real-world scenarios and usage contexts. Each aspect of the trials is carefully considered to ensure comprehensive testing of the system's functionality and performance. The early drop results obtained from these trials offer valuable insights into the project's progress and highlight areas for improvement.

Strict adherence to ethical requirements, as outlined in D6.1, is maintained throughout these validation efforts. Research participants are treated with the utmost respect and consideration, with their well-being and autonomy always prioritised. By upholding these ethical standards, the FLEXI-cross project ensures the integrity and validity of its research activities while fostering trust and confidence among its stakeholders.

Citizens will be involved in the pilots after examining the information sheet and completing a signed informed consent form. These documents, detailed in the annexes, ensure that participants have access to comprehensive information and voluntarily consent to their involvement. Furthermore, key accountable roles have been designated for each pilot: a Data Manager will oversee data privacy and management, ensuring adherence to strict protocols; the User Manager will facilitate participant interactions and ensure procedural compliance; and the Pilot Coordinator will manage logistics and timelines to ensure the pilot's smooth operation and successful execution.

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2 FLEXI-cross validation framework

The FLEXI-cross validation framework is a crucial component in ensuring the robustness and effectiveness of the project's deliverables. Harmonising various elements within the project and providing a structured approach to validating key functionalities and use cases. In the broader context of project deliverables, the validation framework acts as a pivotal checkpoint, ensuring that the developed solutions align seamlessly with predefined objectives and user requirements.
To facilitate a systematic approach, a dedicated timeline for validator training and integration activities has been designed. This timeline serves as a roadmap for the validation process, outlining key milestones and activities that validators will undertake. The training component is instrumental in equipping validators with the necessary skills and insights to effectively assess the project's outcomes. It encompasses an in-depth understanding of the FLEXI-cross system, its operational intricacies, and the expected user experience.
Integration activities within the timeline are strategically placed to allow validators to interact with the system in real-world scenarios. This hands-on approach ensures that validators can thoroughly assess the performance and functionality of the project deliverables within the intended operational environment. The integration phase is not only a validation of technical aspects but also an opportunity to gauge user-friendliness, system responsiveness, and overall user satisfaction.
By establishing a well-defined timeline for validator training and integration, the FLEXI-cross project not only ensures a rigorous assessment of its outcomes but also fosters continuous improvement. This iterative process allows for refinements based on validator feedback, ultimately contributing to the optimisation and fine-tuning of the entire FLEXI-cross validation framework.
In the context of software development and system engineering, the V-model is a structured and systematic approach that organises the phases of verification and validation in a distinctive "V" shape. It emphasises the relationship between development phases and corresponding testing activities, creating a visual representation of the process. In the V-model, the left side of the "V" represents the verification phase, focusing on activities such as reviews, inspections, and design validations, while the right side represents the validation phase, involving testing activities like acceptance testing, integration testing, and module testing. This model ensures a comprehensive and methodical approach to developing high-quality systems by systematically addressing both the correctness of the design and its adherence to user requirements. Applying the V-model to FLEXI-cross involves verifying elements such as end-user requirements, architecture design, hardware installation, and module design, followed by validation activities like acceptance testing, functional testing, integration testing, and module testing.

In the **Verification Phase**, the focus is on specific aspects of the development process:

End-User Requirements: The priority is to ensure the accurate capture and documentation of end-user requirements. This involves conducting thorough reviews and inspections to validate the requirements' clarity, completeness, and feasibility.

Architecture Design: The architectural design of the FLEXI-cross platform includes a robust structure comprised of several layers, each serving a specific and crucial function within the system. The FLEXI-cross architecture is designed to seamlessly integrate various components to ensure efficient and secure operation.

HW Installation: Verification activities in HW installation involve checking that all the components are correctly configured and installed. This phase includes inspections to confirm that the HW setup aligns with the architectural design.

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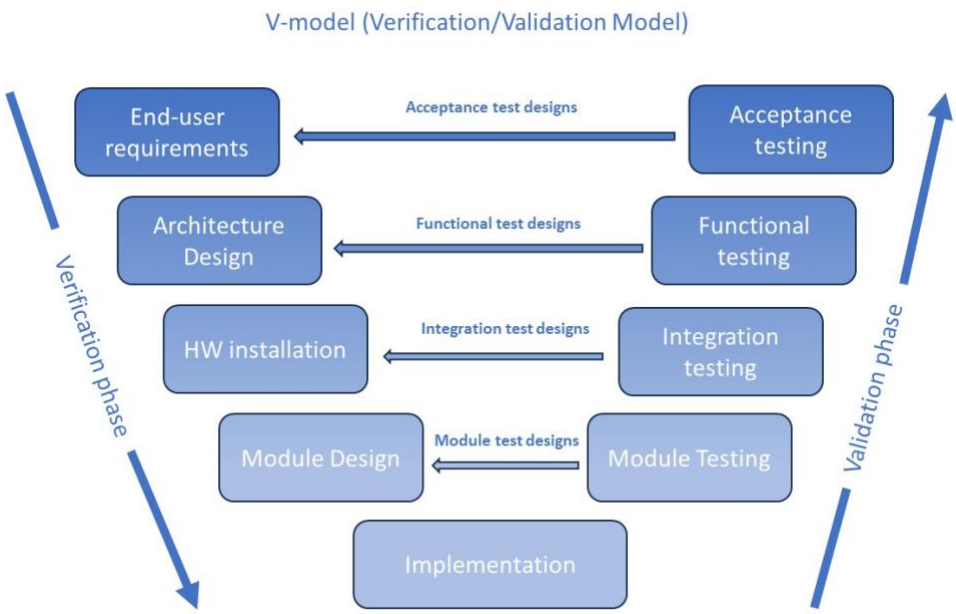

Figure 1. The representation of the V (Verification-Validation) - model.

Module Design: The design of individual modules is rigorously verified to ensure conformity with the overall architecture and fulfilment of the specified requirements. Reviews and inspections are integral to identifying and rectifying any design flaws early in the process.

For the **Validation Phase**, the focus shifts to testing activities:

Acceptance Testing: This phase involves executing acceptance tests to verify that the entire FLEXI-cross system meets end-users expectations. Testing scenarios are designed based on user requirements to validate the system's overall functionality and performance.

Functional Testing: The functional testing stage is dedicated to validating that each module of FLEXI-cross performs according to its design and functional specifications. Test cases are designed to cover various functional aspects, ensuring the correct implementation of features.

Integration Testing: Integration testing is crucial to verifying the interactions and interfaces between different modules of FLEXI-cross. It ensures that the integrated system functions as intended and that data flows seamlessly between components.

Module Testing: At the module level, testing is conducted to validate the functionality of individual modules in isolation. This helps identify and rectify defects within each module before integration.

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3 FLEXI-cross validation pillars

The analysis of the FLEXI-cross validation pillars is a detailed exploration into the essential elements shaping the project's success. In this approach, the examination of KPAs, KPIs, and their association with user requirements across three distinct UCs is paramount. By unravelling the relationships between these components, the analysis seeks to offer a nuanced perspective on how they collectively contribute to achieving project objectives. An integral part of this exploration involves assessing effectiveness through formulated metrics for all UCs. These metrics provide a practical means to measure project performance, ensuring a comprehensive and measurable evaluation of the FLEXI-cross validation pillars. This analysis aims to enhance our understanding of the project's operational intricacies, fostering informed decision-making and optimisation strategies aligned with FLEXI-cross's overarching goals.

3.1 Preserving and Protecting Ethical Principles: Upholding Fundamental Rights in AI Systems

In order to address the six general ethical principles that any AI system must preserve and protect based on fundamental rights as enshrined in the Charter of Fundamental Rights of the European Union (EU Charter) and relevant international human rights law, we defined the following non-functional requirements:

Table 1. List of non-functional requirements ethics requirements.

Ethical principles	ID	Description
1. Respect for Human Agency:	NFU_1	End users and others affected by the AI system MUST NOT be deprived of abilities to make basic decisions about their own lives or have basic freedoms taken away from them.
	NFU_2	It MUST be ensured that AI applications do not autonomously and without human oversight and possibilities for redress make decisions: about fundamental personal issues (e.g. affecting directly private or professional life, health, well-being or individual rights), that are normally decided by humans by means of free personal choices; or about fundamental economic, social and political issues, that are normally decided by collective deliberations, or similarly significantly affects individuals.
	NFU_3	End-users and others affected by the AI system MUST NOT be in any way subordinated, coerced, deceived, manipulated, objectified, or dehumanised.
	NFU_4	Attachment or addiction to the system and its operations MUST not be purposely stimulated. This should not happen through direct operations and actions of the system. It also should be prevented, as much as possible, that systems can be used for these purposes.
	NFU_5	AI applications should be designed to give system operators and, as much as possible, end- users the ability to control, direct and intervene in the basic operations of the system.

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	NFU_6	End users and others affected by the AI system MUST receive comprehensible information about the logic involved by the AI, as well as the significance and the envisaged consequences for them.

Ethical principles	ID	Description
2. Privacy and Data governance	NFU_7	The AI systems MUST process personal data in a lawful, fair and transparent manner.
	NFU_8	The principles of data minimization and data protection by design and by default MUST be integrated into the AI data governance models.
	NFU_9	Appropriate technical and organisational measures MUST be set in place to safeguard the rights and freedoms of data subjects (e.g. appointment of a data protection officer, anonymization, pseudonymisation, encryption, aggregation). Strong security measures MUST be set in place to prevent data breaches and leakages. Compliance with the Cybersecurity Act and international security standards may offer a safe pathway for adherence to ethical principles.
	NFU_10	Data should be acquired, stored, and used in a manner which can be audited by humans. FLEXI-cross consortium must comply with relevant legislation and the highest ethics standards. This means that all partners must apply the principles enshrined in the GDPR.

Ethical principles	ID	Description
3. Fairness	NFU_11	*Avoidance of algorithmic bias:* AI systems should be designed to avoid bias in input data, modelling and algorithm design. Algorithmic bias is a specific concern which requires specific mitigation techniques. Research proposals MUST specify the steps that will be taken to ensure that data about people is representative of the target population, reflects their diversity, and is sufficiently neutral.
	NFU_12	Similarly, research proposals should explicitly document how bias in input data and in the algorithmic design, which could cause certain groups of people to be represented incorrectly or unfairly, will be identified and avoided. This requires considering the inferences drawn by the system, which have the potential to exclude or, in other ways, unfairly disadvantage certain groups of people or single individuals.
	NFU_13	*Universal accessibility*: AI systems (whenever relevant) should be designed to be usable by different types of end-users with different abilities. Research proposals are encouraged to explain how this will be achieved, such as

		by compliance with relevant accessibility guidelines. To the extent possible, AI systems should avoid functional bias by offering the same level of functionality and benefits to end-users with different abilities, beliefs, preferences, and interests.
	NFU_14	*Fair impacts:* Possible negative social impacts on specific groups, including implications other than those resulting from algorithmic bias or lack of universal accessibility, may occur in the short, medium and longer term, especially if the AI is diverted from its original purpose. This MUST be mitigated. The AI system MUST ensure that it does not negatively affect the interests of relevant groups. Methods to identify and mitigate negative social impacts in the medium and the longer term should be well documented in the research proposal.

Ethical principles	ID	Description
4. Individual, Social and Environmental Well-being	NFU_15	AI systems MUST take into account all end-users and stakeholders and must not unduly or unfairly reduce their psychological and emotional well-being.
	NFU_16	AI systems should empower and advance the interests and well-being of as many individuals as possible.
	NFU_17	AI development MUST be mindful of principles of environmental sustainability, both regarding the system itself and the supply chain to which it connects. Whenever relevant, there should be documented efforts to consider the overall environmental impact of the system and the Sustainable Development Objectives, where needed, steps to mitigate it. In the case of embedded AI, this must include the materials used and decommissioning procedures.
	NFU_18	AI systems that can be applied in the area of media, communications, politics, social analytics, behavioural analytics online communities and services MUST be assessed for their potential to negatively impact the quality of communication, social interaction, information, democratic processes, and social relations (for example by supporting uncivil discourse, sustaining or amplifying fake news and deepfakes, segregating people into filter bubbles and echo chambers, creating asymmetric relations of power and dependence, and enabling political manipulation of the electorate). Mitigating actions must be taken to reduce the risk of such harms.
	NFU_19	AI systems MUST not reduce safety in the workplace. Whenever relevant, the application should demonstrate consideration of possible impact on workplace safety, employee integrity and compliance standards, such as with IEEE P1228 (Standard for Software Safety).

Ethical principles	ID	Description

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5. Transparency	NFU_20	It MUST be made clear to end-users that they are interacting with an AI system (especially for systems that simulate human communication, such as chatbots).
	NFU_21	The purpose, capabilities, limitations, benefits, and risks of the AI system and the decisions it conveys MUST be openly communicated to end-users and other stakeholders, including instructions on properly using the system.
	NFU_22	When building an AI solution, one MUST consider what measures will enable the traceability of the AI system during its entire lifecycle, from initial design to post-deployment evaluation and audit or in case its use is contested.
	NFU_23	Whenever relevant, the research proposal should offer details about how decisions made by the system will be explainable to users. Where possible, this should include the reasons.

Ethical principles	ID	Description
6. Accountability and Oversight	NFU_24	It MUST be documented how possible ethically and socially undesirable effects (e.g. discriminatory outcomes, lack of transparency) of the system will be detected, stopped, and prevented from reoccurring.
	NFU_25	AI systems MUST allow for human oversight and control over the decision cycles and operation unless compelling reasons can be provided that demonstrate such oversight is not required. Such a justification should explain how humans will be able to understand the decisions made by the system and what mechanisms will exist for humans to override them.
	NFU_26	To a degree matching the type of research being proposed (e.g. basic or precompetitive) and as appropriate, the research proposal should include an evaluation of the possible ethical risks related to the proposed AI system. This should also include the risk assessment procedures and the mitigation measures after deployment.
	NFU_27	Whenever relevant, how end-users, data subjects, and other third parties will be able to report complaints, ethical concerns, or adverse events should be considered, and how these will be evaluated, addressed, and communicated back to the concerned parties.
	NFU_28	As a general principle, all AI systems should be auditable by independent third parties (e.g., the procedures and tools available under the XAI approach support best practices in this regard). This is not limited to auditing the system's decisions but also covers the procedures and tools used during development. Where relevant, the system should generate human-accessible logs of the AI system’s internal processes.

3.2 KPI for the Key Performance Area: Efficacy of the implementation of ethical principles

According to the comments we received from the external ethics advisor in D6.7, we highlight the following ethics-related KPIs and KPAs, with reference to the non-functional requirements listed in the previous section:

Table 2. List of ethically-related KPAs, KPIs, and qualitative metrics.

KPAs	KPIs	Purpose of KPI	Reference to Non-functional requirements
Efficacy of the implementation of ethical principles	Decision-making and end-user autonomy	To increase the number of situations when an unexpected pattern is detected, all the necessary functionalities must be provided to manually proceed with further operations after evaluating the results of the system.	NFU_1, NFU_2, NFU_3, NFU_4, NFU_5, NFU_6
	Privacy and data governance	To implement technical controls that support governance policies.	NFU_7, NFU_8, NFU_9, NFU_10
	Fairness	To ensure the quality of treating people equally or in a way that is right or reasonable.	NFU_11, NFU_12, NFU_13, NFU_14
	Individual, Social and Environmental Well-being	To define measures to reduce the environmental impact of your AI system's lifecycle and participate in competitions for the development of AI solutions that tackle this problem.	NFU_15, NFU_16, NFU_17, NFU_18, NFU_19
	Transparency	AI applications do not autonomously and without human oversight and possibilities for redress make decisions (Assess the independence of the user decision from AI systems Reference to user requirements	NFU_20, NFU_21, NFU_22, NFU_23

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		(Non-technical requirements a user NFU 1 the system must not influence the user- Ensure unbiased decisions by authorities).	
	Accountability and oversight	To include mechanisms to ensure responsibility and accountability for AI systems and their outcomes, both before and after their development, deployment and use.	NFU_24, NFU_25, NFU_26, NFU_27, NFU_28

All these aspects will be respected in each of the following use cases.

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4 FLEXI-cross trials validation planning and approach

The FLEXI-cross project's trial validation planning and approach encompasses a comprehensive strategy that integrates deployment architectures, operational scenarios, and defined operational steps for evaluation. Each aspect is carefully orchestrated to ensure thorough testing and validation of the project's objectives.

Firstly, the deployment architectures around the UCs are designed to reflect real-world scenarios and facilitate the evaluation of the system's performance and functionality in various contexts. These architectures encompass the integration of legacy systems, hardware components, and software modules, providing a holistic view of system interactions and interoperability.

Operational scenarios and steps simulate different usage scenarios and workflows within the FLEXI-cross ecosystem. These scenarios represent typical border crossing cases, allowing for comprehensive testing across a range of potential scenarios. Each step is carefully planned to emulate real-world processes, ensuring that the trial validation accurately reflects the system's performance in practical settings.

Additionally, metrics are allocated per scenario to measure the effectiveness and performance of the FLEXI-cross system towards the satisfaction of each operational scenario. These metrics enable the quantitative assessment of the system's performance against the predefined operational targets. By allocating metrics per scenario, the trial validation approach ensures that all aspects of system functionality and performance are thoroughly evaluated and optimized.

4.1 General timeline

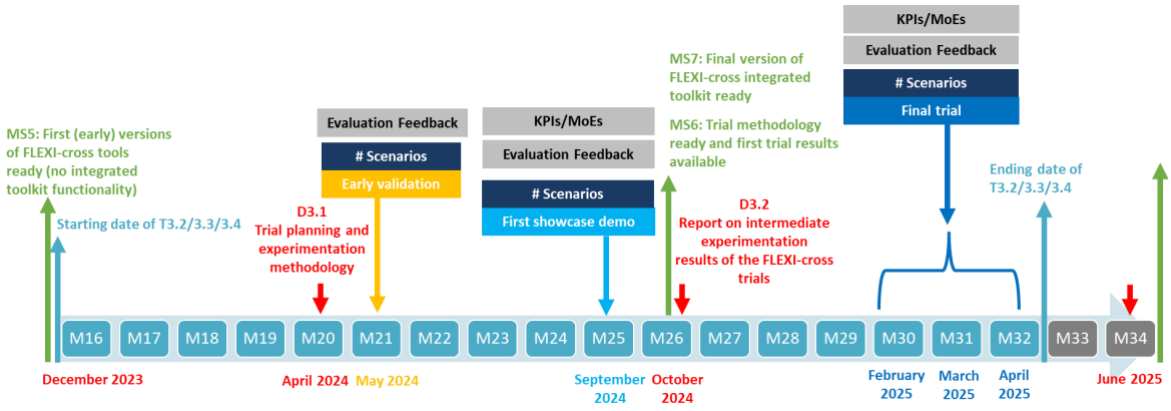

Figure 2. Representation of the general timeline with the most significant Milestones and the validation activities.

In Figure 2, the general timeline illustrates the trial validation phases along with the focused entity of validation, which includes operational scenarios and modules. All the UCs commence at M16 and provide early validation results by M21. Subsequently, a medium-term validation will occur at M25, followed by the final validation period at M30-M32. By following a stepwise approach, we ensure that all modules are successfully developed, allowing ample room for feature improvement. Simultaneously, the added value of the solutions demonstrates a systematic contribution to the operational apparatus.

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4.2 Port-based border-crossing trial

This chapter presents the operational scenarios that are going to be tested in the first use case of the FLEXI-cross project, which will take place at the port BCP in Galati, Romania. The operational scenarios are carefully described, offering a logical blueprint for completing each phase.

Table 3. Introduction of the Operational Scenarios of UC1.

Trial No1: Port-based border-crossing trials (Romania/Galati Port)	
Trial Leader	ATG
Trial Area	**Romania/Galati port - The Galati BCP** Galati is a medium-sized port. The types of vessels regularly calling at Galati are: General Cargo (40%), Inland, Pushtow, six cargo barges (5%), Inland, Unknown (4%), Inland, Motor Freighter (4%), Inland, Pushtow, four cargo barges (3%). The official UN/Locode of this port is ROGAL. Currently, the Port Security Office of the Port Authority deals with security at the border of the port of Galati, which aims to implement and monitor the provisions of the ISPS Code (International Code for Ship and Port Security). For this purpose, laptops, printers, video projectors, biometric fingerprint scanners, servers, fixed ship location and identification stations, VHF radio stations for communication with ships and surveillance radars are currently available. Currently, the port of Galati is used by several national and international companies that transport raw materials and their products and import or export goods. Validating information regarding crew and cargo for a specific boat is done mainly manually, while real-time communication with boats is done by radio. This constantly puts the checking system at risk of human error and makes the procedures slow, which affects transit time. These procedures necessitate the collaboration of multiple public authorities, such as the Border Police and the Port Police.
Goal	The objective of this use case is to demonstrate the capabilities of the FLEXI-cross toolkit and to provide the operators with the capabilities to perform biometrics checks of adult passengers disembarking from vessels arriving at this port, to give the possibility to check in real time what is happening on the scene, supporting the operators in their daily routine with powerful mobile equipment that will allow to the operators to verify the identity of adult passengers crossing and their unusual pattern by analysing some possible risks related to embarking or disembarking activities themselves. This use case will focus on the enhancement of the port security and control procedures for passengers and their luggage 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 sea. Advanced and portable biometric technology will be used by port authorities and local police to validate the IDs of the passengers/crew of berthed ships quickly, safely and securely before disembarkation, providing extremely high levels of data privacy. The technology will be integrated with agents/officers' mobile devices for portability and (re)configurability. At the same time, 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 and the

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	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.
End-Users involved	IGPF (Operational Trial Leader)
Technical Partners involved	ENG (Technical Trial Leader) BEIA, HOLO, ICCS

Table 4. Summary of the Scenarios occurring in UC1.

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 (verification/identification)
	4	The system receives a mis-verification/misidentification event
	5	The FACE-VI mobile app displays the identification and verification results (mis-verification/misidentification)
	6	The system receives a mis-verification/misidentification event
	7	The operator in the control room who receives the event escorts the person to a different location to carry out a thorough check
	8	The operator on site receives the coordinates from the position of the mobile device that performed the face verification/identification via the FACE-VI mobile app and the related images, which are displayed to the operator as holographic content in three dimensions while wearing AR smart glasses
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--UPE platform close to a restricted area Evading crew member location
	4	The system receives a detection/tracking event and a video stream, Video data
	5	The evading crew member is being detected via the INUS-UPE platform in a restricted area
	6	The system receives an unusual pattern extraction event and a video stream
	7	The intervention team of the border police is informed to take action

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	8	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 worn by the on-site operator. Information about their location will be provided to the operator wearing the AR glasses
	9	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
	10	The FACE-VI mobile app displays the identification and verification results (mis-verification/misidentification)
	11	The system receives a mis-verification/misidentification event
	12	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 walks to the port perimeter
	3	The system receives a detection/tracking event and a video stream
	4	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
	5	The person's speed of movement is identified as unusual pattern
	6	The system receives an unusual pattern extraction event and a video stream
	7	The control team on board the ship is informed
	8	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 worn by the on-site operator. Information about their location will be provided to the operator wearing the AR glasses
	9	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
	10	The FACE-VI mobile app displays the identification and verification results (mis-verification/misidentification)
	11	The system receives a mis-verification/misidentification event
	12	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 X-Ray/Radiation devices and VITAL-5G Testbed. Information delivery to on-site operators regarding the suspected

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		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 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
	6	The FACE-VI mobile app displays the identification and verification results (mis-verification/misidentification)
	7	The system receives a mis-verification/misidentification 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.

4.3 Road based border- crossing trial

This chapter is integral to the FLEXI-cross trials validation planning and approach, specifically focusing on the operational scenarios at the BCP of Ormenio within the framework of UC2 that effectively measures and assess the project's performance against the overarching operational objectives. The operational scenarios are systematically detailed, providing a structured template for the execution of each step.

Table 5. Summary of the Scenarios occurring in UC2.

Trial No2: Road-based border-crossing trials (GR-BG)	
Trial Leader	KEMEA
Trial Area	**The Ormenio BCP** It is located at the northern tip of the Evros regional unit and serves as a customs and passport control point on the road border between Greece and Bulgaria. The building houses the Ormenio Passport Control Department and a unit of the Orestiada customs office. As for traffic from the Ormenio BCP, passengers (cars), tourists (buses), and commercial traffic (trucks) are allowed to cross. The Ormenio BCP is designed to have separate exits (northern section) and entrances (southern section) for vehicles. Each section includes three traffic lanes (passenger, bus, and truck) and one backup lane. However, only the southern section of the facilities is active for vehicle entry and exit.
Goal	The objective of the Greek-Bulgarian use case is to demonstrate the capabilities of an integrated system (used by operators and travellers) 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.

	By implementing early checking technologies, the procedures will become faster and more efficient, and border security will be further supported as more in-depth checks take place. Moreover, integrated information from various systems/sensors/devices will provide a more accurate threat level assessment for each incoming vehicle.
End-Users involved	HPOL (Operational Trial Leader)
Technical Partners involved	WINGS (Technical Trial Leader)

Table 6. Summary of the Scenarios occurring in UC2.

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 digital tachometer and performs a visual check on the vehicle, where illegal materials are detected inside.
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 behaviour.
	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 physical inspection 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.
	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	1	A car with two passengers arrives at passport control to enter the country.

Driver/passenger attempts to cross with false documents	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.

4.4 Rail based border- crossing trial

This chapter, which focuses in particular on the operational scenarios at the Giurgiulesti BCP in UC3, is a key component of the FLEXI-cross-test planning and validation strategy. The methodical description of operational scenarios provides a structured paradigm for the deployment of each stage. Colouring these elements ensures a robust and quantifiable validation testing methodology that helps optimize and improve the UC3 system to enhance border control capabilities at BCP Giurgiulesti.

Table 7. Introduction of the Operational Scenarios of UC3.

Trial No3:Rail based border-crossing trials (RO-MD)	
Trial Leader	BEIA
Trial Area	**The Giurgiulesti BCP** It is located at the eastern end of Romania and serves as a customs and passport control point at the rail border between Romania and Moldova. The building houses a Passport Control Department and a unit of the Giurgiulesti customs office.
Goal	The aim of this use case between Romania and Moldova is to develop a smart and secure system for border checks, with a focus on facilitating train travel at the border between the two countries, through a software platform that collects biometric and sensor data, facilitating efficient checks in order to reduce waiting times at the border, increase crime detection and provide a more pleasant experience for travellers, with significant benefits and reduced costs associated with existing procedures, through collaboration between technology partners and law enforcement authorities.
End-Users involved	GIBP: End-user providing challenges, solution requirements, personnel for trials, and solution validation. IGPF: End-user providing challenges, solution requirements, personnel for trials, and solution validation. Access to legacy systems will also be provided.

	TCCFR**:** End-user providing challenges and solution requirements from the rail operator's perspective, providing access to legacy devices and systems, and participating in the execution and validation of trials/solutions.
Technical Partners involved	BEIA (Technical Trial Leader)

Table 8. Summary of the Scenarios occurring in UC3.

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 Railway Border Point
	2	During the border control, the border police utilize a mobile device with multimodal biometric 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, and fingerprint.
	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 Railway Border Point .
	2	During the border control, the documents for the cargo is cross checked 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
	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 Railway Border Point
	2	During the border control, the documents for the cargo is cross checked 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

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	5	Border Police Officers detect (with the use of 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.

5 Early-drop validation results

The evaluation of the FLEXI-cross modules toolkit encompasses three critical aspects aimed at ensuring its effectiveness, efficiency, and overall performance. Firstly, the usage of the toolkit in real-world trials is assessed to gauge its practicality and suitability for diverse applications. Secondly, the compliance of KPIs with established metrics provides quantitative insights into the toolkit's alignment with predefined objectives. Finally, a detailed assessment of each component's functionality ensures that components operate optimally and meet acceptable performance standards. Together, these evaluation aspects provide a comprehensive understanding of the FLEXI-cross modules toolkit's capabilities and suitability for addressing the challenges of modern border security and management.

5.1 FLEXI-cross' trials usage evaluation

5.1.1 UC1

Table 9. The usability questionnaire of UC1.

FLEXI-CROSS TRIALS' USABILITY EVALUATION QUESTIONNAIRE					
Concept & Methodology: The FLEXI-cross project aims to implement and continuously test a range of innovative solutions for border checks in real operational settings. These solutions leverage advanced technologies such as 5G, Internet of Things (IoT), Artificial Intelligence (AI), Machine Learning (ML), Big Data and Predictive Analytics, Cloud and Edge Computing, and more. The objective is to enhance security and reliability in border checks for both individuals and goods. By utilizing these technologies, the project seeks to introduce new capabilities, such as dynamically deploying checkpoints and providing support to border personnel through mobile applications. These advancements aim to maintain a high level of security, safeguard privacy, and uphold fundamental rights. The design and architecture of the solutions will be tailored to meet the technical and service requirements of EU border authorities, such as Frontex, ensuring seamless integration with existing systems and devices. **Questionnaire:** The purpose of this questionnaire is twofold: firstly, to evaluate end-user satisfaction and gauge their perception of the effectiveness and efficiency of the FLEXI-cross toolkit's performance. Secondly, it aims to assess the overall performance of the management team overseeing the project, identifying any issues and opportunities for improvement. Both border guard authorities and passengers participating in the extended validation period, which includes the early validation phase, initial showcase demonstrations, and final trials execution, will complete this questionnaire. Insights gained from interim evaluations will be carefully considered to enhance the organization and execution of the final trials.					
Section 1. Effectiveness					
1.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
1.1.1. I comprehended my tasks while utilizing the system.					
1.1.2. I encountered numerous problems while utilizing the toolkit.					
1.1.3. I successfully accomplished the desired objectives.					
1.1.4. The solution adequately fulfils the tasks I need to perform.					
Section 2. Efficiency					
2.1. How much effort did it take to do the following actions (1-5: Not at all-Extremely)?					
	1	2	3	4	5

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2.1.1. Did you gather and interpret information effectively?					
2.1.2. Could you integrate information from multiple sources?					
2.1.3. Are you able to recall necessary information?					
2.1.4. Do you have convenient access to relevant information?					
2.1.5. How well do you manage information?					
2.1.6. Is all the information displayed by the system understandable?					
2.1.7. Are authorities legally authorized to disclose information to third parties, specifically referring to authorities of other countries?					
2.2. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
2.2.1. Completing tasks requires minimal effort.					
2.2.2. I could effortlessly execute my desired actions while using the system.					
2.2.3. I often need assistance when using this system.					
Section 3. Satisfaction					
3.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
3.1.1. Overall, I find this system easy to use.					
3.1.2. Using this system was straightforward.					
3.1.3. I effectively completed tasks and scenarios using this system.					
3.1.4. Tasks and scenarios were completed quickly using this system.					
3.1.5. It felt easy using this system.					
3.1.6. Learning to use this system was easy.					
3.1.7. I believe I could become productive quickly using this system.					
3.1.8. Error messages from the system were clear and helpful.					
3.1.9. Recovering from mistakes using the system was easy and quick.					
3.1.10. Information provided with the system, such as on-screen messages and documentation, was clear.					
3.1.11. Finding needed information was easy.					
3.1.12 How well-structured was the [first validation/showcase demo/final trial] overall?					
3.1.13 How satisfied are you with the [first validation/showcase demo/final trial]?					
3.1.12 What was your overall experience of the [first validation/showcase demo/final trial]?					
3.1.13 What was your overall duration of the [first validation/showcase demo/final trial]?					
3.1.14 How well-structured was the [first validation/showcase demo/final trial] overall?					
3.1.15 How do you rate the training and support provided during the [first validation/showcase demo/final trial]?					
Section 4. General aspects					
4.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
4.1.1. The FLEXI-cross solution is useful.					
4.1.2. The FLEXI-cross solution is dependable.					
4.1.3. The FLEXI-cross solution performed accurately.					
4.1.4. The FLEXI-cross solution is easy to understand.					

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4.1.5. The FLEXI-cross solution worked in parameters without freezing or crashing.					
4.1.6. Overall, the FLEXI-cross solution significantly improves upon my current systems.					
4.1.7. The FLEXI-cross solution adequately supports my required tasks.					
4.1.8. The FLEXI-cross solution meets the requirements for my required tasks.					
4.1.9. The FLEXI-cross solution provides precise and up-to-date information.					
4.1.10. Using the FLEXI-cross solution increases efficiency compared to current systems.					
4.1.11. Integrating the solution with current systems is easy.					
4.1.12. The FLEXI-cross solution is innovative compared to others on the market.					

Section 5. Open questions
a) What are your overall impressions of the FLEXI-cross system presently?
b) How does FLEXI-cross perform in the context of border control checks?
c) What are the primary advantages of FLEXI-cross in comparison to existing legacy systems? What aspects did you find particularly favourable?
d) Considering the scope of FLEXI-cross, what improvements do you believe are necessary? What aspects did you find unfavourable?
5. Do you believe the FLEXI-cross system, once finally deployed, can meet your operational needs and be used effectively under operational conditions?

5.1.2 UC2

Table 10. The usability questionnaire of UC2.

FLEXI-CROSS TRIALS' USABILITY EVALUATION QUESTIONNAIRE					
Concept & Methodology: The FLEXI-cross project targets the deployment and continuous validation of a toolkit of innovative border-checking solutions in real operational environments. These solutions will deliver increased security and reliability of border checks for people and goods, which can be enabled by innovative technologies [5G and IoT, AI, ML, Big Data and Predictive Analytics, Cloud and Edge Computing and more], aiming at enhancing and improving the border management capabilities. The resulting flexibility and dynamicity of border check planning will offer novel capabilities such as dynamic deployment of checkpoints and support via mobile applications for border personnel while guaranteeing a high level of security, privacy of personal data and protection of people's fundamental rights. The design and architecture of the implemented solutions will be based on the analysis of the technical and service requirements of the EU border authorities (e.g., Frontex) and will offer seamless integration with existing systems and devices currently utilised by them. **Questionnaire:** The aim of this questionnaire is to assess the end-user satisfaction as well as, from their perspective, the effectiveness and the efficiency of the performance achieved by the FLEXI-cross toolkit. Moreover, it will assess the overall management team's performance among the exercise project team in order to identify issues and potential improvements. This questionnaire will be completed by both border guard authorities and passengers who will participate in the long-scale validation period, including the early validation phase, the first showcase demonstrations and the final trial execution. Lessons learned from the intermediate evaluations will be taken into serious consideration for the better organisation and execution of the final trials.					
Section 1. Effectiveness					
1.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
1.1.1. I understood what I had to do while using the system.					
1.1.2. I made a lot of mistakes while using the toolkit.					
1.1.3. I was able to achieve the desired objectives.					
1.1.4. The solution is acceptable to accomplish the tasks of my interest.					
Section 2. Efficiency					
2.1. How much effort did it take to do the following actions (1-5: Not at all-Extremely)?					
	1	2	3	4	5
2.1.1. Gather and interpret information?					
2.1.2. Integrate information from various sources?					
2.1.3. Recall necessary information?					
2.1.4. Access relevant information?					
2.1.5. Manage information?					
2.1.6. Understand all information displayed by the system?					
2.1.7. Share information with other parties, if needed?					
2.2. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
2.2.1. I can complete the tasks without a lot of effort					

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2.2.2. I could easily do what I wanted while using the system					
2.2.3. I must look for assistance most times when I use this system					
Section 3. Satisfaction					
3.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
3.1.1. Overall, I am satisfied with how easy it is to use this system.					
3.1.2. It was simple to use this system.					
3.1.3. I could effectively complete the tasks and scenarios using this system.					
3.1.4. I was able to complete the tasks and scenarios quickly using this system.					
3.1.5. I felt comfortable using this system.					
3.1.6. It was easy to learn to use this system.					
3.1.7. I believe I could become productive quickly using this system.					
3.1.8. The system gave error messages that clearly told me how to fix problems.					
3.1.9. Whenever I made a mistake using the system, I could recover easily and quickly.					
3.1.10. The information (such as on-screen messages, and other documentation) provided with this system was clear.					
3.1.11. It was easy to find the information I needed.					
3.1.12 Overall, how well was the [first validation/showcase demo/final trial] structured?					
3.1.13 Overall, how satisfied are you with the [first validation/showcase demo/final trial]?					
3.1.12 Overall [first validation/showcase demo/final trial] experience.					
3.1.13 Overall duration of the [first validation/showcase demo/final trial].					
3.1.14 Overall planning and organization of the [first validation/showcase demo/final trial].					
3.1.15 Overall training and support provided during the [first validation/showcase demo/final trial].					
Section 4. General aspects					
4.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
4.1.1. FLEXI-cross solution is useful.					
4.1.2. FLEXI-cross solution is reliable.					
4.1.3. FLEXI-cross solution worked accurately.					
4.1.4. FLEXI-cross solution is understandable.					
4.1.5. FLEXI-cross solution worked robustly (e.g., it did not freeze or crash).					
4.1.6. FLEXI-cross solution is overall a significant improvement compared to my current system.					
4.1.7. FLEXI-cross solution is acceptable to accomplish the tasks of my interest.					
4.1.8. FLEXI-cross solution is acceptable to accomplish the tasks of my interest.					
4.1.9. FLEXI-cross solution reports accurate and up-to-date information.					
4.1.10. The use of FLEXI-cross solution increases the efficiency compared to current systems in use.					
4.1.11. It is easy to integrate the solution with the current systems.					

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4.1.12. FLEXI-cross solution is innovative compared to others on the market.						
Section 5. Open questions						
a) What is your overall impression of the FLEXI-cross system at the moment?						
b) How does FLEXI-cross respond to the border control checks?						
c) What are the main advantages of FLEXI-cross in correlation with the existing legacy systems? What did you like more?						
d) Having in mind the scope of FLEXI-cross, what do you believe that needs to be improved? What did you dislike?						
5. Do you believe that FLEXI-cross system, as soon as it is finally deployed, can serve your operational needs and can be used under operational conditions?						

5.1.3 UC3

Table 11. The usability questionnaire of UC3.

FLEXI-CROSS TRIALS' USABILITY EVALUATION QUESTIONNAIRE					
Concept & Methodology: The FLEXI-cross project aims to implement and consistently validate a set of cutting-edge border inspection solutions in authentic operational settings. These solutions are designed to enhance security and dependability in border inspections for both individuals and goods, leveraging innovative technologies such as 5G and IoT, AI, ML, Big Data and Predictive Analytics, Cloud and Edge Computing, among others. The objective is to bolster and refine border management capabilities. The enhanced flexibility and adaptability in border check planning will introduce innovative features like the dynamic establishment of checkpoints and assistance through mobile applications for border personnel. These advancements will ensure a superior level of security, safeguarding the privacy of personal data and upholding individuals' fundamental rights. The design and framework of the deployed solutions will be formulated based on an analysis of the technical and service prerequisites of EU border authorities (e.g., Frontex), ensuring smooth integration with their current systems and devices. **Questionnaire:** The purpose of this questionnaire is to evaluate end-user satisfaction and gauge their perception of the effectiveness and efficiency of the FLEXI-cross toolkit's performance. Additionally, it will evaluate the overall performance of the management team within the project team to pinpoint any issues and areas for potential improvement. Both border guard authorities and passengers participating in the extensive validation period, encompassing the early validation phase, initial showcase demonstrations, and final trial execution, will complete this questionnaire. Insights gathered from intermediate evaluations will be carefully considered to enhance the organization and execution of the final trials.					
Section 1. Effectiveness					
1.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
1.1.1. I comprehended the things required while utilizing the system.					
1.1.2. I encountered numerous errors while utilizing the toolkit.					
1.1.3. I successfully accomplished the intended goals.					
1.1.4. The solution succeeded in fulfilling the tasks I'm interested in.					
Section 2. Efficiency					
2.1. How much effort did it take to do the following actions (1-5: Not at all-Extremely)?					
	1	2	3	4	5
2.1.1. Collect and analyse data?					
2.1.2. Combine information gathered from different sources?					
2.1.3. Remember the necessary information?					
2.1.4. Could you access pertinent information?					
2.1.5. Handle information?					
2.1.6. Can you comprehend all the information presented by the system?					
2.1.7. Can you disseminate information to other parties, if necessary?					
2.2. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
2.2.1. I can effortlessly accomplish the tasks					
2.2.2. I was able to achieve my desired tasks while utilizing the system effortlessly.					
2.2.3. I frequently need to seek assistance when using this system.					

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Section 3. Satisfaction					
3.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
3.1.1. In general, I find the ease of use of this system satisfactory.					
3.1.2 Using this system was easy.					
3.1.3. I was able to accomplish tasks and scenarios with this system successfully.					
3.1.4. Using this system allowed me to swiftly complete tasks and scenarios.					
3.1.5. I felt at ease while using this system.					
3.1.6. Learning to use this system was straightforward.					
3.1.7. I'm confident I could quickly become productive using this system.					
3.1.8. The system provided error messages that clearly instructed me on how to resolve issues.					
3.1.9. If I made an error while using the system, I could swiftly and effortlessly recover from it.					
3.1.10. The information provided, including on-screen messages and other documentation, was easily understandable by this system.					
3.1.11. Finding the necessary information was straightforward.					
3.1.12 How effectively was the structure of the [initial validation/showcase demo/final trial] arranged overall?					
3.1.13 How satisfied are you with the [initial validation/showcase demo/final trial] overall?					
3.1.12 Overall experience of the [initial validation/showcase demo/final trial].					
3.1.13 Overall duration of the [first validation/showcase demo/final trial].					
3.1.14 Overall planning and organization of the [first validation/showcase demo/final trial].					
3.1.15 Overall training and support provided during the [first validation/showcase demo/final trial].					
Section 4. General aspects					
4.1. Please answer the following questions (1-5: Strongly disagree-Strongly agree):					
	1	2	3	4	5
4.1.1. FLEXI-cross solution is beneficial.					
4.1.2. FLEXI-cross solution is fiable.					
4.1.3. The FLEXI-cross solution operated with precision.					
4.1.4. FLEXI-cross solution is clear.					
4.1.5. The FLEXI-cross solution functioned reliably without freezing or crashing.					
4.1.6. Overall, the FLEXI-cross solution represents a substantial improvement over my current system.					
4.1.7. The FLEXI-cross solution adequately fulfils the tasks I need to accomplish.					
4.1.8. The FLEXI-cross solution adequately fulfils the tasks I need to accomplish.					
4.1.9. The FLEXI-cross solution provides precise and current information.					
4.1.10. Employing the FLEXI-cross solution enhances efficiency when compared to the current systems in use.					
4.1.11. Integrating the solution with existing systems is straightforward.					
4.1.12. The FLEXI-cross solution stands out for its innovation compared to other offerings in the market.					
Section 5. Open questions					

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a) What are your general thoughts or impressions about the current state of the FLEXI-cross system?
At the moment, we are pleased with the results achieved with the system.
b) How does FLEXI-cross handle border control checks?
c) What are the primary benefits of FLEXI-cross compared to the current legacy systems? What aspects did you find particularly appealing?
d) Considering the scope of FLEXI-cross, what areas do you think require improvement? What aspects did you find unsatisfactory?
5. Do you think that once the FLEXI-cross system is fully implemented, it will meet your operational requirements and function effectively under operational conditions?

5.2 KPI compliance evaluation with predetermined targets

5.2.1 Common methodology of KPI compliance evaluation for all UCs.

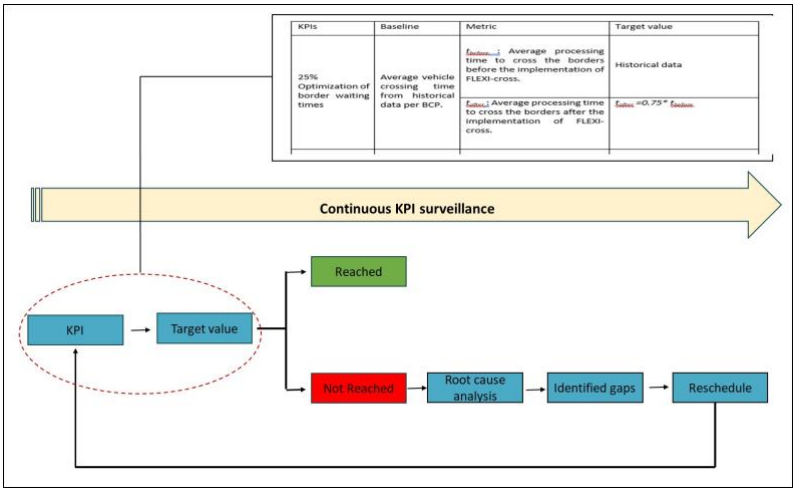

Figure 3. The illustration of the KPI compliance evaluation with metrics flow.

The basis of the KPI compliance evaluation with predetermined targets is depicted in Fig.2. As a first step, several pilots have assigned the essential metrics to the promised KPIs, providing the data needed to assess the performance in relation to KPIs. Next, a benchmark analysis is conducted, comparing the measured metrics against predetermined targets to determine the extent to which the several KPIs are reached or not. Following this, a root cause examination is performed to uncover the underlying factors that may be affecting KPI adherence. Once identified, the pilots will implement enhancements based on the root cause analysis, taking corrective measures to address any gaps in meeting the KPIs effectively. Finally, continuous surveillance is maintained, with the pilots monitoring metrics on an ongoing basis and refining the evaluation process as necessary to ensure ongoing alignment with the promised KPIs.

5.3 Component functionality assessment for performance compliance

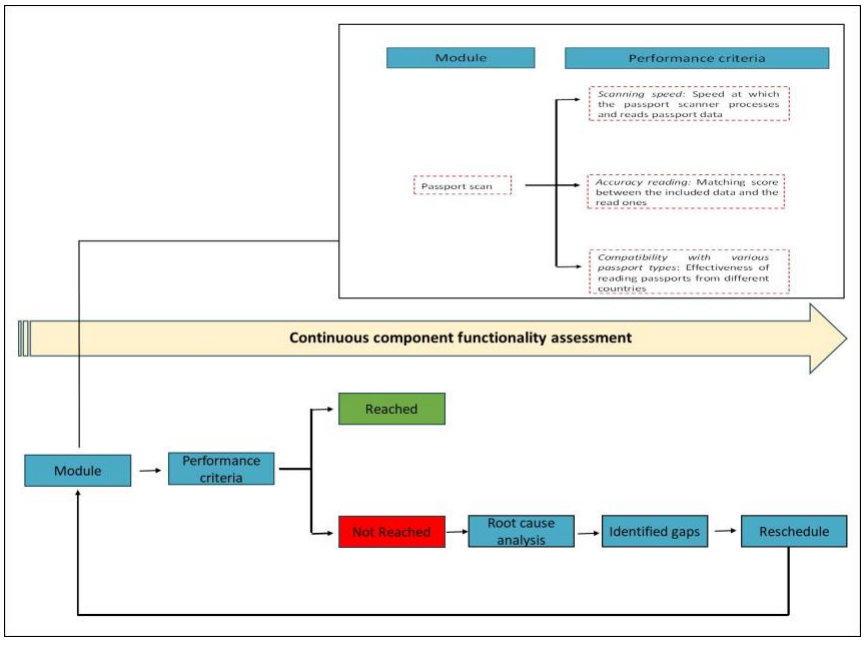

Figure 4. Illustration of the component functionality assessment of the several modules.

Component functionality assessment for performance compliance involves evaluating the functionality of individual system components to ensure they meet specified performance criteria. This assessment aims to verify that each component operates effectively within the system architecture, contributing to overall performance and efficiency. During the assessment process, each component's functionality is scrutinized against predetermined performance metrics (including speed, responsiveness, and consistency of extracted data.

Based on the assessment results, adjustments, optimizations, or remediation actions may be required to enhance the component's performance and ensure compliance with performance requirements. This may include fine-tuning configuration settings, optimizing algorithms, or implementing performance-enhancing techniques.

Continuous monitoring and periodic reassessment of component functionality are essential to maintain performance compliance over time, as system requirements and operational and environmental conditions may change. FLEXI-cross prioritizes the optimal performance, responsiveness, and reliability of its various modules by conducting comprehensive assessments and proactively resolving performance issues. With a primary focus on meeting the needs and satisfaction of end-users, FLEXI-cross ensures that every aspect of its system undergoes rigorous evaluation and optimization to deliver an exceptional user experience.

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Annex I: Informed Consent Form[1]

INFORMED CONSENT FORM

I,___ _____ Born on _____/_____/_____, resident in _____ hereby freely and voluntarily give my CONSENT to participate in the study, organized and conducted on the

- ☐ UC1 - Enhanced protection and biometric checks for European ports
- ☐ UC2 - Intelligent dynamic customs procedures for improved border-crossing experience on the road
- ☐ UC3 . Intelligent, secure and portable border checking system, for the facilitation of rail travel

at

- ☐ Galati
- ☐ Ormenio
- ☐ Giurgiulesti

by the FLEXI-cross Consortium. Giving my consent, I undersign that:

1. I HAVE CAREFULLY READ and UNDERSTOOD THE INFORMATION SHEET.

2. All questions that I posed have answered to my satisfaction

3. I AM FULLY AWARE THAT:

i. It is my right to withdraw from the study at any time without consequences and without affecting the lawfulness of processing based on consent before its withdrawal;
ii. Any videos, pictures, audio recordings, and information about myself will be treated as confidential by the research team members;
iii. Videos, pictures and audio recordings will be stored in a protected folder by the research team and only used for research purposes related to the evaluation of the FLEXI-cross;
iv. In any publication resulting from FLEXI-cross my personal details will not be revealed and it will not be possible to retrieve any data which might disclose my identity;
v. My address and other personal data may be disclosed upon my consent only in case of formal ethical investigations by scientific journals or academic societies challenging the existence itself of this empirical investigation.

HAVING READ, UNDERSTOOD AND ACCEPTED ALL OF THE ABOVE,

- ☐ I agree to participate in the exercise
- ☐ I do not agree to participate in the exercise ___
- ☐ I agree to the session being audio taped and video recorded
- ☐ I do not agree to the session being audio taped and video recorded ___

I agree that short extracts of video or photograph recordings, in which what I say or what I do cannot be precisely determined and which in no way damage my reputation, may be used by the The consent form will be translated in the local languages of the involved countries (i.e., Greek, Romanian, Bulgarian)

- ☐ FLEXI-cross Consortium Members for dissemination and illustrative purposes of the research results

[1] The consent form will be translated in the local languages of the involved countries (i.e., Greek, Romanian, Bulgarian)

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☐ I do not agree that short extracts of video or photograph recordings, in which what I say or what I do cannot be precisely determined and which in no way damage my reputation, may be used by the FLEXI-cross Consortium Members for dissemination and illustrative purposes of the research results ___

Place _____ Date: _____/_____/_____

Signature of the Participant: _____

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Annex II: Information Sheet - UC1[2]

INFORMATION SHEET TEMPLATE

You are being invited to take part in a research study in the framework of the FLEXI-cross project. Before you decide whether to participate it is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully. If there is anything that is not clear, or if you would like more information, please get in touch with the research team (contact details at the end of this information sheet).

1. What is the purpose of this project?
This research is carried out under the HORIZON EUROPE project "FLEXI-cross", which aims to increase security and reliability of EU border checks for people and goods, while enhancing and improving the border management capabilities, through the development, deployment and validation of a toolkit of innovative border-checking solutions, in real operational environments, addressing road, rail and port borders.

2. Why have I been chosen?
You are being asked whether you would like to participate in this survey because you are an end user

3. Do I have to take part?
It is up to you to decide whether or not to take part. As the data processing is based on point (a) of Article 6(1) GDPR, if you do decide to take part, you would be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason, without affecting the lawfulness of processing based on consent before its withdrawal. You are always welcome to come back to it at a later time. Please note that whether you will participate in the study or not this will not have any negative impact on you.

4. **What will be taking part involve?**
If you decided to participate, you will have to test the functionalities and the processes of the implemented toolkit specific for each use case

5. How the data will be used?
The researchers involved in the project will pre-process the data in an anonymous and confidential manner.
Research results will be published in journal articles, conference presentations and via any other mode of scientific exchange and dissemination that will be seen as appropriate by the researchers, while protecting the participants' anonymity.

6. Does the research involve any risk?
There are not foreseen disadvantages or risks to taking part. However, if at any time, you should become tired or feel other forms of discomfort, you can simply quit the participation to the FLEXI-cross. You are always welcome to come back to it at a later stage.

7. Who is the data controller?

[2] The information sheet will be translated in the local languages of the involved countries (i.e.,Romanian)

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The data controller is ATG and the contact details are ASOCIATIA TEHNOPOL - GALATI established in SALISTE 20, GALATI 800023, Romania; the DPO is (name and surname of DPO for ATG), who can be contacted at the following address: email of DPO for ATG) (*if applicable*)

8. What personal data do we collect?

We are collecting/ collect the following kinds of information: full name, email address and the organization you are working at *(e.g. your contact information, such as full name and email address; your username and password; the organization you are working at…)*

9. What is the purpose and the legal ground for the data processing?

The treatment we carry out has the following purposes: to test and receive feedback for the technical implementations adopted by each pilot…….
Also, we process the information mentioned above, on the following legal grounds:…consent…….

10. Who are the recipients of the personal data?

Your personal data will only be shared, for the purposes referred to in the previous paragraphs, with persons authorized by ATG … (*data controller – partner conducting the activity*) to the processing of personal data necessary to carry out activities strictly related to the achievement of the FLEXI-cross project activities, which are committed to or have an appropriate legal obligation of confidentiality.

11. Is my personal data transferred to third countries or international organisation?

No…….. (Yes/No. In case of "yes", please provide reference to the appropriate or suitable safeguards and the means by which to obtain a copy of them or where they have been made available)

12. Do I have any right related to my personal data?

Yes, you can exercise all the rights provided for by GDPR in articles 15-22, including the right of access, erasure, rectification, restriction of processing or to object to processing as well as the right to data portability. Moreover, you have the right to lodge a complaint with a supervisory authority.

13. Also to consider/ HEU Ethics Principles

The study respects the ethical principles defined by the Helsinki Declaration/ HORIZON EUROPE ethics principles on research with human beings.

Personal data will be retained by the data controller during the 36-month period of the duration of the project and for a 5-year period after the project's completion (September 2030) according to A20.1 of FLEXI-cross Grant Agreement as a maximum.

Questions:

For any further doubt or clarification request, do not hesitate to ask! You can contact the FLEXI-cross Coordinator,
Giuseppe Vella
Giuseppe.vella@eng.it

Annex III: Information Sheet -UC2[3]

INFORMATION SHEET TEMPLATE

You are being invited to take part in a research study in the framework of the FLEXI-cross project. Before you decide whether to participate it is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully. If there is anything that is not clear, or if you would like more information, please get in touch with the research team (contact details at the end of this information sheet).

1. What is the purpose of this project?
This research is carried out under the HORIZON EUROPE project "FLEXI-cross", which aims to increase security and reliability of EU border checks for people and goods, while enhancing and improving the border management capabilities, through the development, deployment and validation of a toolkit of innovative border-checking solutions, in real operational environments, addressing road, rail and port borders.

2. Why have I been chosen?
You are being asked whether you would like to participate in this survey because you are an end user

3. Do I have to take part?
It is up to you to decide whether or not to take part. As the data processing is based on point (a) of Article 6(1) GDPR, if you do decide to take part, you would be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason, without affecting the lawfulness of processing based on consent before its withdrawal. You are always welcome to come back to it at a later time. Please note that whether you will participate in the study or not this will not have any negative impact on you.

4. **What will be taking part involve?**
If you decided to participate, you will have to test the functionalities and the processes of the implemented toolkit specific for each use case

5. How the data will be used?
The researchers involved in the project will pre-process the data in an anonymous and confidential manner.
Research results will be published in journal articles, conference presentations and via any other mode of scientific exchange and dissemination that will be seen as appropriate by the researchers, while protecting the participants' anonymity.

6. Does the research involve any risk?
There are not foreseen disadvantages or risks to taking part. However, if at any time, you should become tired or feel other forms of discomfort, you can simply quit the participation to the FLEXI-cross. You are always welcome to come back to it at a later stage.

7. Who is the data controller?

[3] The information sheet will be translated in the local languages of the involved countries (i.e., Greek, Bulgarian)

The data controller is KEMEA and the contact details are KENTRO MELETON ASFALEIAS established in P KANELLOPOULOU 4 ST, ATHINA 10177, Greece; the DPO is (name and surname of DPO for KEMEA), who can be contacted at the following address: email of DPO for KEMEA) (*if applicable*)

8. What personal data do we collect?
We are collecting/ collect the following kinds of information: full name, email address and the organization you are working at *(e.g. your contact information, such as full name and email address; your username and password; the organization you are working at…)*

9. What is the purpose and the legal ground for the data processing?
The treatment we carry out has the following purposes: to test and receive feedback for the technical implementations adopted by each pilot…….
Also, we process the information mentioned above, on the following legal grounds:…consent…….

10. Who are the recipients of the personal data?
Your personal data will only be shared, for the purposes referred to in the previous paragraphs, with persons authorized by KEMEA … (*data controller – partner conducting the activity*) to the processing of personal data necessary to carry out activities strictly related to the achievement of the FLEXI-cross project activities, which are committed to or have an appropriate legal obligation of confidentiality.

11. Is my personal data transferred to third countries or international organisation?

No…….. (Yes/No. In case of "yes", please provide reference to the appropriate or suitable safeguards and the means by which to obtain a copy of them or where they have been made available)

12. Do I have any right related to my personal data?
Yes, you can exercise all the rights provided for by GDPR in articles 15-22, including the right of access, erasure, rectification, restriction of processing or to object to processing as well as the right to data portability. Moreover, you have the right to lodge a complaint with a supervisory authority.

13. Also to consider/ HEU Ethics Principles
The study respects the ethical principles defined by the Helsinki Declaration/ HORIZON EUROPE ethics principles on research with human beings.

Personal data will be retained by the data controller during the 36-month period of the duration of the project and for a 5-year period after the project's completion (September 2030) according to A20.1 of FLEXI-cross Grant Agreement as a maximum.

Questions:
For any further doubt or clarification request, do not hesitate to ask! You can contact the FLEXI-cross Coordinator,
Giuseppe Vella
Giuseppe.vella@eng.it

Annex IV: Information Sheet – UC3[4]

INFORMATION SHEET TEMPLATE

You are being invited to take part in a research study in the framework of the FLEXI-cross project. Before you decide whether to participate it is important that you understand why the research is being done and what it will involve. Please take the time to read the following information carefully. If there is anything that is not clear, or if you would like more information, please get in touch with the research team (contact details at the end of this information sheet).

1. What is the purpose of this project?
This research is carried out under the HORIZON EUROPE project "FLEXI-cross", which aims to increase security and reliability of EU border checks for people and goods, while enhancing and improving the border management capabilities, through the development, deployment and validation of a toolkit of innovative border-checking solutions, in real operational environments, addressing road, rail and port borders.

2. Why have I been chosen?
You are being asked whether you would like to participate in this survey because you are an end user

3. Do I have to take part?
It is up to you to decide whether or not to take part. As the data processing is based on point (a) of Article 6(1) GDPR, if you do decide to take part, you would be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason, without affecting the lawfulness of processing based on consent before its withdrawal. You are always welcome to come back to it at a later time. Please note that whether you will participate in the study or not this will not have any negative impact on you.

4. **What will be taking part involve?**
If you decided to participate, you will have to test the functionalities and the processes of the implemented toolkit specific for each use case

5. How the data will be used?
The researchers involved in the project will pre-process the data in an anonymous and confidential manner.
Research results will be published in journal articles, conference presentations and via any other mode of scientific exchange and dissemination that will be seen as appropriate by the researchers, while protecting the participants' anonymity.

6. Does the research involve any risk?
There are not foreseen disadvantages or risks to taking part. However, if at any time, you should become tired or feel other forms of discomfort, you can simply quit the participation to the FLEXI-cross. You are always welcome to come back to it at a later stage.

7. Who is the data controller?

[4] The information sheet will be translated in the local languages of the involved countries (i.e., Romanian)

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The data controller is BEIA and the contact details are BEIA CONSULT INTERNATIONAL SRL established in STREET POIANA NARCISELOR 12 1ST FLOOR APARTMENT 3 SECTOR 1, BUCURESTI 010158, Romania; the DPO is (name and surname of DPO for BEIA), who can be contacted at the following address: email of DPO for BEIA) (*if applicable*)

8. What personal data do we collect?
We are collecting/ collect the following kinds of information: full name, email address and the organization you are working at *(e.g. your contact information, such as full name and email address; your username and password; the organization you are working at…)*

9. What is the purpose and the legal ground for the data processing?
The treatment we carry out has the following purposes: to test and receive feedback for the technical implementations adopted by each pilot……
Also, we process the information mentioned above, on the following legal grounds:…consent……

10. Who are the recipients of the personal data?
Your personal data will only be shared, for the purposes referred to in the previous paragraphs, with persons authorized by BEIA … (*data controller – partner conducting the activity*) to the processing of personal data necessary to carry out activities strictly related to the achievement of the FLEXI-cross project activities, which are committed to or have an appropriate legal obligation of confidentiality.

11. Is my personal data transferred to third countries or international organisation?

No…….. (Yes/No. In case of "yes", please provide reference to the appropriate or suitable safeguards and the means by which to obtain a copy of them or where they have been made available)

12. Do I have any right related to my personal data?
Yes, you can exercise all the rights provided for by GDPR in articles 15-22, including the right of access, erasure, rectification, restriction of processing or to object to processing as well as the right to data portability. Moreover, you have the right to lodge a complaint with a supervisory authority.

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Personal data will be retained by the data controller during the 36-month period of the duration of the project and for a 5-year period after the project's completion (September 2030) according to A20.1 of FLEXI-cross Grant Agreement as a maximum.

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