(Projects funded under the Call 2014 onwards must use this format)

LIFE Project Number

LIFE20 ENV/IT/000436

Final Report

Covering the project activities from 01/10/2021[1] to 30/09/2025

Reporting Date[2]

16/01/2026

LIFE PROJECT NAME or Acronym

LIFE SECURDOMINO

Data Project

Project location:	
Project start date:	01/10/2021
Project end date:	30/09/2025
Total budget:	1,586,206 €
EU contribution:	834,681 €
(%) of eligible costs:	52.62%

Data Beneficiary

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[1] Project start date

[2] Include the reporting date as foreseen in part C2 of Annex II of the Grant Agreement

1. Table of contents

2. List of key-words and abbreviations

Acronyms of partners

UNIPI: University of Pisa; DATACH: DataCH Technologies S.r.l.; ARPAT: Regional Agency for Environmental Protection of Tuscany; LEIDENU: Leiden University; CRISISPLAN: Crisisplan BV.

Acronyms and symbols

3D	Three-dimensional
ANPA	Italian National Agency for Environmental Protection
API	American Petroleum Institute
ASSESS	Analytic System and Software for Evaluating Safeguards and Security
ATEX	Explosive Atmosphere
ATLAS	Adversary Time-Line Analysis System
BMC	Business Model Canvas
BRZO	Dutch Major Accidents (Risks) Decree
C	Consequences
C2M	Close-to-Market
CCTV	Closed Circuit Television
DEMO	Demonstration site
DSS	Decision Support Systems
EASI	Estimate of Adversary Sequence Interruption
ENAC	Italian Civil Aviation Authority
ENI	Italian National Hydrocarbon Agency
EU	European Union
EU-MS	Member States of the European Union
FTE	Full Time Equivalent
HSE	Health, Safety and Environment
INAIL	Italian Institute for Insurance against Accidents at Work
ISS	Integrated Safety and Security
IT	Italy
KPI	Key Performance Indicator
L	Likelihood, events/year
LPG	Liquefied Petroleum Gas
LUP	Land Use Planning
NL	the Netherlands
OMWB	Central and West Brabant Environment Agency
PM	Project Manager
PMB	Project Management Board
R	Risk, events/year
RINA	Italian Naval Registry
SVA	Security Vulnerability Assessment
TCB	Technical Coordination Board
V	Vulnerability
ΔV	Vulnerability variation (i.e., expected reduction)

Time indications

Deadlines and time indications are given as follows: **MON-YY**, where **MON** is the abbreviation of the month (JAN = January, and so on) and YY is the year (23 for 2023, etc.). The Deliverables and additional materials are respectively indicated with [DZZ] and [ADZZ] where ZZ is the number and will be made available on request.

3. Executive Summary

Industrial facilities storing and processing hazardous materials may be targets of external acts of interference (terrorism, sabotage, was scenarios, etc.). External attacks may trigger cascading effects, with release of flammable/explosive/toxic substances in the environment. Also, domino effects are likely, with the propagation of accidents from the attacked units to the rest of the plant. Accidents caused by integrated safety and security (ISS) threats may affect coasts, rivers, lakes, and densely populated urban areas at regional and national scale. Hence, preventing and/or mitigating ISS events and domino effects in industrial facilities is strategic to avoid attempts to public health and environment.

The aim of LIFE SECURDOMINO is to develop a method implemented in a software tool for the ISS assessment of hazard, risks, and related domino effects in Seveso sites. The present report describes the financial and technical activities developed in the period of implementation (01/10/21-30/09/25).

Due to the interdisciplinary approach needed to assess ISS, a key aspect of the project relies in the Consortium and in the managerial strategy, as detailed in [D01]. UNIPI, Italy (IT) coordinates the project, given the combined expertise in risk assessment and security, DATACH (IT) develops the software tool, which is reviewed by ARPAT, the Competent Authority for Seveso sites inspection in Tuscany (IT). LEIDENU, the Netherlands (NL) develops policy and security aspects, supported by CRISISPLAN (NL), a crisis management consultancy company.

The software tool is developed in Action B1 and is based on the three-dimensional (3D) reconstruction of an industrial plant, mapping each plant element (tanks, pumps, warehouses, etc.) into a virtual reality. The plants elements and layout are reconstructed by image acquisition from drone inspection and subsequent 3D graphics refining. Next, real-time data (process conditions, maintenance status, process documents, etc.) are associated with each mapped element, as well as safety-security barriers and emergency measures. This enables for the real-time evaluation of probabilities and 3D consequence of accidents, quantifying the vulnerability and risk level induced by ISS accidents and dominos. All the models and barriers are collected in an open-web repository [D17], which is hosted in the project website. Models and data contained in the repository were specifically gathered for the project, and the method was published in an international Journal [AD1].

For the sake of demonstration, the aim of the project was to test the software in 3 DEMO sites (Action B5), which were recruited since the proposal stage. However, 2 out of 3 initial DEMOs quit the project during the first 6 months. They were replaced in Oct-22, obtaining the final set of DEMO sites: DEMO1 (Costieri D'Alesio S.p.A., Livorno) and DEMO2 (Manetti & Roberts, Calenzano) located in Tuscany (IT); DEMO3 (Wilhelmsen Ships Service, Rotterdam) located in NL. They feature different capacity, materials, locations, thus they enable picturing all possible applications of the tool in different EU-MS (Member States of the European Union), deriving information for the implementation of Seveso and Environmental Protection Directives. The delay due to DEMO recruitment did not impact on the other actions and, most important, on the application of the tool. The Alpha version of the tool was finalized in Mar-23. This version implemented models for fires only and static data from the demos. The development of the repository and the site inspections at the DEMO sites enabled for the eventual development of the software, obtaining the final version as foreseen (Nov-24). This version of the software implements real-time process data from the field (i.e., temperature, pressure, level) as well as meteorological conditions (e.g., wind speed, direction, etc.), which are received with a dedicated MQTT sever of DATACH.

DEMO2 was the first site analyzed and completed, due to the absence of specific restrictions for drone flight. However, despite the DEMO analysis was completed on Oct-24, real time connections could be only implemented early 2025 due to prolonged refurbishing of distributed

control system at DEMO2. The final version of the deliverable of Action B5 [D15] was thus completed in March 2025 including the explanation of real time parameters assessment.
DEMO1 faced problems related to drone flight restrictions, as explained in [D15]. The solution for completing DEMO1 was to flight only over its perimeter and below 40m, obtaining a basic photogrammetric 3D model, with medium definition, which constitutes the starting point for further manual refinement, based on pictures taken during future site inspections with a high-resolution camera [D15]. The same limitations applied to DEMO3 in NL, with the additional restriction of a dedicated permit to flight a drone over a Seveso plant. Hence, in order to obtain the drone data, an authorized contractor was recruited for the preliminary assessment. Next, the refinement of DEMO3 was completed according to the same procedure adopted for DEMO1.
The implementation of the LIFE SECURDOMINO tool has improved the safety-security status of the DEMO sites, reducing the vulnerability towards ISS threats by 40%. This value was set based on the results of an expert survey that was aimed at raising awareness of regulators, competent authorities, industrial managers, and consultants on prevention and mitigation of domino effects by external acts of interference. The method adopted in the survey development and the detailed results are reported in [D06]. Experts' data elicitation confirmed that the implementation of the software and monitoring strategy developed reduces by at least 40% the current level of vulnerability (and, consequently, risk) of a given Seveso site, thus having an impact on the reduction of potential emissions of pollutants, chemicals, greenhouse gases (i.e., impacting on climate), emissions noxious to the biodiversity, and water consumption. These are the main Key Performance Indicators (KPIs) that were monitored under Actions C and uploaded in the LIFE KPI webtool.
A key project aspect is related to the assessment of the current EU policies and strategies for the control of major accidents induced by external acts of interference. EU level directives and their local implementation in Italy and the Netherlands were investigated in Action B3. The results are summarized in [D07], to expand and clarify the project policy implications. It was confirmed that the current safety regulation (i.e., the Seveso directive) does not explicitly cover the "security-related" dominos, despite the security aspects are covered in other policies, such as EU Directive 2022/2557 on the protection of the resilience of critical entities. The harmonization of these aspects would be beneficial for the enhancement of integrity of industrial activities, as specified in the Whitepaper on integrated safety-security issues [D14].
A handbook and a specific set of guidelines for adaptation in Italy and the Netherlands was then developed [D16], laying the foundations for developing the business plan [D13] and replicating the system [D19] in Seveso sites in IT and NL, achieving the result of assessing total 250 plants 5 years after the project end.
However, the communication and dissemination of the results obtained is of utmost importance for the success of the project and future replication. A specific Communication and Dissemination plan was developed [D3]. The website [D2] has achieved a significant visibility (141.057 visits 30/09/25), also due to the promotion on social media (Facebook and LinkedIn); 8 noticeboards are installed in key locations of the project, i.e., at the DEMOs and at partners main locations [D05]. Participation to international conferences enabled gaining visibility among the technical/scientific community related to ISS assessment.

4. Introduction

Industrial facilities storing and processing relevant quantities of hazardous chemicals have an inherent hazard potential that may be exploited by malevolent agents, causing accidents that may propagate among process units, leading to cascading events or domino effects. Major accidents, such as severe fires, explosions, toxic dispersions and environmental contaminations, may occur in case of successful attack. The events occurred in France in 2015 (the attack to a gas production facility located in Saint-Quentin-Fallavier and a sabotage of two oil-derivatives storage tanks near Marseille) documented the credibility of potential domino effects caused by external acts of interference in the European context.

Security-related threats could affect coasts, rivers, lakes and densely populated areas at regional and national scale. The EU Major Accident Reporting System reported 557 accidents in EU for the period 1990-2020; 23 of these accidents resulted in domino effects causing €1.1 billion of damages and €3.2 million of environmental damage.

The European Programme for Critical Infrastructure Protection promotes the prevention, preparedness and response to terrorist attacks to energy and transport installations. The European Seveso-III Directive (2012/18/EU) asks for an assessment of the domino effects focusing on safety and related issues but does not address security vulnerability. The link between the two policies has not been established. Hence, no guidance is currently available to identify potential domino effects on lifelines and Seveso establishments and to assess/control security-related scenarios trough the adoption of barriers.

"Barriers" are layers of protection against domino propagation of a hazard to people/environment/other installations: "Safety" ones (hardware, operations, procedures, design strategies, fireproofing, emergency shut down…) aim at domino prevention/mitigation; "Security" barriers (cameras in CCTV, mesh gate with padlock, automatic biometrics check…) protect against external act of interference. To manage these aspects some decision support systems (DSS) and software are available: DOMIFFECT (1998) free software for domino evaluation and risk estimation, biased by oversimplified assumptions; DOMINOXL2.0 (2002) oversimplified software tool and not supporting risk estimation; ARIPAR-GIS (2006) sold by JRC, applied in risk studies in Italy, is not suitable for real-time update and does not assess multiple level dominos; FREEDOM2 (2014), and DomPrevPlanning© (2007) rely on simplifying assumptions. DSS used in the nuclear sector (EASI, ASSESS, ATLAS…) enable vulnerability calculation but not risk estimation. All of them do not support: safety AND security (S/S) quantitative indicators (vulnerability, individual and societal risk); quantitative assessment of S/S barriers; RT evaluation of safety-security status for Seveso installations; real time data processing; 3D spatial representation.

Lack of awareness and of prevention and mitigation strategies, along with the absence of specific tools and DSS for an integrated safety-security evaluation, is hindering competent authorities in the EU from making safety and security assessments and from effectively managing industrial sites. Thus, the security of industrial sites must be addressed, both from the legislative and technical point of view, as an issue of the greatest urgency.

The LIFE SECURDOMINO project addresses the above-mentioned safety-security interface issues, and the need to integrate them in SEVESO plants in order to prevent health and environmental damages associated with the escalation of possible domino effects triggered by external acts of interference. In particular, the proposed action aims at developing an innovative tool for the assessment and management of risks induced by security threats, i.e., external acts of interference or terrorist attacks, in SEVESO plants. In other words, the core of the work is supporting the integrated safety-security assessment of industrial facilities, developing advanced approaches based on the probabilistic and deterministic assessment of domino effects triggered by cyber-physical agents and threats.

The main outcome of the project is a tool for assessment of safety-security hazard and risks and related domino effects in Seveso sites. The tool consists of: a) plant inspection by drone with aerial photogrammetry acquisition; b) 3D reconstruction of the plant on a graphic interface; c) association of real-time data (process conditions, maintenance status, alarms, etc.) and documentation (certificates, permit to work…) to each mapped element; d) evaluation of probabilities and consequences of accidents, given real time and/or user input data (meteorological conditions, type of rupture, etc.); e) hazard-risk assessment and visualization of possible dominos following accidental events; f) real-time mapping of barriers and their performance supporting emergency response. The complete set of models and barriers performance data for steps d)-f) will be reported in an open web repository. The tool is intended for use by companies, consultants and competent authorities involved in the assessment, control and management of major accidents, specially dealing with security scenarios.
The tool developed was "tested" in two DEMO SITES in Italy and one in the Netherlands and, at the same time, was validated/verified by ARPAT for Tuscany (Italy), the reference public body for the implementation of SEVESO directive in Italy. DEMO1 (Costieri D'Alesio S.p.A.) is a petroleum tank farm that does not carry out any product processing process, but only storage and handling of finished products in large amounts. The facility is located in Livorno (IT). DEMO2 (Manetti & Roberts) operates in the industry of cosmetics, personal care, and homecare. It is a productive plant located in Calenzano, near Florence (IT). The main activities taking place in the plant are the production and packaging of cosmetics, featuring the storage and processing of LPG (liquefied petroleum gas). DEMO3 (Wilhelmsen Ships Service) is a global provider of standardised product brands and service solutions to the maritime industry, focusing on marine products, and marine chemicals. The International Distribution Center located in Rotterdam (NL) stores chemicals of different nature (flammable and toxic materials). Hence, the DEMOs feature different capacity, materials, locations, thus they enable picturing all possible applications of the tool in different EU-MS, deriving information for the implementation of Seveso and Environmental Protection Directives.
The tool application has improved the safety-security status of the DEMO sites reducing the vulnerability (at least 40% each) and of risk scores (at least 20% each) with respect to the initial situation. The decrement in vulnerability impacts on the potential emission reduction, thus with a benefit on climate change mitigation, due to the reduction of greenhouse gases potentially released in case of major accidents. At the same time, mitigating the impact of NOx emissions due to major fires and explosions, has an impact on the air quality and, on turn, a positive effect on the biodiversity. The implementation of the LIFE SECURDOMINO project produced a set of guidelines and effective actions to raise awareness related to the integration of safety-security in the assessment of major accident hazards; this will constitute a relevant support in the revision and improvement of current regulatory framework at EU-MS level (guidance for the evolution of the Seveso directive, land use planning, critical infrastructure protection, etc.). After the project conclusion, the experience obtained with the DEMOs will facilitate and enable the extension of the procedure in the considered regions of interest, potentially affecting the risk monitoring and reduction of other 51 plants in Tuscany (IT), 196 plants in the Netherlands for a total foreseen number of 250 plants assessed five years after the project end. In long-term perspective, the foreseen regional extension of the procedures may enable the development of national and EU implementation, thus affecting the existing ~12,000 Seveso establishments. At the same time, the tool and approach may be extended to non-Seveso plants featuring the presence of hazardous materials, and other manufacturing facilities.

5. Administrative part

Project management process, the working method, meetings, and outcomes

SECURDOMINO management was designed to ensure an efficient decision-making and an effective communication among partners, while maximizing collaboration and flexibility. A unique decision-making body integrating all partners representatives and a professional project manager was structured, while each Action was managed by a single leading institution that coordinated its implementation, performed progresses monitoring and was responsible of schedule respect. Guidelines and Best practices for LIFE project management have been made available to the partnership in January 2022 (Deliverable [D01]) and agreed with all partners. A specific session was held in the frame of the Kick-off meeting (10/12/21).

Structure of the Board: The Project Management Board (PMB) included the Technical Coordinator (UNIPI) and a representative of each associated beneficiary. The Project Manager (PM) was also integrated into the PMB. The PMB performed continuous project management and monitoring to ensure: i) coherence and integration of project activities; ii) consistency, quality and significance of the technological achievements; iii) proper networking with similar project, proper reporting and dialogue with the EC; iv) setting of prevention or mitigation actions in the frame of risk management.

The detailed list of PMB in-presence and structured web meetings is as follows: kick off meeting M1 10/12/21 (in Pisa-IT); First PMB meeting, on 30/03/22 (virtual meeting); [NEEMO visit on 24/05/2022]; second PMB meeting on 26/07/2022 (virtual meeting); third meeting on 15/12/2022 (face to face in Pisa-IT); [ELMEN visit on 07/06/2023 in Pisa-IT]; fourth PMB meeting 06/12/2023 (virtual meeting); fifth PMB meeting 17/07/2024 (virtual meeting); sixth PMB meeting 11/02/2025 (face to face in The Hague-NL); [ELMEN visit on 26-27/05/2025 in Pisa-IT]; seventh PMB meeting on 19/09/2025 (face to face in Pisa-IT).

The PM monitored the overall project schedule respect, budget allocation, proper and timely report to the EC, meetings organization and minuting. The PM performed risks management for all risks specifically related to Project management issues and submitted to the Technical Coordinator possible prevention and mitigation actions. She assisted the Technical Coordinator in all duties related to project financial and technical monitoring and reporting. The aim of the internal monitoring was to verify if the project was implemented as foreseen and resources are used as planned, and to eventually adapt the plan to the situation in order to reach Milestones, produce Deliverables, and Outputs as planned. An internal communication platform was set up on MS OneDrive: SECURDOMINO SharePoint folder acts as a repository for all project documents. For reporting purposes, for every structured meeting/conference/training the following documents are collected: attendance lists; agenda; minutes.

All partners participated in the meetings in an active and collaborative way, with a technical and financial update concerning the actions developed and foreseen for the following periods. No major difficulties encountered.

Communication with the Agency and Monitoring team

The communication with the monitoring team was smooth and effective. The monitor has been regularly updated on the progresses of the project, issues were discussed and addressed in duly time. The project received a monitoring visit on the 24/05/2022, a second visit on 07/06/2023 (after the mid-term reporting period), and a final visit on 26-27/05/2025 in Pisa-IT. After each visit the project received written feedback from the Agency and the external monitor.

6. Technical part

6.1.Technical progress, per Action

6.1.1. Action A.1 Technical planning and stakeholders' consultation

Foreseen start date: 01/10/2021 Actual start date: 01/10/2021
Foreseen end date: 31/03/2022 Actual end date: 14/10/2022

6.1.1.1.Activities undertaken and outcomes

The action supported the dissemination and communication of LIFE SECURDOMINO by identifying and preliminarily involving selected stakeholders, such as plant managers, site security and HSE (health, safety, environment) managers, industrial consultants, public authorities. All partners adopted their respective network to inform and promote the project.

Table A.1.1 summary of LIFE SECURDOMINO DEMO sites

DEMO SITE	Country/ region	Modified and finally confirmed (14/10/22)
DEMO1	(IT, Tuscany)	Costieri D'Alesio Spa, Livorno 
DEMO2	(IT, Tuscany)	Bolton Group (Manetti & Roberts), Calenzano 
DEMO3	(NL, South Holland)	Wilhelmsen Ships Service, Rotterdam 

Next, the core of the activity was gathering and analysing data, described in [D04], to prepare the technical actions dedicated to the implementation of the LIFE SECURDOMINO software tool for integrated safety and security assessment of selected Seveso sites. In particular, three DEMO sites are involved (see Table A.1.1). UNIPI carried out field inspections of the DEMO sites and meetings with plant personnel to set up the preliminary activities for the project [D04].

6.1.1.2.Planned output in the reporting period

Deliverable [D4]: *SECURDOMINO D04 A1 "DEMO Sites data collection and stakeholders' involvement report"*
Due date: 31/03/22 Final version delivery date: 14/10/2022

6.1.1.3.Main difficulties, modifications, and actions taken

As shown in Table A.1.1, two out of three initially considered DEMOs decided to quit the project and were replaced. The motivation they adduced was due to widespread and uncertainties due to COVID19 (DEMO3) and, soon as the project started, the crisis in Ukraine (DEMO2). The need to replace two DEMO sites caused the delay in the preparation of the final deliverable. The first version was completed in limited delay with respect to the considered plan (May-22), including the final data of DEMO1 and DEMO2. However, the deliverable was put on hold and necessarily amended, as soon as the novel DEMO3 in the Netherlands confirmed its availability and provided technical data (Oct-22).
Impact on the project: as the aim of the project is to develop and apply a software tool capable to carry out the real time 3D ISS assessment of Seveso facilities, any kind of Seveso plant is suitable for the sake of demonstration of the SECURDOMINO tool. The features of the novel DEMOs recruited have a similar damage potential compared to the former ones, and with respect to the former DEMOs offer advantages: 1) DEMO2 holds LPG, so it enables to introduced in the analysis pressurized tanks; 2) DEMO3 holds a greater variety of materials, thus flammable, toxic and ecotoxic. Hence, this modification does not have an impact on the project.
Impact on the other actions: despite the delay, no relevant impact on the other actions was experienced. Action B5, involving the analysis of DEMO sites, regularly started in Oct-22, once all the three DEMOs were defined and information properly gathered in advance.
Overspending: the allocated budged, mainly personnel, was sufficient to compensate the additional work needed to replace the DEMOs and further analyse the novel DEMO2 once the former DEMO2, which was preliminarily assessed, left the project.

6.1.1.4.Perspectives for continuing the action after the end of the project.

The data collection may be repeated to any kind of industrial activity prior to the reconstruction of the plant and 3D assessment. As a matter of fact, the needed data set is available at each Seveso plant in EU. The experience gained in this activity, with particular reference to the organization of information and classification of input data, is the necessary basis for the replication to other Seveso plants after the project end.

6.1.2. **Action B.1 Tool development**

Foreseen start date: 02/01/2022 Actual start date: 02/01/2022
Foreseen end date: 30/09/2024 Actual end date: 30/09/2024

6.1.2.1.Activities undertaken and outcomes

The LIFE SECURDOMINO software tool was developed to provide an integrated platform for the real-time, 3D assessment of safety and security risks in Seveso sites. Its main objective is to enable the combined evaluation of vulnerability and potential domino effects triggered by both accidental and intentional external events, offering a decision-support environment for plant managers and competent authorities.

The development process was carried out jointly by UNIPI and DATACH. The UNIPI research group focused on the creation of analytical models for the estimation of accident consequences, vulnerability, and domino propagation, which were initially implemented in MATLAB. DATACH then integrated these models into the 3D visualization and management environment using VB.NET and C++ programming languages. This ensured full compatibility between the analytical routines and the real-time graphical engine.

The 3D representation of each industrial plant followed a structured workflow comprising aerial data acquisition, model generation, and refinement. Drone inspections were performed to collect several hundred high-resolution photographs per site, later processed with the Agisoft Metashape software to produce detailed photogrammetric reconstructions (Figure B.1.1).

The resulting 3D models were optimized in Luxology Modo 3D to enhance visual quality and computational performance before being exported through a proprietary Lightwave 3D plugin. This plugin converts the models into the MSH2 format, ensuring seamless integration with the SECURDOMINO engine. For interior environments, CAD drawings and extensive photographic documentation were used to recreate textures and geometry with high fidelity.

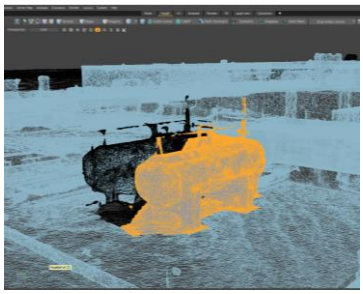
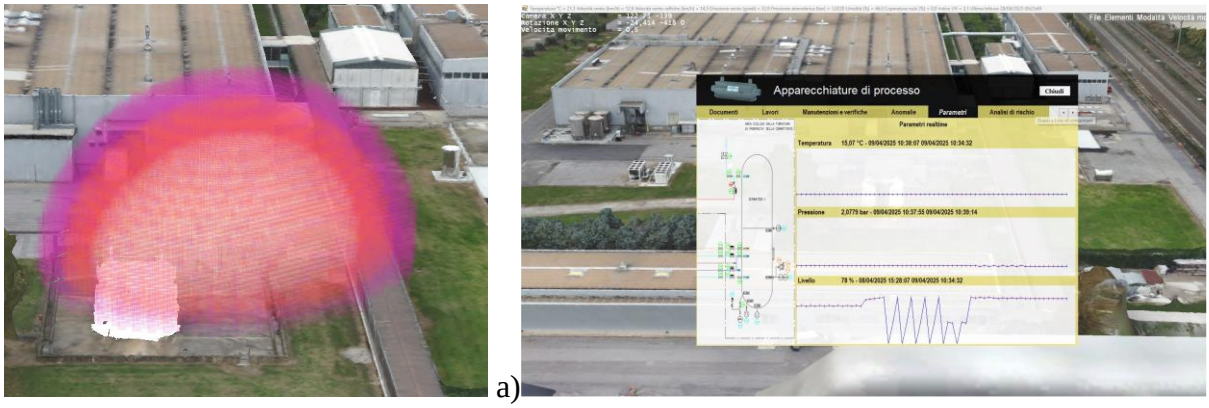

a)

b)

Figure B.1.1: a) Example of polygonal 3D model with textures created with Agisoft Metashape; b) detail of the LPG tank at DEMO2.

The physical-effect models incorporated into the software cover fires, explosions and dispersion scenarios. The thermophysical properties of substances were derived from the DIPPR 801 database, while representative materials were identified for each demonstration site. This allowed for site-specific scenario definition and the reproduction of realistic process conditions. Figure B.1.2a illustrates the rendering output produced by using point sprites with varying levels of transparency values.

A further component of the software concerns the management of real-time data. The telemetric system, based on the MQTT communication protocol, enables the continuous exchange of information between plant sensors and the SECURDOMINO tool. Data on pressure, temperature, and level are transmitted to the Sensor Service, processed, and stored in a Microsoft SQL Server database (Figure B.1.2a). In parallel, static information such as technical documentation, maintenance reports, and work permits is organized and linked to

each mapped object within the 3D model, creating a complete digital representation of the facility.



a)

Figure B.1.2 a) Example of polygonal 3D model with textures created with Agisoft Metashape; b) Example of real time data extracted from DEMO2 (Temperature, pressure, level).

For Seveso risk analysis (as required by Italian regulations, see [D16]) it was needed to render 2D circles within a 3D space (Figure B.1.3a). GPUs are inherently unable to render true circle areas directly, as they operate solely with polygons (triangles), even point sprites are composed of two triangles forming a rectangular surface). The circular areas were divided into triangles with a process called 'triangularization' (see Figure B.1.3b rendered in white for better visibility, wireframe)

Figure B.1.3 a) Example of risk contours according to Italian regulation (see [D16]; b) example of calculation grid adopted for triangularization of circular areas.

To achieve full integration between the analytical and graphical environments, UNIPI and DATACH tested different approaches for converting MATLAB routines into compiled code. MATLAB Coder was ultimately chosen as the most efficient solution, allowing direct translation into C/C++ while maintaining high computational performance and offering post-processing optimization capabilities.
The final version of the tool, delivered in Sep-24, includes the complete suite of functions for real-time risk and vulnerability assessment. It visualizes the physical effects of fires and explosions, quantifies their propagation potential, and dynamically represents the status of safety and security barriers. The result is a user-friendly interface that combines 3D plant visualization with quantitative assessment methods, providing a powerful support for inspection, emergency planning, and preventive risk management

6.1.2.2.Planned output in the reporting period

Deliverable [D11]: LIFE SECURDOMINO Tool (link)
Due date: 30/09/2024 Delivery date: 30/09/2024

6.1.2.3.Main difficulties, modifications, and actions taken

The main technical challenge concerned the conversion of MATLAB routines into programming languages suitable for integration within the real-time 3D environment. Complex mathematical structures and data types required dedicated adjustments, and the automated tools initially tested showed limitations in handling certain variables. The adoption of MATLAB Coder resolved most of these issues by providing a more flexible conversion process, although several optimization and debugging steps were necessary to ensure the stability of the integrated code.

Minor visualization problems were also encountered during the rendering of heat-radiation fields and risk contours within the 3D space. These were solved through shader optimization and the implementation of adaptive transparency, which improved the graphical representation of the hazard intensity fields. No major delays or cost deviations were recorded during the development phase, and all milestones were achieved according to the planned schedule.

6.1.2.4.Perspectives for continuing the action after the end of the project.

The final version of the SECURDOMINO tool provides a solid basis for replication and further development. The modular architecture allows for the integration of additional models, such as condensed-phase explosions or contamination of soil and water, as well as the connection with external databases and monitoring networks. After the end of the project, the software will continue to be used within the demonstration sites for monitoring and training purposes, and it will serve as the reference platform for future replication activities under Action B7. Its flexibility makes it adaptable to a wide range of industrial contexts, including non-Seveso facilities where hazardous materials are present. The tool represents a significant advancement in the combined management of safety and security, providing a unique and operational framework that can be extended across the EU to strengthen the resilience of industrial installations against both accidental and intentional threats.

6.1.3. Action B.2 Open web repository of models and barriers

Foreseen start date: 02/01/2022 Actual start date: 02/01/2022
Foreseen end date: 31/01/2025 Actual end date: 31/01/2025

6.1.3.1.Activities undertaken and outcomes

Action B2 was dedicated to the creation of the open-access web repository of models and barriers, which constitutes the scientific and methodological core of the LIFE SECURDOMINO software. The repository (see snapshot in Figure B.2.1) was conceived as a structured database integrating validated physical-effect models, event-tree logic, and performance data for both safety and security barriers, ensuring full transparency and reproducibility of the risk-assessment process.

The development was led by UNIPI, with the scientific contribution of ARPAT for verification and validation of models and DATACH for software integration. The repository was published on the project website (https://securdomino.eu/open-web-repository) and remains open for consultation and further updates.

A schematic diagram (Figure B.2.1) illustrates the complete workflow: identification of release scenarios, source-term evaluation, consequence assessment, and domino-effect propagation, with parallel branches for safety-barrier performance and Physical Protection System (PPS) reliability.

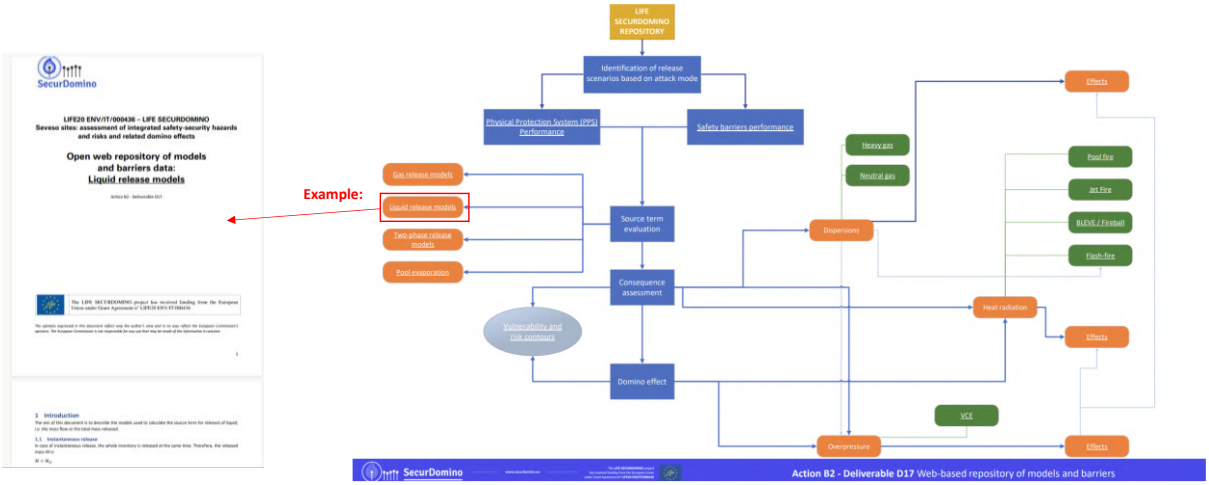


Figure B.2.1. Snapshots taken from the open web repository.

From a methodological standpoint, the repository groups the models into a logical flow that links the attack or accidental release mode to the physical consequences and subsequent domino escalation. The models implemented cover all major categories of effects relevant to Seveso establishments:

- Gas and liquid releases, including two-phase flashing flows and pool evaporation;
- Dispersion phenomena, for both neutral and heavy gases
- Fire and explosion scenarios, such as pool fire, jet fire, flash fire, BLEVE/fireball, and vapour-cloud explosion (VCE);
- Thermal radiation and overpressure effects for people and equipment, expressed through deterministic thresholds and probabilistic probit relations;
- Toxic exposure effects, with dose–response models based thresholds and probabilistic probit relations;
- Domino-effect modelling, representing the probability of escalation from a primary event to nearby units based on thermal or mechanical load.

Each model is documented with equations, parameter ranges, bibliographic sources (mainly TNO Green, Yellow, and Purple Books, API 581), and, when applicable, reference validation against DNV Phast simulations.

The repository also includes detailed data on barrier performance, distinguishing safety barriers (firefighting, deluge, venting, pressure relief, containment) and security barriers (perimeter fences, CCTV, access control, alarms). Their reliability parameters are expressed as probabilistic gates within event trees used in the SECURDOMINO software to calculate vulnerability and risk indices. A specific study on the development of ISS event trees was realized by UNIPI, partially financed by the LIFE resources, exploiting the competencies acquired during the development of the action. The outcomes of the study were published in an international Journal [AD1]. This is the technical foundation of the ISS implemented in the software.

By assembling all these elements, the repository represents a unique digital reference for integrated safety-security (ISS) risk modelling in process industries. It provides the computational foundation of the SECURDOMINO tool and ensures traceability of each model used in the site simulations and demonstrations.

6.1.3.2.Planned output in the reporting period

Deliverable [D17]: Open web repository of models and barriers data
Due date: 31/01/2025 *Delivery date: 31/01/2025*
Additional material: [AD1] *Casson Moreno et al. 2022, Rel. Eng. Syst. Saf.*

6.1.3.3.Main difficulties, modifications, and actions taken

The development of the repository did not encounter major obstacles. The main effort was related to harmonising the different modelling approaches—deterministic, semi-probabilistic, and fully probabilistic—so that they could operate consistently within the SECURDOMINO analytical framework. Another technical challenge concerned the conversion of MATLAB routines into formats compatible with the 3D environment and the online repository.
No overspending or delay was recorded during the action implementation.

6.1.3.4.Perspectives for continuing the action after the end of the project.

The repository is designed as a living system: new models and barrier data can be uploaded as soon as updated correlations, performance datasets, or regulatory requirements become available. Future expansions will include:

- Additional physical models for condensed-phase explosions and environmental contamination (soil and water);
- Updates of barrier reliability data based on field evidence collected during inspections;
- Inclusion of climate-related parameters, such as extreme temperature and wind variability, to support adaptation to evolving environmental conditions.

After the project closure, the repository will remain online for at least five years, maintained by UNIPI and DATACH as part of the SECURDOMINO digital infrastructure. It will continue to serve both as a technical reference for researchers and authorities and as a knowledge base for further replication of the tool in other industrial sectors.

6.1.4. Action B.3 Regulatory framework adaptation

Foreseen start date: 01/04/22	Actual start date: 01/04/22
Foreseen end date: 30/06/23	Actual end date: 30/06/23

6.1.4.1.Activities undertaken and outcomes

The action focused on the adaptation of the LIFE SECURDOMINO tool to the regulatory frameworks of Italy and the Netherlands, the two Member States where the project demonstration sites are located. The activity was jointly led by LEIDENU and UNIPI, with contributions from ARPAT for the Italian implementation and CRISISPLAN for the Dutch context.
The work started from a comparative review of safety and security legislation applicable to Seveso establishments, as reported in [D07]. The analysis clarified that while safety aspects are comprehensively covered by the Seveso III Directive (2012/18/EU), security aspects are addressed separately under the European Programme for Critical Infrastructure Protection (EPCIP) and its implementing Directives 2008/114/EC and 2022/2557/EU.

- *Safety- the Seveso framework*

The Seveso directive was reviewed across its three main evolutions. Seveso I (1982) introduced the concept of major-accident hazard prevention; Seveso II (1996) expanded the scope to include land-use planning (LUP) and Major Accident Prevention Policy (MAPP); and Seveso III (2012) aligned the classification of hazardous substances with the CLP Regulation and strengthened the responsibilities of operators and competent authorities.
In Italy, Seveso III is transposed through Legislative Decree 105/2015, which defines a top-down institutional architecture. The Ministry of Environment coordinates the national policy; the Ministry of the Interior and the Regional Technical Committees (CTR) perform

technical evaluations and inspect safety reports; and the Prefectures are responsible for external emergency plans. Fire brigades and Civil Protection authorities constitute the operational response level.
In the Netherlands, the Directive is implemented via the BRZO Decree (1999, 2015), the Safety Regions Act (2010), and, since 2024, the Omgevingswet, which consolidates environmental and spatial planning rules. The Dutch system adopts a risk-based and decentralised approach, where Safety Regions—regional consortia of municipalities—manage inspections and emergency coordination.

- *Security- towards multi-hazard*

Parallel to the safety framework, the EPCIP and the subsequent Directive 2008/114/EC were analysed as the foundation of the European security policy for critical infrastructures. This legislation originally targeted the energy and transport sectors, introducing the concepts of Operator Security Plans (OSP) and Security Liaison Officers, while the recent Directive 2022/2557/EU on the resilience of critical entities broadens the scope to all vital sectors, although chemical industries remain indirectly covered.
National transpositions reveal different strategies. Italy established the NISP – Nucleo Interministeriale Situazione e Pianificazione, which identifies European Critical Infrastructures and coordinates with the Prefectures through the Operator Security Plans (PSO). Security responsibilities are thus segregated from safety regulation. In the Netherlands, conversely, security falls within an all-hazards resilience model, coordinated by the Ministry of Justice and Security together with sectoral ministries. Operators in the twelve identified vital sectors, including the chemical industry, conduct their own risk assessments that are consolidated into a National Risk Assessment encompassing both safety and security.

- *Safety-Security integration*

The comparative study confirmed a structural gap between the safety and security domains at EU level. Seveso III does not explicitly include security-related events in the assessment of major accidents, whereas EPCIP and its implementing directives do not address hazards induced by the storage and processing of dangerous substances. The integration gap is therefore evident and has practical implications for the management of Seveso sites, where intentional interference may trigger cascading or domino effects.
This observation led to the drafting of the LIFE SECURDOMINO Whitepaper [D14], which consolidates the outcomes of this action. The Whitepaper highlights that the Seveso Directive explicitly mentions natural events as aggravating factors but omits security-related threats; it also stresses that the integration of Seveso and EPCIP frameworks would enable a coherent “all-hazards” approach to industrial risk governance.
Finally, the results of Action B3 directly supported the preparation of the Handbook and Guidelines (Action B4), by providing the legal and policy context required to tailor the SECURDOMINO tool to the Italian and Dutch regulatory systems, especially in relation to land-use planning and emergency-response criteria.

6.1.4.2.Planned output in the reporting period

Deliverable [D07]: Regulatory framework adaptation guideline
Due date: 30/06/23 Delivery date: 04/07/23

6.1.4.3.Main difficulties, modifications, and actions taken

The main challenge encountered was the fragmentation of legislative sources and the linguistic heterogeneity of the reference documents, which required a coordinated effort

among Italian and Dutch partners. In the Netherlands, the frequent updates to the BRZO and Omgevingswet frameworks required additional verification rounds to ensure full alignment. No major delays or budget deviations occurred. The outcomes were incorporated into [D07] and later synthesised in the Whitepaper to enhance clarity and visibility for external readers.

6.1.4.4.Perspectives for continuing the action after the end of the project.

The results of Action B3 provide the legal foundation for the future replication and adaptation of the SECURDOMINO tool across other Member States. The methodology developed for analysing national transpositions of EU directives can be replicated in any country to ensure compatibility between safety-security assessment tools and local legislation.
In the coming years, the partners plan to disseminate the Whitepaper through institutional and scientific networks, advocating for the integration of safety and security within the next revision of the Seveso Directive and in the implementation of Directive 2022/2557/EU. This action will contribute to the broader EU objective of promoting resilience of critical entities through harmonised, all-hazards risk management.

6.1.5. Action B.4 Handbook and guidelines

Foreseen start date: 01/04/23 Actual start date: 03/04/23
Foreseen end date: 31/12/24 Actual end date: 31/12/24

6.1.5.1.Activities undertaken and outcomes

Action B4 focused on transforming the technical outcomes of the SECURDOMINO project into operational guidelines and a complete handbook supporting the use of the software tool, the digitalisation of inspections, and the adaptation of procedures to the regulatory environments of IT and NL. The work was jointly coordinated by CRISISPLAN and UNIPI, with contributions from LEIDENU (legislative framework following Action B3, part 1), ARPAT (for inspection methodology, part 2) and DATACH (for the operational interface of the tool, part 3).

Part 1 - legislative framework adaptation guideline. The first part aimed at consolidating the legal, technical, and methodological requirements derived from Action B3 into the operational structure of the SECURDOMINO tool. The work was completed in a changing regulatory landscape, particularly on the Dutch side, which required the consortium to demonstrate flexibility and resilience. While the initial planning of Action B4 was based on the BRZO Decree (2015) and the Safety Regions Act (2010), the entry into force of the Omgevingswet on Jan-24 significantly changed the governance of land-use planning and environmental risk in NL.
Instead of delaying the action, the consortium adapted its workflow in real time. Leiden University and CRISISPLAN immediately reviewed the final version of the Act and updated the adaptation section of the handbook, ensuring full consistency between the tool and the new national environmental framework. This quick reaction allowed LIFE SECURDOMINO to remain aligned with the latest Dutch regulation.
For IT, the tool was aligned with the deterministic framework of Legislative Decree 105/2015 and the Ministerial Decree of 9 May 2001, which define safety distances and vulnerability classes (A–F) for land-use planning. The SECURDOMINO software automatically calculates these damage zones, integrating the radiation, overpressure, and toxicity thresholds derived from the repository of models developed in Action B2.

For the Netherlands, the software configuration was revised twice during the action to keep pace with the evolving regulatory context. Initially based on the probabilistic Land Use Planning (LUP) criteria of the BRZO framework (using the plaatsgebonden risico or individual risk contour at 10^{-6} y^{-1}), the tool was subsequently updated to reflect the dual deterministic–probabilistic approach introduced by the Omgevingswet. This update also included the capability to visualise "attention areas" (aandachtsgebieden), newly defined by the law as zones requiring additional safety measures or information obligations. The feature was implemented in the SECURDOMINO engine through a dedicated module for real-time mapping of effect areas and vulnerable receptors.
The adaptation process therefore produced two fully functional and interoperable configurations of the SECURDOMINO tool: a deterministic configuration tailored to the Italian regulatory framework; and a probabilistic–deterministic hybrid configuration compliant with the Dutch Omgevingswet. This outcome was achieved without modifying the project timeline or scope, demonstrating the flexibility of the tool and the responsiveness of the consortium to unexpected legislative developments.

Part 2 - Development of inspection procedures and digitalisation. The second part of Action B4 focused on the digitalisation of inspection activities in Seveso establishments. ARPAT developed and tested a dual-phase inspection protocol that became a national reference. The approach, originally introduced during the COVID-19 pandemic, consists of:
• Phase 1 – Remote documentation review, during which operators provide the Major Accident Prevention Policy, internal audits, risk scenarios, barrier performance data, and NaTech assessments through a secure online platform.
• Phase 2 – Onsite inspection, conducted by interdisciplinary teams (Environmental Agency, Fire Brigade, INAIL) to verify key technical and organisational elements, simulate emergency sequences, and interview personnel or contractors on site.
Within LIFE SECURDOMINO, this inspection model was integrated by UNIPI into the tool environment:
• The Phase 1 digital pre-inspection can now be supported through the SECURDOMINO repository, where operators upload safety documentation and vulnerability maps.
• During Phase 2, inspectors can use the 3D model to visualise equipment, barriers, and real-time process data, optimising inspection time and ensuring traceability of checks.
This innovation directly supports Article 27 of the Seveso III Directive concerning inspection planning, providing a reproducible method that improves efficiency, transparency, and harmonisation among competent authorities.

Part 3 - Handbook and operational manual of the tool. The third part delivered the LIFE SECURDOMINO handbook, a technical and practical reference describing the software architecture, installation procedures, and operational functions. The manual guides users through scenario creation, data input, and visualisation of results, allowing interactive selection of accident types (fire, explosion, toxic release), definition of meteorological conditions, and export of vulnerability and risk maps in standard formats.

The tool was tested in all three DEMO sites to ensure user-friendliness and to verify the consistency between calculated effects and regulatory acceptance criteria. This practical interface—based on a "click-and-run" philosophy—enables operators, consultants, and authorities to navigate a plant, open equipment tabs, check barriers, and run simulations with a single command, thus improving communication and awareness.

The final version of the handbook [D16] also includes a synthesis of best practices for hybrid inspections, references to the adaptation of the Seveso inspection article, and methodological guidance for the integration of the SECURDOMINO tool in future policy developments.

6.1.5.2.Planned output in the reporting period

Deliverable [D07]: LIFE SECURDOMINO tool: handbook and guidelines
Due date: 31/12/24 Delivery date: 10/12/2024, revised 17/04/25

6.1.5.3.Main difficulties, modifications, and actions taken

The main challenge concerned the entry into force of the Dutch Omgevingswet (Environment and Planning Act) on 1 January 2024, which profoundly changed land-use and risk-governance rules while the action was ongoing. The consortium promptly adapted the tool and handbook, updating the Dutch configuration to include the new attention areas and the hybrid deterministic–probabilistic approach. This was achieved without delays or additional costs, confirming the project's flexibility and resilience in facing regulatory changes. The version was updated in light of discussions with the Dutch competent authorities. The experience ultimately strengthened the interoperability of the SECURDOMINO framework between the Italian and Dutch systems and its readiness for future policy updates.

6.1.5.4.Perspectives for continuing the action after the end of the project

The handbook and its inspection guidelines will serve as a reference model for competent authorities and industrial operators beyond the LIFE SECURDOMINO project. The dual-phase inspection approach—combining digital pre-assessment and targeted onsite verification—is now recognised as a best practice and will continue to be applied by ARPAT and proposed to other regional agencies.
The SECURDOMINO tool will be further refined to allow direct uploading of inspection results, real-time comparison of barrier performance, and generation of inspection reports aligned with Seveso requirements. The methodological framework developed under this action is suitable for replication in other EU Member States, particularly in view of the forthcoming alignment between the Seveso Directive and the new Directive 2022/2557/EU on the resilience of critical entities, which promotes the digital transition of risk governance systems.

6.1.6. Action B.5 Tutorial application in DEMO SITES

Foreseen start date: 01/10/2022 Actual start date: 01/10/2022
Foreseen end date: 30/11/2024 Actual end date: 30/11/2024

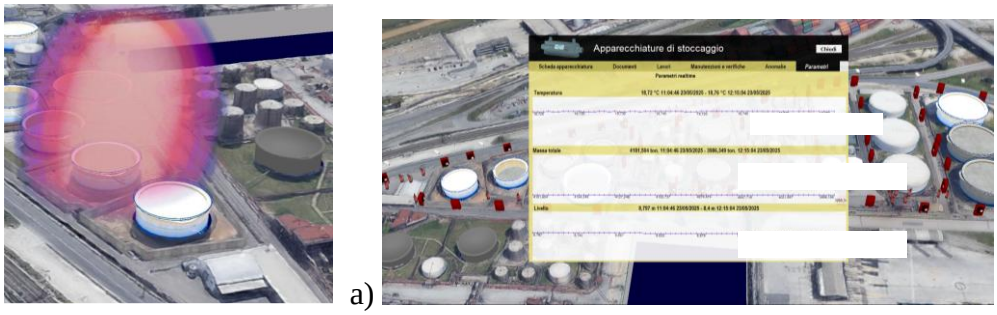
6.1.6.1.Activities undertaken and outcomes

Action B5 was devoted to the tutorial application of the LIFE SECURDOMINO tool in three demonstration sites representative of different Seveso contexts.
The activity validated the full functionality of the software under real operational conditions, consolidating the workflow for 3D reconstruction, data integration, and vulnerability–risk assessment.
In the first reporting period (Oct21-Jul23), only DEMO2 (Manetti & Roberts, Calenzano) had been fully implemented and described in the Mid-Term Report. In the following period, the approach was extended to DEMO1 (Costieri D'Alesio, Livorno) and DEMO3

(Wilhelmsen Ships Service, Rotterdam), thus completing the demonstration phase and providing an operational comparison among plants located in two Member States (Italy and the Netherlands) and under different regulatory systems.
Before applying the tool, each site underwent an assessment of the initial level of vulnerability, as required by the simplified revision of Annex II to the Grant Agreement. This preliminary evaluation provided the baseline conditions to be used as reference for subsequent KPI monitoring. The adopted formulation derives from the API RP 780 methodology, where the overall security risk R is defined as: $R=(A\times T)\times V\times C$, where A represents the attractiveness of the asset, T the threat level, V the vulnerability (probability of attack success given existing barriers), and C the potential consequences. The baseline evaluation of V was carried out through targeted Security Vulnerability Assessments (SVA) at each DEMO, complemented by stakeholder interviews and expert elicitation. The numerical values and their evolution over time are discussed in Section 6.1.9 C.1 – System and Impact Monitoring.
Each DEMO represented a specific technological configuration and type of hazard, providing the opportunity to test the versatility of the SECURDOMINO tool. Quantitative vulnerability and risk analyses were validated by NYX S.r.l., external independent contractor, using comparative QRA calculations and DNV Phast™, ensuring consistency between SECURDOMINO outputs and established industrial benchmarks (see [D15]). Across all demonstrations, the SECURDOMINO tool successfully integrated real-time meteorological and process data with 3D spatial representations. The repository of models (Action B2) and the database of barrier performances were fully coupled to the graphical interface, allowing users to run scenario simulations and visualise their cascading effects directly on plant layouts. In the following, a brief summary of the main activities for each demo are provided, the full set of activities and results obtained is discussed in [D15].

DEMO1 – Costieri D'Alesio S.p.A. (Livorno, Italy)
The Livorno site, operated by Costieri D'Alesio S.p.A., is an upper-tier Seveso petroleum terminal located within the industrial port area. The presence of large fuel tanks and the proximity to the airport imposed strict operational constraints for aerial inspections. In particular, ENAC Regulation ATM-09A limited drone flight height to 40 m, while the ATEX Directive 2014/34/EU prohibited the use of non-certified devices inside potentially explosive areas.
To address these restrictions, DATACH Technologies developed an in-house strategy based on a peripheral drone flight combined with ground-level high-resolution photography. The flight campaign, executed entirely by the Italian team, focused on the plant perimeter and safe access points, ensuring compliance with both ENAC and ATEX requirements. The resulting imagery (see Figure B.5.1, left) was processed through Agisoft Metashape, and the 3D model was manually refined to reconstruct tanks, pipe racks, and loading bays with sufficient accuracy for risk analysis (see Figure B.5.1, right).
This 3D reconstruction enabled the execution of fire simulations within the SECURDOMINO tool, evaluating thermal radiation fields and potential domino propagation among tanks. The approach proved that even under severe flight restrictions, a reliable photogrammetric model can be obtained using standard equipment and internal expertise—an important precedent for Seveso sites located in port or restricted airspace zones. The final reconstruction of DEMO1 with the heat radiation contours of a pool fire scenario is shown in Figure B.5.2a. Figure B.5.2 shows also real time data obtained from the plant (temperature, total mass – inventory, level).

Figure B.5.1 3D reconstruction from peripheral flight and refinement of the tanks



a) b)

Figure B.5.2. Details from the SECURDOMINO software for DEMO1: a) Example of heat radiation contours from pool fire; b) snapshot of real-time data interface.

DEMO2 – Manetti & Roberts (Calenzano, Italy)

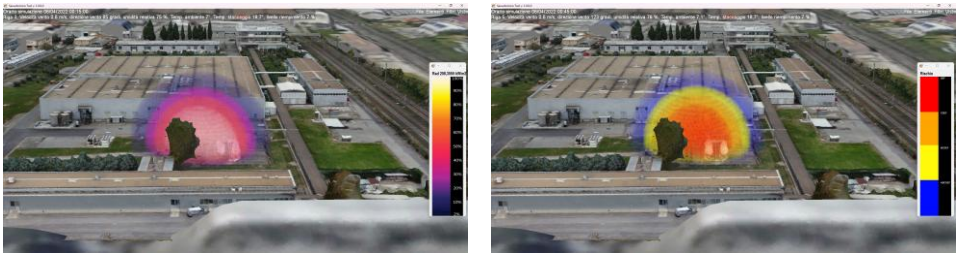
The plant is located in an industrial context and confines with a railway on North side. The plant stores LPG in two aboveground tanks (see Figure B.5.3a). DATACH coordinated site inspections DEMO2 to consolidate and preliminarily implement the ALPHA version of the tool and the final one, with consolidated real time connections from the plant (Mar-25). The delay in completing the real time connection was due to refurbishment of the distributed control system of the plant and not on the software development, which completion was carried out in due time.

Figure B.5.3.b shows the data obtained in real time, such as temperature, pressure and level in the tanks.

Figure B.5.3 Details from the SECURDOMINO software for DEMO2: a) Detailed view of the LPG tanks; b) snapshot of real-time data interface.

Figure B.5.4 shows an example of the results that are elaborated with the tool. A 2” (50mm) release from one of the two LPG tanks is assumed to occur due to accidental failure. Following the immediate ignition of the released material, a jet fire occurs, which heat radiation contours (in kW/m^2) are calculated by the software based on input temperature, pressure, level, ambient conditions. The results are shown in Figure B.5.4a. This event is

included in the safety report of the DEMO site. Based on this information, the risk map shown in Figure B.5.4b is obtained according to the Italian guideline for LUP [D16].



a) b)

Figure B.5.4. Snapshots taken from the software simulating the real-time risk assessment of DEMO2. Panels a and b show the consequences (kW/m^2 radiation map) and risk classification according to the Italian LUP for the jet fire scenario, respectively.

DEMO3 – Wilhelmsen Ships Service (Rotterdam, The Netherlands)
DEMO3 is a medium-scale Seveso site used for the storage and distribution of marine chemicals and gases. With respect to the situation at the Italian DEMO sites, a specific authorization was needed to flight over the plant in Rotterdam, due to the simultaneous presence of the Seveso plant (BRZO+ regulation) and airport area. Therefore, in order to perform the drone inspection in this peculiar context and avoid project delays, an external contractor was recruited, namely DDC - Smart Inspections, which holds the specific permit needed by the Dutch regulation. Next, the same refining procedure adopted at DEMO1 was used to produce the 3D simulation (Figure B.5.5).
The demonstration at DEMO3 verified the tool's adaptation to the new Omgevingswet regulatory framework (in force since January 2024). This required implementing the hybrid deterministic–probabilistic approach to land-use planning and the mapping of attention areas (aandachtsgebieden) within the SECURDOMINO interface [D15,D16]. Figure B.5.5 shows two views of the physical effects associated with a jet fire from the acetylene cylinders area.

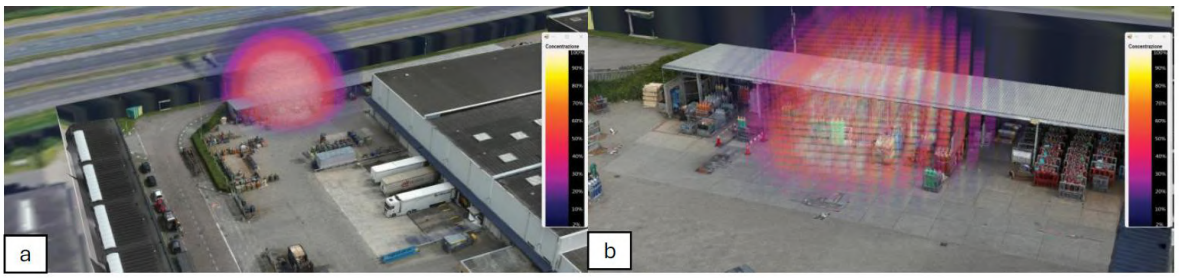


Figure B.5.5. Example of different view of heat radiation contours following the accidental fires at the cylinders area at DEMO3

6.1.6.2.Planned output in the reporting period

Deliverable [D15]: DEMO SITES integrated safety-security assessment
Due date: 30/11/24 Delivery date: 30/11/2024, revised 31/03/25

6.1.6.3.Main difficulties, modifications, and actions taken

Difficulties encountered during Action B5 mainly concerned the drone inspections and data collection phases. At DEMO1, drone flight was challenging due to airport restrictions and ATEX limitations, requiring low-altitude flights and alternative inspection strategies. At

DEMO3, the simultaneous presence of a Seveso site and an airport zone necessitated the recruitment of an external contractor (DDC – Smart Inspections), due to the complex Dutch regulatory framework. Finally, although DEMO2 allowed for unrestricted drone access, a significant delay occurred in the transmission of real-time process data, which were eventually received in March 2025, well after the initial deadline (30/11/2024); however, the software had already been adapted in anticipation of the data.
Overspending: the budget for equipment was reallocated to purchase a camera and external assistance costs covered the recruitment of contractors, namely NYX for extended validation of the software, and DDC for the preliminary flight over DEMO3. However, the overspending on personnel costs by UNIPI and DATACH (reaching approximately 105% of the original budget allocation) is justified by the additional technical work required to complete and validate the tool across all three DEMO sites. In particular, UNIPI dedicated extended efforts to the modelling of ISS scenarios, integration of feedback from industrial stakeholders, and adaptation of the code to site-specific constraints. DATACH was responsible for managing the iterative development and deployment of the software platform, including unexpected customisations requested during the replication and demonstration phases. These site-specific constraints emerged during the project, notably the introduction of the Dutch *Omgevingswet* in 2024, which required the team to enhance the tool's functionalities to support the new deterministic zoning approach (*aandachtsgebieden*) applicable to Seveso sites in the Netherlands. These adaptations were essential to ensure full regulatory alignment and usability of the software in both the Italian and Dutch contexts.

6.1.6.4.Perspectives for continuing the action after the end of the project

The procedure developed for the 3D rendering, coupling of real-time parameters, calculation routines for risk and vulnerability assessment may be tailored and extended to other industrial Seveso and non-Seveso sites (i.e., manufacturing sector, food processing, etc.) and is suitable for zones with multiple flight restrictions, as demonstrated by developing the analysis for DEMO1 and DEMO3.

6.1.7. Action B.6 Business plan

Foreseen start date: 01/04/2022	Actual start date: 01/04/2022
Foreseen end date: 31/10/2024	Actual end date: 31/10/2024

6.1.7.1.Activities undertaken and outcomes

The action was carried out by DATACH and UNIPI supported by an external contractor (METRON srl). The activity was divided into two parts: i) Preliminary evaluation for the business plan development strategy; ii) Development of the business plan, based on the developed strategy, still ongoing. Among the activities, a preliminary call and questionnaire for the Close-to-Market C2M initiative highlighted the key aspects for the preparation of the business plan strategy (08/09/22). The Business Model Canvas (BMC) was applied to set up the development strategy. The BMC was constantly updated. The preliminary analysis of the industrial survey (Action D1) enabled for the determination of stakeholders needs.
The inputs gathered through the survey were instrumental in identifying the needs and expectations of both Seveso and non-Seveso site operators, especially concerning digitalisation, regulatory compliance, and integration of safety-security (S/S) evaluations. These insights informed the refinement of the BMC blocks—specifically value proposition, customer segments, and key partners—allowing the business model to evolve in line with market expectations. In parallel, a first assessment of the market size and growth potential

was carried out. The analysis estimated a total addressable market of approximately 12,000 Seveso sites in the EU, with an initial focus on high-potential regions (Tuscany in Italy, with 51 remaining sites, and about 200 in the Netherlands). The plan foresees the possibility of scaling to non-Seveso industrial sectors (e.g., logistics, water treatment, food processing), based on the modularity of the SECURDOMINO tool and its capacity to adapt to different plant layouts and regulatory settings.
UNIPI contributed to the definition of the technical scalability of the tool, evaluating the feasibility of implementing new accident scenarios (e.g., contamination of water and soil, condensed-phase explosions), while DATACH refined the strategy for licensing and service provision. The plan outlines a hybrid business model combining Software-as-a-Service (SaaS) licensing with optional services, including inspection support, training, and model customization. This approach aims to ensure accessibility for smaller operators while offering full-feature packages to larger players or competent authorities. In economic terms, three market uptake scenarios were defined: pessimistic, probable, and optimistic.
Finally, a dedicated interview and business readiness assessment were carried out in the final year in the framework of C2M initiatives. This confirmed the tool's technical maturity and commercial potential. The interaction with C2M experts helped refine the business model and identify suitable replication pathways. As highlighted during the final interview, the project effectively bridged the gap between academic innovation and market exploitation, paving the way for concrete post-LIFE uptake by both public and private stakeholders.

6.1.7.2.Planned output in the reporting period

Deliverable [D13]: LIFE SECURDOMINO tool: business plan
Due date: 31/10/24 *Delivery date: 01/10/2024, revised 20/11/24*

6.1.7.3.Main difficulties, modifications, and actions taken

The preliminary version of the business plan development strategy was improved as soon as more data from the survey (Action D1) became available, and the BCM segments were contacted. The BCM is constantly evolving and updated. No major difficulties were encountered during the implementation of this action. The strategy was progressively refined based on survey results and expert input, without deviations from the planned timeline or budget.
Impact on the project and actions: no significant impact
Overspending: part of the budget allocated to audit costs (not to be reported, so without extra resources) was used by UNIPI to set up the strategy for the entire project.

6.1.7.4.Perspectives for continuing the action after the end of the project

The Business Plan 6 will serve as the operational roadmap for the exploitation of the SECURDOMINO tool in the post-project phase. DATACH, as the lead actor for commercialisation, will apply the same strategic framework to promote SECURDOMINO and related digital solutions developed within the company. The modularity of the tool, combined with the validated methodology and the engagement of inspection authorities ensures that the approach is ready for market launch.
Replication efforts foreseen under Action B.7 will rely on this plan to support adoption in at least 250 sites within five years after the project, targeting both Seveso and non-Seveso establishments. UNIPI and DATACH will maintain the technical and organisational capacities needed to support future clients, offer configuration services, and continue

updating the tool with new models and data. In this context, the Business Plan constitutes not only a financial strategy but a pillar of the long-term exploitation and scaling process.

6.1.8. Action B.7 Project replication

Foreseen start date: 01/10/2023 Actual start date: 01/10/2023
Foreseen end date: 30/06/2025 Actual end date: 30/06/2025

6.1.8.1.Activities undertaken and outcomes

Although formally scheduled to start in the final year of the project, Action B.7 was progressively implemented throughout the duration of LIFE SECURDOMINO to maximise continuity and support post-project replication. Activities were carried out in both Italy and the Netherlands, focusing on the involvement of public authorities, potential users, and technical partners. More details are reported in [D19].

In Italy, ARPAT played an active role in promoting SECURDOMINO during site inspections and through dissemination initiatives, including targeted outreach to 51 Seveso sites across Tuscany. UNIPI coordinated bilateral meetings with potential industrial users and participated in B2B sessions to explore adaptation to NaTech risk analysis and RAMS modelling, with feedback integrated into future development planning.

In the Netherlands, Crisisplan and Leiden University activated a structured cooperation with OMWB and the ministry of environment to explore replication across Dutch Seveso or high-risk sites, leveraging regulatory transitions under the new Omgevingswet. Pilot demos and dedicated workshops helped raise awareness and position SECURDOMINO as a tool supporting hybrid risk governance. The tool flexibility and adaptability were tested in the three DEMO sites (Livorno, Calenzano, Rotterdam), confirming that the methodology can be applied to diverse industrial contexts. The replication plan includes a step-by-step protocol (see Section 3.2 of D19) and a roadmap for progressive scaling, with the goal of reaching at least 250 sites in the 5 years following project conclusion. Stakeholder engagement was reinforced by participation in professional events, including the final conference in Pisa (September 2025), co-organised with the Order of Engineers of Pisa, and other networking initiatives under Actions D2 and D3.

6.1.8.2.Planned output in the reporting period

Deliverable [D19]: Replication and adaptation plan
Due date: 31/05/25 Delivery date: 10/08/2025

6.1.8.3.Main difficulties, modifications, and actions taken

As the current legislation (i.e., Seveso III directive) is not systematically asking for a specific security assessment [D7], the policy making engagement in promoting detailed safety-security analyses and requirements during the inspection is not an assumption but a condition that is not under the Beneficiaries control. Policymakers' engagement was foreseen during the project and part of the action, due to the involvement of public authorities. Significant activities related to dissemination and promotion are planned for the AfterLIFE.

Impact on the project: no significant impact
Impact on the actions: no significant impact
Overspending: none

6.1.8.4.Perspectives for continuing the action after the end of the project

The replication and adaptation activities developed under Action B7 are designed to continue beyond the end of the LIFE SECURDOMINO project. Thanks to the strong involvement of institutional partners and the high level of interest expressed by Seveso and

non-Seveso operators, the foundations are in place for ongoing dissemination and uptake of the tool.
In Italy, the collaboration with ARPAT and the network of 51 Seveso sites contacted during the project will serve as a starting point for regional-scale replication initiatives. UNIPI will remain available to support training and technical integration in future applications, leveraging the Handbook, open repository, and protocols developed within the project. In the Netherlands, the connection with the Omgevingswet framework open a clear opportunity to scale the SECURDOMINO methodology in other Dutch regions.
The After-LIFE Plan (see dedicated annex) foresees specific actions to maintain the network established during the project, including annual stakeholder meetings, technical seminars, and conferences. The SECURDOMINO platform will be maintained in SaaS format by DATACH, ensuring continuity of access for both demonstration and commercial use. The replication protocol and cooperation agreement (Annex I of [D19]) will be promoted as templates for engaging new industrial partners and facilitating site-level adaptation. In the medium term, the SECURDOMINO approach is expected to support EU-wide reflection on how to embed security aspects within safety inspections under the Seveso framework.

6.1.9. **Action C.1 System and Impact monitoring**

Foreseen start date: 01/10/2021 Actual start date: 01/10/2021
Foreseen end date: 30/09/2025 Actual end date: 30/09/2025

6.1.9.1.Activities undertaken and outcomes

LIFE SECURDOMINO system and impact monitoring was based on indexes established in the risk and safety/security field (see API standard 780). In particular, the action was aimed at quantifying the ISS indexes, monitoring the status of the DEMO sites vulnerability (V), according to the security risk (R) definition: $R=L\cdot V\cdot C$, where L is the likelihood of attack derived from API 780 indications on the EU context, and C are the expected consequences. V is defined as the average probability of attack success given all the considered attack paths in the considered Seveso facility. The baseline uploaded vulnerabilities were equal for all sites. We considered a baseline of total 250 sites (2 DEMOs in Tuscany, 1 in the Netherlands, 51 remaining sites in Tuscany, and 196 in the Netherlands) object of the analysis.
The baseline value for each DEMO was then quantified based on a preliminary SVA (security vulnerability assessment) developed in Action B5, the results of are shown in the third column Table C.1.1. The values obtained through the SVA are coherent with the uploaded baseline vulnerability. The vulnerability of generic Seveso sites does not change throughout the development of the project but will change during the 5 years period after the project end due implementation in order Seveso sites.
For the three DEMO sites object of Action B5, the reduction of vulnerability $\Delta V= -40\%$ has been achieved due to completed projects' actions and confirmed by the data obtained from the survey [D6]. If DEMO sites were informed about the project but preparatory actions were carried out (without setting the software, so in the initial DEMO2-Cheddite Italy), then a partial reduction of vulnerability was considered. The partial reduction of $\Delta V= -10\%$, namely the lowest value considered in the industrial survey of action D1 [D6] in relation to the implementation of the projects' action. For the industrial plants only informed about the project with specific dissemination on safety-security issues, half of the lowest value (so, $\Delta V= -5\%$) was considered. This value was assigned to 50 remaining sites in Tuscany, and also 51 sites informed in the Netherlands. The other 145 sites in the Netherlands part of the initial snapshot remained with the baseline vulnerability.

More details on the indicators are reported in the KPI explanation and justification uploaded on the KPI webtool https://webgate.ec.europa.eu/life/kpi/module. The export of the KPI module is reported in the additional documentation [AD3].
As part of the impact assessment under Action C1, a Life Cycle Assessment (LCA) of the SECURDOMINO solution was performed [D21] to evaluate the environmental footprint associated with the tool's implementation in Seveso-type facilities. The analysis considered the full life cycle of the tool, from development (software and algorithm coding, data modelling), through operational deployment (drone flights, 3D model generation, user interface usage), to its maintenance and expected updates in the After-LIFE phase.
The LCA was based on ISO 14040/44 principles and included both direct and indirect environmental impacts, such as electricity consumption for drone charging and server hosting, electronic waste from drone operations, and emissions associated with field data acquisition. Compared to conventional inspection methods (paper-based checklists, manual visual assessment, and static risk modelling), the SECURDOMINO system demonstrated a reduction in inspection time and travel-related emissions, thanks to remote data capture and digital documentation.
While the environmental impact of the software component was found to be minimal, the introduction of drone-based inspections brought measurable benefits in terms of reducing physical access risks for operators and limiting site disturbance during inspections. The use of open-source libraries and the modularity of the platform also contribute to minimizing the environmental burden associated with software updates and scalability.
Overall, the LCA confirmed that the deployment of SECURDOMINO has a low environmental footprint and is consistent with the objectives of sustainable digitalisation, especially when used to support inspections in high-risk or hard-to-access environments. The analysis will be used as a benchmark for future updates of the tool and to inform sustainability criteria in the post-LIFE exploitation phase.

6.1.9.2.Planned output in the reporting period

Deliverable [D21]: Report on the assessment of project impact indicators
Due date: 31/07/25 *Delivery date: 26/09/2025*
The report includes the *LCA report* as part of the deliverable.

6.1.9.3.Main difficulties, modifications, and actions taken

The main difficulty is the gathering of vulnerability reduction data, which is the necessary basis for KPIs calculation. However, the industrial survey allowed to get these data. Despite the delivery of the report on project impact indicators was due by Jul-25, it was decided to amend the document in order to include the evaluation of the indicators close to the project end.
Impact on the project and actions: no significant impact
Overspending: part of the budget allocated to audit costs (not to be reported) was used by UNIPI to recruit an external contractor for support in preparation of the deliverable including the LCA report, requested in Appendix to Annex II of the Grant Agreement.

6.1.9.4.Perspectives for continuing the action after the end of the project

The vulnerability and risk will be monitored at the DEMO sites for five years after the project end by means of the developed software, which will be applied in each DEMO. The same monitoring system in place will be maintained. Once the software will be applied in other locations in EU (IT and NL), the same parameters will be monitored.

6.1.10. **Action C.2 LIFE Key Project-level Indicators monitoring**

Foreseen start date: 01/10/2021 Actual start date: 01/10/2021
Foreseen end date: 30/09/2025 Actual end date: 30/09/2025

6.1.10.1. Activities undertaken and outcomes

Action C2 was dedicated to the monitoring and reporting of project performance indicators through the official LIFE KPI webtool (https://webgate.ec.europa.eu/life/kpi/module), in line with the LIFE Programme requirements. The export of the KPI module is reported in the additional documentation [AD3]. The activity was coordinated by UNIPI with input from all beneficiaries, and relied heavily on the methodological framework defined under Action C1. Full documentation and justification of the selected indicators were uploaded to the webtool as part of the action deliverable [D20].

The process began with the identification of relevant core indicators, impact indicators, and project-specific KPIs, with particular attention to the innovative scope of SECURDOMINO in integrating safety and security risk management. Given the lack of standard environmental KPIs directly applicable to software or digital risk assessment tools, the team developed a tailored methodology linking the tool's functionalities with expected reductions in vulnerability, improved inspection efficiency, and institutional awareness.

Among the key LIFE KPIs reported:

- ENV14 – Reduction of vulnerability due to the implementation of SECURDOMINO, expressed as a percentage (validated at ~40%, based on expert elicitation in Action D1).
- ENV13 – Number of inspections or risk assessments supported by the tool.
- IND07 – Number of organisations or institutions using the tool or expressing interest in replication.
- IND08 – Number of technical guidelines or procedures improved or created.

The KPIs were regularly monitored on the LIFE webtool platform. In particular, the final values were informed by the outcomes of Actions B5 (demonstration), B6 (business modelling), B7 (replication), and the surveys conducted under Action D1. A dedicated technical note ("KPI explanation and justification") was submitted via the platform to clarify how the selected indicators reflect the unique characteristics of the SECURDOMINO approach, which focuses not only on environmental metrics but also on system resilience and prevention of cascading risks in industrial settings.

Overall, Action C2 ensured that project results were traceable, measurable, and aligned with the reporting obligations of the LIFE Programme. The experience gained in defining digital-environmental KPIs may also serve as a reference for future LIFE projects working on risk governance and technological resilience.

6.1.10.2. Planned output in the reporting period

Deliverable [D20]: Final report on LIFE KPI monitoring
Due date: 31/07/25 Delivery date: 26/09/2025

6.1.10.3. Main difficulties, modifications, and actions taken

The main difficulty is the gathering of vulnerability reduction data, which is the necessary basis also for LIFE KPIs calculation. The explanation given for Action C.1 also applies here. The industrial survey allowed to elicit data on vulnerability reduction [D6]. Despite the delivery of the report on project impact indicators was due by Jul-25, it was decided to amend the document in order to include the evaluation of the indicators close to the project end. *Impact on the project and actions:* no significant impact

Overspending: no overspending, support for monitoring LIFE KPIs by external contractor recruited for Action C.1

6.1.10.4. Perspectives for continuing the action after the end of the project

The LIFE KPI uploaded on the KPI web-tool will be monitored for five years after the project end by means of the developed software, which will be applied in each DEMO. The same monitoring system in place will be maintained. Once the software will be applied in other locations in EU (IT and NL), the same parameters will be monitored.

6.1.11. Action D.1 Stakeholders' awareness raising

Foreseen start date: 01/10/2021 Actual start date: 01/10/2021
Foreseen end date: 30/09/2025 Actual end date: 30/09/2025

6.1.11.1. Activities undertaken and outcomes

Sub-action D.1.1 – Industrial Survey

An industrial survey was launched to capture the attitudes and awareness of EU industries (Seveso and non-Seveso sites) regarding vulnerabilities and ISS aspects. The expected results were of a two-fold nature: 1) determining the needs of industries for the development of the business plan (Action B6); 2) Expert elicitation of quantitative data on vulnerability reduction expected for the eventual quantification of KPIs. It was planned to reach 450 experts; the network of ALL the partners enabled to reach such an amount, while effective responses received are 85. However, this allowed to address the needs of industrial realities towards ISS software and for the gathering of quantitative data, confirming the expected vulnerability reduction of 40% [D6]. At the same time, it contributed to the awareness raising about ISS.

Sub-action D.1.2 – Events

In the first reporting period, an event was organized to support awareness rising towards ISS aspects. The event was registered in the Life is 30 initiative and was successfully run on 16/12/22. More details, including the presentations given during the event, are hosted on project website https://securdomino.eu/safety-and-security-integration-webinar/ The event was attended in presence by 10 registered people and followed by 45 persons remotely. Industrial events and technical focus groups were then organized after the completed set-up of the software.

Industry workshop in Pisa: The event, "Seminario su Aspetti di "Safety e Security" degli stabilimenti Seveso", was organized on the 17th October 2024 at the Engineering Department of UNIPI and counted the participation of 42 people from remote, and 29 in presence, with the participation of many ARPA (Regional Environment Protection Agencies) of Italy: ARPA Toscana, ARPA Lombardia, ARPA Liguria, ARPA Friuli Venezia Giulia, ARPA Umbria, ARPA Marche, ARPA Molise, ARPA Campania, ARPA Puglia, ARPA Sicilia, Provincial Environmental and Climate Protection Agency (Bolzano), INAIL (National Institute for Insurance against Accidents at Work), local Administrations, Fire Fighters, port Authorities, industries and technical experts, among others. The presentations shown during the event are available from the project website: https://securdomino.eu/seminario-su-aspetti-di-safety-e-security-degli-stabilimenti-seveso/. A certificate of participation was issued to participants, under request. The recording of the event is available for reporting purposes.

Event at LEIDEN University: On 20 May 2025 the symposium Securdomino was held at Leiden University in The Hague. The event marked the close conclusion of the four-year Securdomino project, with the afternoon dedicated to sharing its outcomes in the

Netherlands. Together with Leiden University, the University of Pisa, DataCH technologies, Crisisplan BV and ARPAT, there were also participants from the field. Experts from various safety regions, the Ministry of Justice and Security, the Dutch labour inspection, the Netherlands Institute for Public Safety (NIPV), and the National Institute for Public Health and the Environment (RIVM) were present. These organizations could adopt the tool to enhance the protection of their facilities. Representatives from several chemical companies located in the Rotterdam-Rijnmond port area also took part. A total of 28 people participated.

A special session has been organized at **ESREL 2024**, the 34-th European Safety and Reliability Conference, which was held from 23 to 27 June 2024 in Cracow, Poland. See the special session SS4. LIFE SECURDOMINO. Real-time risk assessment of industrial facilities based on the integration of safety and security. Organizers: Zdenek Vintr, Gabriele Landucci.

Final Event in Pisa

The event was organised together with the Engineers Association in Pisa (Ordine degli Ingegneri) and gave the opportunity to Engineers to receive training credits (5CFP), this helped the participation of engineers from Tuscany. UNIPI, DATACH and ARPAT were present. Among the participants also engineers working on plant safety assessment, professors and students at UNIPI. UNIPI also issued participation certificates under request. Participation was also possible from remote, with Regione Sardegna, Regione Lombardia, Regione Marche, Provincia di La Spezia, ISPRA. The final event in Pisa was organised on the 18 September 2025, at the MAAC, Meeting and Art Craft center.

The presentations presented during the event are downloadable from the event's website https://securdomino.eu/life-scurdomino-final-event/ There were 44 participants face to face and 22 from remote. After the lunch break a try-out of the Securdomino tool was possible. A shopping bag was distributed to participants, containing the agenda of the event, the project final brochure, the Layman's report, the Securdomino whitepaper, a "Securdomino pen" and a "Securdomino usb drive". A certificate was issued like in previous events.

6.1.11.2. Planned output in the reporting period

Deliverable [D6]: *SECURDOMINO D06 D1 "Final report on industrial survey"*
Due date: 30/04/2023 Final version delivery date: 05/06/2023

Milestone: *Focus group – seminar extended to industrial stakeholder (AIDIC ESRA conference) setting completed*
Due date: 30/11/2023 Final version delivery date: 30/11/2024

Milestone: *SECURDOMINO Workshop 1 - Tuscany; setting completed*
Due date: 31/01/2024 Final version delivery date: 19/07/2024

Milestone: *SECURDOMINO Workshop 2 - The Netherlands; setting completed*
Due date: 31/07/2025 Final version delivery date: 20/05/2025

6.1.11.3. Main difficulties, modifications, and actions taken

Despite the survey was launched in due time, it was decided to wait for the feedback of the first responders to adjust and modify the survey prior to further share it in the partners' network. Hence, the eventual launch was shifted in May-23 in order to implement the modifications. Consequently, it was decided to shift the end date.

The Focus group – seminar extended to industrial stakeholder was foreseen to be held at an AIDIC conference (Italian association framework conference) but was instead presented at an ESREL conference in the framework of the European association, therefore widening the scope of the dissemination, in terms of participation in the conference, and distribution of the proceedings of the conference.
Overspending: Given the additional budget (10k€ to shift from E1 – auditor cost) the event organization was funded without overspending.

6.1.11.4. Perspectives for continuing the action after the end of the project

Similar events may be organized in the future, in the period after the project end, in order to promote the software as soon as other market segments will be contacted and more experience is gained with the use of the software.

6.1.12. Action D.2 Communication and dissemination actions

Foreseen start date: 01/10/2021 Actual start date: 01/10/2021
Foreseen end date: 30/09/2025 Actual end date: 30/09/2025

6.1.12.1. Activities undertaken and outcomes

Action D.2 consists of all activities that increase the visibility of SECURDOMINO, based on the effective communication of progress made and disseminating the results obtained. The activity is coordinated by UNIPI in cooperation with ALL partners. A dissemination plan was first drafted in order to define the strategy for communication and dissemination. In this phase, an external contractor, Mentarossa srl, was specifically recruited by UNIPI to support the partners and implement the communication plan [D3]. The final report on communication and dissemination actions [D18] shows the outcomes of these activities.
The website (www.securdomino.eu) is the primary tool for communication of the project and is catered not only to the audience, but also to partners and stakeholders; for this reason, the working language is English. The aim of the website is to reach the audience and stakeholders not only with news and events related to the project, but also with progress and results.
The website (www.securdomino.eu) [D2] was online in November 2021, after the definition of the visual identity of the project. User-friendly and suitable for a mixed audience, it has been designed and maintained in collaboration with Mentarossa srl. Maintenance is currently a responsibility of Mentarossa srl, but it will pass to UNIPI after the end of the project. The site will be available 5 years after the end of the project. The target of the website was to achieve 30.000 visits at the project end, having 141.057 visits at the end of September 2025. More details on the features of website and targets reached are reported in [D18].
SECURDOMINO project has two social channels: one on Facebook and one on LinkedIn, administered by Mentarossa srl, that posts information regarding the project and its progresses. Facebook page and LinkedIn page are active since December 2021. It was recognized that institutional communication (thus, more LinkedIn) fits best the aim of the project, as the target of communication is not the general public. In fact, the project aims at reaching Professionals, Researchers, Experts in the field of operational safety and security, Policy makers at regional and EU level, Seveso and non-Seveso plant managers. LinkedIn and communication channels were beneficial to i) share project outcomes and, ii) to get experts opinions informing about the survey (Action D1).
The publication of news and articles related to SECURDOMINO is important not only to spread the project results, but also to raise awareness about the project and its aims. News about the project and its progress was published on the coordinator website (Università di Pisa – Dep. Civil and Industrial Engineering), with a dedicated page: https://www.dici.unipi.it/progetti/life-securdomino. The news of the funded SECURDOMINO project was also spread through the website of the partners. Across project span, ARPAT has shared news of the main LIFE

SECURDOMINO events through the ARPATnews newsletter ARPAT's newspaper, with the aim of disseminating environmental information, which also covered news from sources outside the Agency. The newsletter is shared every 15 days, and it counts averagely 1.000 registered subscriptioners [D18]. The project was showcased on the Leiden University's Institute of Security and Global Affairs - ISGA website. DATACH put a link on the home page as well as CRISISPLAN on Crisisplan website. Given the innovative aspect of the project, associated with the systematic implementation of the assessment of intentional threats in the industrial domain, a whitepaper on the systematic integration of safety-security aspects was issued after the completion of the main implementation actions (B1-B5) and diffused, exploiting the contacts of the industrial survey (see D1) and the contacts of the industrial partners [D14]. Publications in international journals and conferences have been used to reach the general public and to raise the awareness of public-private entities dealing with the safety/security aspects of SEVESO plants; the articles include the mention of the LIFE20 ENV/IT/ 000436 – LIFE SECURDOMINO "Seveso sites: assessment of integrated safety-security hazards and risks and related domino effects" with the contribution of LIFE program of the European Union. Table D.2.1 summarizes the participation in international conferences and exhibitions, together with the indication of published articles; hereby the four manuscripts published in international journals with peer reviews are reported:

- Marroni et al., 2023, Chemical Engineering Transactions, 99, 349-354, DOI: 10.3303/CET2399059 (Gold Open Access)
- Casson Moreno, et al., 2022, Reliability Engineering and System Safety, 228, 108772, DOI: 10.1016/j.ress.2022.108762
- Marroni et al., 2024, Reliability Engineering and System Safety, 243, art. no. 109880, DOI: 10.1016/j.ress.2023.109880
- Marroni et al., 2024, Chemical Engineering Transactions, 111, pp. 487 - 492, DOI: 10.3303/CET24111082 (Gold Open Access)

Participation in events was a key action to spread the results of SECURDOMINO, as well as to allow networking and engagement with stakeholders and the audience. The dedicated template presented in this document will be used in the events.

Presentations were held in specific events, such as conferences and networks related to industrial safety/security to catalyze the interest of **public-private bodies** and to promote the LIFE SECURDOMINO tool. Table D.2.1 summarizes the participations in conferences and events, together with the reference to publications.

Name of meeting/ conference/ activity	Detailed descriptions	Relevance to the project.	Organizer	Location	Date of event	Link	Partner
Loss Prevention Conference	The Working Party on Loss Prevention and Safety Promotion in the Process Industries (WP Loss Prevention) started in 1971 as a group of very motivated people who decided at the symposium Major Loss Prevention in the Process Industries that an international effort would be necessary. The status of the group became established as a Working Party of the European Federation of Chemical Engineering (EFCE) in 1973. The conference of 2022 was the 17th organized by EFCE. Loss Prevention Symposia series has been successful in stimulating and sharing both theoretical and practical knowledge among the Loss Prevention community and considerable progress has been achieved in the field of safety in the chemical and process industries worldwide, promoting conservation and care of global resources, health, safety and the environment. Actually, even more industries are involved and have been profiting from advances in safety knowledge. Industries such as oil and gas, energy, pharmaceutical, food, manufacturing companies and the related service industries also use chemicals on a daily basis and are very much involved as well.	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders. In particular, the participation at the early stage of the project enabled sharing the methodological aspects related to safety security integration and starting the dissemination of the preliminary outcomes of the project. In fact, during the conference, the preliminary set up of the 3D model analyzing safety-security scenarios was shown illustrating the relevance of these scenarios on the risk profile of industrial facilities.	EFCE International Symposium on Loss Prevention and Safety Promotion in Process Industries	Prague, Chech Republic	5-8/06/2022	link	UNIPI
32nd European Safety and Reliability Conference ESREL conference	The ESREL conference is organized by ESRA, which aims at the promotion and application of safety and reliability techniques and risk management in all branches of technology. Five days of intense exchange on scientific research and industry practices on the various themes and areas underpinning this year title: "Understanding and Managing Risk and Reliability for a Sustainable Future" *Presented publication:* Marroni G., Landucci G., Tamburini F., Bartolucci A., Kuipers S., Broekema W., Casson Moreno V., Development of equipment fragility models to support the security management of process installations	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders. Besides, the participation to ESRA activities was aimed at achieving a twofold project objecting: laying the foundation for the special session dedicated to the project (ESREL 2024) and starting the contact for the last event in 2025, in which the software at the final step will be shown	ESRA European Safety and Reliability Data Association	Dublin, Ireland	31/08/2022	link	UNIPI
61st ESREDA conference	The aim of the seminar is to discuss the state of the art and on-going developments in the NaTech risk assessment techniques and methodologies and to discuss their strength, weakness, and uncertainties in the assessment of the safety and resilience of complex systems. More in general, the seminar offered a multi-hazard perspective	Participation in this conference constituted a relevant dissemination activity to academic stakeholders. In particular, the multi-hazard perspective of the conference, essentially dealing with the analysis of external events affecting industrial activities (such as NaTech) offered the possibility to share the LIFE SECURDOMINO methodology and to illustrate the analysis of	ESReDA European Safety and Reliability of Data Association	Turin, Italy	22-23/09/2022	https://www.esreda.org/event/61st-esreda-seminar-22-23-sep-2022-politecnico-di-	UNIPI

Name of meeting/ conference/ activity	Detailed descriptions	Relevance to the project.	Organizer	Location	Date of event	Link	Partner
		domino effects triggered by security events				torino-italy-2/	
ICHEAP16, 16th International Conference on CHEMICAL AND PROCESS ENGINEERING	This event is as an opportunity to exchange up-to-the minute information on industrial needs, new technology developments and research opportunities. The previous events attracted leading Industrialists, practitioners, and Academics from all over the world and provided a state of the art on Chemical and Process Engineering. The full set of final selected papers are published into Chemical Engineering Transactions Journal, indexed by SCOPUS and SCHOLAR Presented publication: Marroni et al., 2023, Chemical Engineering Transactions, 99, 349-354, DOI: 10.3303/CET2399059 (Gold Open Access)	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders, mostly industrial partners. It is the occasion to show the method, the possible results obtained and to meet industrial potential industrial partners to set the project replication.	AIDIC Italian Association of Chemical Engineering	Naples, Italy	21-24/05/2023	https://www.aidic.it/icheap16/	UNIPI
33rd European Safety and Reliability Conference ESREL conference	The ESREL conference is organized by ESRA, which aims at the promotion and application of safety and reliability techniques and risk management in all branches of technology. Five days of intense exchange on scientific research and industry practices on the various themes and areas underpinning this year title: "Understanding and Managing Risk and Reliability for a Sustainable Future"	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders. Besides, the participation to ESRA activities was aimed at achieving a twofold project objecting: laying the foundation for the special session dedicated to the project (ESREL 2024) and starting the contact for the last event in 2025, in which the software at the final step will be shown	ESRA European Safety and Reliability Data Association	Southampton, UK	3-7/09/2023	https://www.esrel2023.com/	UNIPI
European Researchers' Night event Bright Night -Marie Skłodowska-Curie GA 101061075	BRIGHT is the European Researchers' Night and part of a Europe-wide initiative supported by the European Commission. BRIGHT (Brilliant Researchers Impact on Growth Health and Trust in research) aims to bring science and society closer together. Held every year in September, the event features a wide range of activities designed to showcase scientific research in an accessible and engaging way. Researchers from various disciplines present their work through interactive experiments, workshops, guided tours, talks, and exhibitions. The goal is to highlight the value of research and innovation in everyday life while inspiring curiosity among people of all ages.	Participation in this conference was foreseen in the project, as dissemination activity to the general public	University of Florence, Pisa and Siena are the main organizers	Pisa, Italy	29/09/2023	https://www.bright-night.it/2023/intervista-al-pianeta-terra-2/	UNIPI
ESREL 2024 - European Conference on Safety and Reliability (ESREL)	The ESREL conference is organized by ESRA, which aims at the promotion and application of safety and reliability techniques and risk management in all branches of technology. Five days of intense exchange on scientific research and industry practices on the various themes and areas underpinning this year title: "Understanding and Managing Risk and Reliability for a Sustainable Future" Nr. 4 papers published as proceedings of the ESREL CONFERENCE 2024.	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders. The participation to this edition was crucial for the project, as a SECURDOMINO special session was organized as specific dissemination activity requested for the project. The	ESRA European Safety and Reliability Association	Kracow, Poland	23-27/06/2024	https://esrel2024.com/	UNIPI, DataCH, LEIDENU

Name of meeting/ conference/ activity	Detailed descriptions	Relevance to the project.	Organizer	Location	Date of event	Link	Partner
	1. Kuipers et al., Integration Of Safety And Security Aspects In EU Context: Comparative Analysis Of Legislative Frameworks; 2. Marroni et al., Real-Time Three-Dimensional Safety-Security Assessment Of Process Facilities In Critical Areas; 3. Marroni et al., Development Of Advanced Tools For Safety-Security Integration Based On The Implementation Of Site-Specific Protections, 4. Tamburini & Landucci, Maghreb As Critical Area For The Oil And Gas Facilities In Security Context: Algeria Case Study	theoretical aspects of the project were presented together with a preliminary demonstration of the software, laying the foundation for presenting the final version in the upcoming events (2025)					
CISAP 11 - INTERNATIONAL CONFERENCE ON SAFETY & ENVIRONMENT IN PROCESS & POWER INDUSTRY	CISAP 11 is the eleventh edition of the International Conference on Safety & Environment in Process & Power Industry, a key event for professionals, researchers, and stakeholders involved in risk management and sustainability. Organized in collaboration with leading academic and industrial partners, the conference provides a multidisciplinary platform to share the latest advances in safety engineering, environmental protection, and process optimization. Topics include accident prevention, quantitative risk assessment, safety culture, emerging technologies, and regulatory frameworks. CISAP promotes scientific exchange and networking, encouraging solutions to today's challenges in complex industrial systems.	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders, mostly industrial partners. It is the occasion to show the method, the possible results obtained and to meet industrial potential industrial partners to set the project replication.	AIDIC Italian Association of Chemical Engineering	Naples, Italy	15-18/09/ 2024	https://www.aidic.it/cisap11/	UNIPI, ARPAT
ESREL 2025 - European Safety and Reliability (ESREL) and Society for Risk Analysis Europe (SRA-E) conferences together	ESREL 2025 brings together experts, researchers, and practitioners in the fields of safety, reliability, and risk analysis. Organized in collaboration with the Society for Risk Analysis – Europe (SRA-E), the conference offers a unique platform for interdisciplinary exchange on topics such as probabilistic risk assessment, resilience engineering, human factors, and decision-making under uncertainty. ESREL is recognized internationally for fostering innovation and promoting best practices across a wide range of sectors, including energy, transportation, critical infrastructure, and process industries.	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders. The participation to this edition will enable presenting the theoretical aspects of the project and having a stand and exhibition with the final version of the tool	ESRA European Safety and Reliability Association	Stavanger, Norway	15-19/06/2025	https://esrel2025.com/	UNIPI, DATACH
Loss Prevention Conference 2025	Loss Prevention 2025 is a major international conference dedicated to process safety and risk management in the chemical and process industries. With a strong focus on accident prevention, the event addresses key themes such as hazard identification, consequence analysis, safety design, and emergency preparedness. Participants include engineers, safety professionals, researchers, and regulators from around the world. The conference provides an essential forum for sharing lessons learned, exploring innovative safety solutions, and discussing evolving regulatory frameworks. Through technical presentations, poster sessions, and panel discussions, Loss Prevention 2025 fosters the exchange of knowledge aimed at reducing risks and improving industrial safety.	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders. In particular, the participation at the end of the project helps sharing the methodological aspects related to safety security integration and starting the dissemination of the preliminary outcomes of the project.	EFCE International Symposium on Loss Prevention and Safety Promotion in Process Industries	Bologna, Italy	08-11/06/2025	https://www.aidic.it/lp2025/	UNIPI, DATACH

Name of meeting/ conference/ activity	Detailed descriptions	Relevance to the project.	Organizer	Location	Date of event	Link	Partner
ICHEAP17 17th International Conference on CHEMICAL AND PROCESS ENGINEERING	The conference covers a broad range of topics, including process intensification, sustainable energy systems, CO_2 capture, waste valorization, and advanced modeling techniques. ICHEAP serves as a bridge between academia and industry, encouraging the application of innovative solutions to real-world challenges in process design and operation. It attracts scientists, engineers, and policy-makers engaged in shaping the future of chemical and process industries, with an emphasis on efficiency, safety, and environmental sustainability.	Participation in this conference was foreseen in the project, as dissemination activity to relevant stakeholders, mostly industrial partners. It is the occasion to show the method, the possible results obtained and to meet industrial potential industrial partners to set the project replication.	AIDIC Italian Association of Chemical Engineering	Florence, Italy	29/06-02/07/2025	https://www.aidic.it/icheap17/	UNIPI
RETASTE: Rethink Food Resources, Losses, and Waste 5th International Conference	In cooperation with the Greek Life National Contact Point, the Greek Green Fund (https://prasinotameio.gr/) a Life dedicated event was organised, as part of Rethink Food Resources, Losses and Waste (RETASTE) 2025 Conference	The aim of the event includes an opportunity to present the project (Session A, Presentations), forward our experience regarding the preparation of the proposal, as well as, its realization (Session B, Round Table), and also participate in a networking event, a speed dating action (rotating 15' meetings), in which people from various entities involved in the RETASTE (Ministries, SME, Universities, Public Authorities etc), as well as, the Greek Green Fund and the monitoring authorities, participated (Session C, Speed Dating). The aim of this "match making" was to seek for full scale applications other than Seveso sites (Afterlife plan)	organized under the Auspices of the Hellenic Ministry of the Environment and Energy	Athens, Greece	24-27/09/2025	https://retaste.gr/	UNIPI

(Projects funded under the Call 2014 onwards must use this format)

6.1.12.2. Planned output in the reporting period

Deliverable [D2]: *website www.securdomino.eu*
Due date: 30/11/2021 Final version delivery date: 30/11/2021
Deliverable [D3]: *Communication and Dissemination Plan*
Due date: 31/12/2021 Draft version delivery date: 10/12/2021
Final version delivery date: 28/02/2022
Deliverable [D5]: *n.5 Notice boards installed in the key locations of the project*
Due date: 31/12/2022 Notice boards received and installed: 31/12/2022
Final version delivery date: 31/01/2023
Deliverable [D9]: *Mid-term report on Communication and Dissemination monitoring*
Due date: 31/10/2023 Draft version delivery date: 31/10/2023
Final version delivery date: rev 06/12/2023 during PMB meeting
Deliverable [D12]: *LIFE SECURDOMINO Layman's report*
Due date: 31/10/2024 Final version delivery date: 31/10/2024
Deliverable [D14]: *Whitepaper on safety-security integration diffused*
Due date: 31/10/2024 Final version delivery date: 31/10/2024
Deliverable [D18]: *Final report on Communication and Dissemination monitoring*
Due date: 29/12/2025 Draft version delivery date (monitoring): 30/04/2025
Final version delivery date: 09/01/2025
Milestone [M20]: *Final conference setting completed (Pisa, Sep 2025)*
Due date: 31/07/2025 Final version delivery date: 31/07/2025

6.1.12.3. Main difficulties, modifications, and actions taken

There are no particular difficulties or modifications. The communication plan was firstly designed with the external contractor, Mentarossa srl, then the communication plan document (deliverable) was drafted together with the project manager (staffed in December 2021). The final version of the plan was defined in February 2022, when the details of the events were clear. Instead of the 5 noticeboards initially foreseen, 8 noticeboards were installed in order to have a noticeboard at the premises of each partner (added noticeboards are ARPAT, DATACH, CRISISPLAN). The budget available for this item was sufficient.
Impact on the project and actions: added visibility for the project at partners' premises.

6.1.12.4. Perspectives for continuing the action after the end of the project

Website will be online 5 years after the project end and constantly updated as soon as novel DEMO sites will be analysed. Participation to the same conferences is foreseen disseminating the results of novel developments and features of the software, in case of updates (see AfterLIFE plan).

6.1.13. Action D.3 Networking with other projects

Foreseen start date: 01/10/2021 Actual start date: 01/10/2021
Foreseen end date: 30/09/2025 Actual end date: 30/09/2025

6.1.13.1. Activities undertaken and outcomes

A networking activity was carried out with other LIFE and non-LIFE projects addressing themes related to industrial safety and/or security. A network section of the project website was established to evidence the ongoing activities under action D3, https://securdomino.eu/networking/. These are the projects for which an interaction was established:

- LIFE3H - LIFE20 ENV/IT/000575: preliminary call (13/04/2022) to set potential cooperation in developing the safety assessment of hydrogen refuelling stations;
- LIFE AUGIA - LIFE 19 ENV/IY/000669: support for the design of safety barriers (venting panel for explosion protection) on the gasification reactor and heat exchanger;
- INTREPID project - Horizon 2020 grant agreement No. 883345. This project develops tools for real time disaster assessment and emergency management, thus with similar purpose of the LIFE SECURDOMINO tool. Experts from UNIPI are in the external advisory board and participated in the pilot test of the INTREPID tool (Madrid, 19-21 Sep. 2023)

In September 2025 the LIFE SECURDOMINO project participated in the RETASTE conference in Greece, where a special session was organized to share experiences between LIFE projects, in collaboration with the Greek LIFE focal point. T

Collaboration and support from LIFE C2M initiative
The project went through a collaboration and support process with the LIFE C2M initiative. As a result the LIFE SECURDOMINO was showcased in the October 2025 LIFE Newsletter, with a dedicated page on the LIFE website https://cinea.ec.europa.eu/news-events/news/accelerating-life-securdominos-market-readiness-close-market-support-2025-10-15_en and a LinkedIn post with a video interview of Prof. Gabriele Landucci (UNIPI) and Dino Dentone (DATACH), which was registered in July 2025, and published by CINEA in October 2025.

6.1.13.2. Planned output in the reporting period

Deliverable [D10]: *Focus group – LIFE networking event in Pisa April 2024*
Due date: 30/11/2021 Actual delivery date: 11/04/2024

6.1.13.3. Main difficulties, modifications, and actions taken

The current international situation generated delays in developing activities in cooperation with some LIFE projects.
Impact on the project and actions: no significant impact, as LIFE AUGIA and INTREPID offer better and concrete possibility to cooperate and the activities are still ongoing.
Overspending: no overspending

6.1.13.4. Perspectives for continuing the action after the end of the project

The networking with other projects will be continued after the project end, offering the key competencies available in the LIFE SECURDOMINO Consortium, thus safety and/or security and/or ISS analyses, support in the design of safety-security barriers, development of vulnerability and risk assessment studies. Moreover, the experience obtained in developing advanced real-time 3D software for industrial installation may be exploited for providing support to other project in need of a user-friendly interface for training and simulation of industrial processes.

6.1.14. Action E.1 Technical and financial project management

Foreseen start date: 01/10/2021 Actual start date: 01/10/2021
Foreseen end date: 30/09/2025 Actual end date: 30/09/2025

6.1.14.1. Activities undertaken and outcomes

SECURDOMINO management is designed to ensure an efficient decision-making and an effective communication among partners, while maximizing collaboration and flexibility. The PMB – Project Management Board was first established, in order to coordinate the technical implementation and the financial reporting. Each technical action is managed by a single leading institution, while UNIPI coordinates and reviews the outcomes and related milestones and deliverables. The PMB – Project Management Board includes the Technical Coordinator (UNIPI) and a representative of each associated beneficiary. A Project Manager was hired by UNIPI (0.5 FTE) and integrated into the PMB with no voting rights. To ensure consistency of administrative and financial management practices among partners, guidelines and best practices for LIFE project management were prepared [D1] and preliminarily illustrated during the Kick-off meeting, which was held in Pisa (10/12/2021). Next, the PMB meetings were carried out (1 per year), while individual financial reporting sessions (online) were carried out on 6-months basis. PMB members keep constantly in contact on a day-by-day base to develop the technical actions.
During the reporting period, one monitoring visit was hosted by UNIPI (24/05/22). The second monitoring visit (07/06/23) and a final monitoring visit was hosted by UNIPI on the 26-27/05/2025.

6.1.14.2. Planned output in the reporting period

Milestone: *Kick off meeting and presentation of the management staff*
Due date: 31/10/2021 Kick-off meeting on 10/12/2021

Milestone: *Agenda and confirmed participants for the first PMB meeting (web meeting)*
Due date: 15/02/2022 Final version delivery date: 22/02/2022

Milestone: *Agenda and confirmed participants for the second PMB meeting*
Due date: 15/11/2022 Final version delivery date: 11/11/2022

Milestone: *Agenda and confirmed participants for the third PMB meeting M24 (web meeting)*
Due date: 15/09/2023 Final version delivery date: 12/10/2023

Milestone: *Agenda and confirmed participants for the Fourth PMB meeting M31*
Due date: 15/12/2024 Final version delivery date: 10/01/2025

Milestone: *Agenda and confirmed participants for the Final PMB meeting M48*
Due date: 31/07/2025 Final version delivery date: 16/09/2025

Deliverable [D1]: *Guidelines and best practices for LIFE project management and monitoring*
Due date: 30/11/2021 Final version delivery date: 12/01/2022

Deliverable [D8]: *Project's Mid-term Report*
Due date: 31/07/2023 Final version delivery date: 31/07/2023 Addendum: 03/08/2023

Deliverable [D23]: Project's Final Report
Due date: 29/12/2025 Final version delivery date: 16/12/2025

6.1.14.3. Main difficulties, modifications, and actions taken

The signed Grant Agreement was received on 14/10/23; this delay did not affect the regular start of the Actions, but the recruitment activities (for the Project Manager) and also orders for services (i.e., recruitment of communication contractor) and materials were delayed.
Impact on the project and actions: The Kick-off meeting and the deliverable [D1] were delayed but this did not affect the regular development of preliminary project actions.
Overspending: no overspending.

6.1.14.4. Perspectives for continuing the action after the end of the project

As the final report is due to 30/12/2025, the action continued after the end of the project (30/09/25) in order to summarize the main outcomes and prepare for the final reporting.

6.1.15. Action E.2 After LIFE Plan

Foreseen start date: 01/10/2021 Actual start date: 01/10/2021
Foreseen end date: 30/09/2025 Actual end date: 30/09/2025

6.1.15.1. Activities undertaken and outcomes

The After-LIFE Plan defines the long-term strategy to maintain, disseminate, and scale up the results of the LIFE SECURDOMINO project after its conclusion. It includes both a technical roadmap for the replication of the integrated safety-security (ISS) risk assessment tool and a comprehensive communication and visibility strategy. The plan builds on the deliverables from Actions B6 and B7 and outlines concrete activities for the next five years, including the extension of the tool to at least 250 new Seveso or high-risk sites across the EU and the transfer of the methodology to other sectors (e.g. food processing, port logistics). Key institutional partnerships—such as with ARPAT, OMWB, INAIL, and INERIS—are maintained to support both regulatory alignment and practical uptake. Communication actions focus on scientific dissemination (e.g. ESREL yearly conferences), stakeholder engagement, online visibility, and collaborations through Horizon Europe and national programmes. All project resources (software, repository, website) will remain accessible, and the consortium is committed to supporting training, promotion, and targeted B2B initiatives to ensure the integration of the SECURDOMINO methodology into European risk governance frameworks.

6.1.15.2. Planned output in the reporting period

Milestone: *First B2B meeting set*
Due date: 01/06/2024 Final version delivery date: 09/05/2024

Milestone: *Second B2B meeting set*
Due date: 01/04/2025 Final version delivery date: 26/02/2025

Deliverable [**D22**]: *After Life Plan*
Due date: 30/12/2025 Final version delivery date: 16/01/2026

6.1.15.3. Main difficulties, modifications, and actions taken

None.

6.1.15.4. Perspectives for continuing the action after the end of the project

The After-LIFE plan is issued at the project's end in order to set the activities to extend the analysis to total 250 Seveso sites in EU and, in perspective, developing a tool for the manufacturing industry (food processing).

6.2. Main deviations, problems and corrective actions implemented

6.2.1. Issue T1: the change of DEMO sites.

The aim of the project was to apply the developed software for monitoring and assessing vulnerability and risk in 3 DEMO sites, i.e., industrial plants falling under the obligations of the Seveso Directive. However, 2 out of 3 initially considered DEMOs decided to quit the project during the first six months. As the aim of the project was to develop and apply a software tool capable to carry out the real time 3D ISS assessment of Seveso facilities, any kind of Seveso plant is suitable for the sake of demonstration of the SECURDOMINO tool. Therefore, the solution was to replace DEMO2 and 3 with other plants having relevant features for the sake of demonstration and comparable environmental impact in case of accident. This modification did not have a significant impact on the project, as the DEMO sites have similar features and are subjected to major accident risk. The issue of DEMO sites modification caused only a delay in the preparation of deliverable [D04], but no relevant impact on the other actions. In fact, Action B5, involving the analysis of DEMO sites, regularly started in Oct-22, once all the three DEMOs were defined and information properly gathered in advance, and completed in due time.

6.2.2. Issue T2: the drone flight restrictions.

DEMO1 (in IT) and DEMO3 (in NL) are located in a zone with some drone flight restrictions. Deliverable [D15] describes the actions taken to overcome both limitations.
For DEMO1, i) the drone did not fly over plant areas, while it was kept at a safe distance and flew around the perimeter of the plant, in order to obtain a baseline photogrammetry; ii) the technicians paid close attention to the potential presence of seagulls nearby the drone; iii) the drone was flown at an height under 40 m, in accordance with the circular ENAC ATM09.This enabled for the obtainment of a baseline 3D representation of DEMO1 having a medium quality, which will be then enhanced using other techniques as documented in [D15].
DEMO3, located in the Rotterdam harbour area, falls within a complex regulatory context due to the simultaneous presence of a Seveso BRZO+ classified site and a controlled airspace near Rotterdam airport. In accordance with Dutch aviation and security regulations, it was not possible to perform the drone flight using internal project resources. Therefore, to avoid delays and ensure full compliance, an external certified aerial contractor (DDC – Smart Inspections) was recruited. DDC holds the specific operational authorisations required under national law. The contractor successfully performed the photogrammetric survey of the site, and the 3D model was processed using the same pipeline as for DEMO1. Further details on constraints and technical adaptations are provided in [D15].
Despite the two flight restrictions for two out of three DEMO sites, Action B5 was completed in due time demonstrating the flexibility of the LIFE SECURDOMINO approach.

6.2.3. Issue T3: Real time connection of process parameters.

In DEMO2, while drone inspection and 3D modelling were carried out without access restrictions, a delay occurred in the transmission of real-time plant data. The issue was caused by the absence of prior modifications to the DCS (Distributed Control System), which prevented the data stream from reaching the SECURDOMINO platform. Although the software had been configured in advance to receive and process live data, the effective connection was only finalised in March 2025, well after the planned integration date

(30/11/2024). During this interim period, the tool remained fully operational in default or simulated mode and was subsequently updated once the real data feed became available. This sequence is fully documented in [D15].

6.2.4. Issue T4: Change in special session from AIDIC (IT) to ESREL/ESRA (EU)

Originally, a special session on the SECURDOMINO project was planned within the framework of an AIDIC (Italian Association of Chemical Engineering) conference. However, the session was eventually organised as part of the ESREL 2024 conference, under the umbrella of the European Safety and Reliability Association (ESRA). This change resulted in a significant added value, as it allowed the project outcomes to be showcased in a broader European context, reaching a wider audience of experts and institutional stakeholders in the fields of risk analysis, safety-security integration, and regulatory innovation. ESRA is actively involved in promoting cross-cutting research and transnational dialogue, while AIDIC is primarily focused on Italian process industry and chemical engineering. Therefore, the shift was fully aligned with the replication and policy engagement goals of the project.

6.3. Evaluation of Project Implementation

The methodology adopted in the project enabled for the development of LIFE SECURDOMINO software tool and, at the same time, provided lessons learned for the future development and implementation in other sites. The integrated use of drone flight imaging and pictures taken during inspections enables for the refined 3D assessment of industrial site and overcomes limitations due to flight restrictions. Finally, the models and barriers data were consolidated with an international publication, obtaining a high visibility of the current methodology with international impact. The actions were carried out with cost-efficiency as no overspending and in line with the project expectation. With respect to the initially foreseen costs, it was decided to shift to the second half of 2023 the acquisition of a server machine for running the models. More in details, the following table compares the results achieved against the objectives and expected results foreseen in the proposal for the ***technical and dissemination actions:***

Action	Foreseen in the revised proposal	Achieved	Evaluation
A1	*Objectives:* preliminary activities for the implementation of actions. *Expected results*: input data set and plant data from the 3 DEMOs and identify stakeholders and their role	Input data set completed for 3 DEMO sites; 2 DEMOs were modified but the same information was gathered; Stakeholders identified [D4]	All the necessary information is gathered. The modification of DEMOs did not change the demonstration feature of the LIFE SECURDOMINO tool
B1	*Objectives:* development of the software tool *Expected results*: mapping the risks for people and environment due to safety/security scenarios and domino effects.	The final version of the tool was developed [D11], with 3D reconstruction of plant based on drone integrating models for fires, probabilities analysis, ISS barriers and real time site data	Code effectively developed; difficulties related to the conversion of Matlab files into C++ enabled developing a procedure which was adopted to complete the implementation

Action	Foreseen in the revised proposal	Achieved	Evaluation
B2	*Objectives:* development of models to run the software calculations *Expected results*: develop an open web repository with the models and barriers implemented in the software	A complete repository of models for fires, explosions, toxic dispersion following the release of hazardous chemicals in case of unintentional events (safety) or intentional attacks (security) [D17]. Domino effects are so assessed, also considering the contribution of safety-security barriers. A specific publication [AD1] explains more details on the methodology.	The models developed are effectively implemented in the software, also accounting for the integrated safety-security barriers. The repository can be updated in the 5 years after project's end as soon as better models and data will be available.
B3	*Objectives:* tailoring the methodology for Italy and the Netherlands *Expected results*: regulatory framework adaptation guideline	Complete set of regulations and local implementations gathered [D7]	Obtaining input for risk and vulnerability; limitations of the current EU policy with respect to safety-security addressed
B4	*Objectives:* summarize software input, output, procedure, and local adaptation to Italy and the Netherlands. Innovative procedure for digitalization in Seveso inspections *Expected results*: Handbook and guidelines	Handbook and guidelines [D16] were delivered, describing the tool functionalities, integration in inspections, and use for land use planning in Italy, mainly deterministic approach, and the Netherlands, mainly probabilistic approach, with recent introduction of *aandachtsgebieden* (attention areas) under the Omgevingswet (2024).	Effective confirmation of calculation procedures and threshold values for risk; the handbook was issued after the completion of software development, flexibility of the approach coping with legislative framework modification during the project
B5	*Objectives:* software implementation in 3 DEMO sites *Expected results*: monitoring system of real time vulnerability and risk at 3 DEMO sites	The three demonstration sites were analysed, each with different levels of accessibility. DEMO1 had drone restrictions; DEMO2 was delayed due to DCS data; DEMO3 required a certified external contractor. Nonetheless, 3D models were created and used for ISS assessment [D15].	All DEMO applications were successfully completed. Despite logistical and regulatory difficulties, the methodology proved adaptable and robust across diverse contexts.
B6	*Objectives:* commercialize the software developed *Expected results*: business plan	A full Business Plan [D13] was developed, with three market scenarios (pessimistic, probable, optimistic). SaaS and consulting services were defined, with expected breakeven by year 4 in the most probable case.	The Business Plan is realistic and aligned with the tool's functionalities and potential user base. Its structure allows adaptation to future funding and market conditions.
B7	*Objectives:* project replication to 250 sites in Italy and the Netherlands *Expected results*: Replication and adaptation plan	A dedicated strategy was defined [D19], based on stakeholder engagement, demo outcomes, and regulatory alignment. The tool is ready for application in	The replication plan is technically and operationally sound. However, the large-scale uptake of the SECURDOMINO tool

Action	Foreseen in the revised proposal	Achieved	Evaluation
		250+ sites, and the step-by-step protocol supports further replication.	depends on future regulatory developments. Without a formal requirement to integrate security into Seveso inspections, adoption is likely to remain limited to frontrunner authorities or voluntary users. A broader replication will require explicit recognition of integrated safety-security assessments in the Seveso framework.
D1	*Objectives*: support stakeholders' awareness raising towards integrated safety-security aspects. *Expected results*: measure awareness by survey; organise 3 events to promote the tool.	Survey launched and analysed [D6]; 85 expert responses received; vulnerability reduction (-40%) confirmed; 3 major events completed (Life is 30 event, industry workshop in Pisa, symposium at Leiden University).	Survey results confirmed the expected vulnerability reduction of 40% thanks to the implementation of the software [**D6**]; The event obtained the expected visibility in-presence (10) and remotely (total 45)
D2	*Objectives*: communicate and disseminate project results. *Expected results*: reach targeted stakeholders as documented in [D4]. Final event in Pisa	Communication Plan delivered [D3]; website active (141,057 visits); social media launched; 8 noticeboards installed [D5]; 4 peer-reviewed publications, one determining the foundation of actions B1,B2, B5 [AD1]; presence in 15+ conferences and final event in Pisa (2025). Whitepaper published [D14]. A Layman's Report was produced in English, Italian, and Dutch to summarise the project outcomes for a non-technical audience.	The communication activity exceeded expectations in terms of visibility and engagement. Website target overachieved by 370%, LinkedIn proved most effective channel; SECURDOMINO gained international recognition in risk/safety networks.
D3	*Objectives:* synergy with other LIFE and non-LIFE projects *Expected results*: focus group on LIFE projects	Cooperation established with LIFE AUGIA and H2020 INTREPID; participation in RETASTE 2025 (LIFE networking session); preliminary contacts with LIFE3H.	Strong networking with ongoing EU projects enabled exchange of methodologies and extended impact. LIFE3H cooperation remains on standby due to external constraints, but other synergies fully met expectations.

6.3.1. **Policy impact of LIFE SECURDOMINO project**

The LIFE SECURDOMINO project clearly reveals a structural gap in the current European risk governance framework: Directive 2012/18/EU (Seveso-III) does not formally require the integration of security-related threats—such as sabotage, terrorism or cyber-attacks—

into the risk assessment of Seveso establishments. This lack of regulatory clarity persists despite the increasing recognition of such threats as part of the broader risk landscape faced by critical infrastructures.

The project contributes to facilitating the implementation of Seveso-III by providing a practical and modular digital tool to assess integrated safety-security (ISS) risks, including cascading (domino) effects. However, as confirmed by the regulatory analysis in [D7] and the White Paper on Safety-Security Integration [D14], no formalised link exists between Seveso and the EU Directive 2022/2557 on the resilience of critical entities, which is the current reference for protecting infrastructure from intentional threats.

The industrial survey (Action D1 – [D6]) confirmed that Seveso operators across Europe recognise security risks as relevant, but they also report that current obligations are not sufficient. Many implement site-specific measures voluntarily, pointing to a fragmented situation. Barriers to integration include cultural factors, the lack of performance-based criteria for security systems, and the absence of formal enforcement mechanisms.

Furthermore, the comparison between Italy and the Netherlands reveals two contrasting approaches: the Italian system is traditionally deterministic, while the Dutch system has been probabilistic. However, the recent entry into force of the *Omgevingswet* (2024) in the Netherlands introduces a shift towards deterministic risk zoning—attention areas—aligned with SECURDOMINO's logic and similar to the Italian DM 9/5/2001. This convergence creates an opportunity for cross-border harmonisation of ISS practices.

The project deliverables (particularly the Handbook [D16] and the White Paper [D14]) propose concrete methodological steps for embedding security into existing Seveso inspections and safety reports. These include the definition of intentional triggering events, conditional probability trees, and performance indicators for security barriers.

In light of these findings, the project supports the consideration of a future revision of the Seveso Directive, aiming to:

- formally integrate security scenarios into mandatory risk assessments;
- link Seveso enforcement to the requirements of Directive 2022/2557;
- and develop a unified EU approach to risk scenarios triggered by both natural and intentional events.

Such evolution would ensure a consistent application of the all-hazard approach, already adopted in national resilience frameworks (e.g. Dutch Safety Regions Act), and strengthen the overall protection of people, assets, and the environment.

6.3.2. **Climate and biodiversity impact**

The actions carried out within the LIFE SECURDOMINO project produced measurable environmental benefits in terms of climate change mitigation and biodiversity protection. By reducing the vulnerability of Seveso-type sites to intentional external events (sabotage, terrorism, etc.), the project significantly lowered the probability of hazardous substance releases and associated atmospheric emissions.
Thanks to the full implementation of the tool and methodology across the three demonstration sites—DEMO1 (Livorno), DEMO2 (Calenzano), and DEMO3 (Rotterdam)—a 40% reduction in site vulnerability was achieved and validated through expert elicitation in Action D1 [D6], and confirmed in the impact monitoring conducted under Action C1, including the LCA assessment [D21], and LIFE KPIs [D20]. This decrease directly correlates with the potential reduction in emissions of greenhouse gases

(GHG) such as CO_2, NO_x, CO, and PM_{10}, typically resulting from industrial fires, explosions, or toxic releases triggered by external attacks.
The estimated 40% reduction in potential GHG emissions is considered a direct climate benefit of the project. Additionally, the reduction of NO_x emissions contributes to biodiversity preservation, as NO_x is a critical factor in air quality deterioration and ecological stress in industrial zones (see ANPA, Manuali e Linee Guida 2/2001, ISBN 88-448-0256-2). The correlation between vulnerability and environmental impact was integrated into the project's KPI structure and monitored throughout Action C2.
These results confirm that the digitalisation and integration of ISS risk assessments in Seveso establishments, as promoted by SECURDOMINO, not only increase human and infrastructure safety, but also provide tangible environmental benefits. The project therefore contributes to the objectives of the European Green Deal and the EU Biodiversity Strategy by reducing emissions at the source and enhancing prevention.

6.4. Analysis of benefits

6.4.1. **Environmental benefits**

The LIFE SECURDOMINO project contributed to environmental protection by reducing the likelihood and potential consequences of major industrial accidents, in particular those triggered by intentional external events. By decreasing the vulnerability of the demonstration sites to cascading accident scenarios, the project generated quantifiable reductions in pollutant releases, with direct positive effects on air quality, climate, and biodiversity.

a. Direct and quantitative environmental benefits:

- A 40% reduction in potential emissions of greenhouse gases (GHG) and particulate matter (PM10) was achieved at all three DEMO sites, as a result of the implementation of the integrated safety-security (ISS) tool. This figure was confirmed through expert elicitation and validated in the impact assessment (Action C1, [D21]) and LIFE KPI monitoring (Action C2, [D20]).
- A 40% reduction in the potential release of hazardous substances was also estimated in all DEMO sites, including toxic compounds and flammable materials typically present in Seveso establishments.
- The risk to surrounding populations and ecosystems was reduced accordingly, with a corresponding 40% reduction in vulnerability to accident scenarios.
- A 40% reduction in firefighting water demand was estimated, due to the improved early detection and response capacity enabled by the tool. This contributes to more sustainable resource use in emergency management.

b. Qualitative environmental benefits:

- The SECURDOMINO tool enables continuous monitoring of Seveso sites, fostering preventive maintenance, better barrier management, and real-time scenario analysis.
- The project raised awareness among competent authorities and plant operators regarding the environmental risks posed by intentional attacks, enhancing their preparedness and response capacity.

6.4.2. **Economic benefits**

The implementation of the SECURDOMINO tool in all three demonstration sites produced significant economic benefits, primarily by reducing site vulnerability to intentional external events and cascading accident scenarios. As vulnerability is a key driver of both direct and indirect economic losses in industrial settings, a reduction of 40%—validated through expert elicitation in Action D1 [D6] and confirmed in the project's impact assessment—corresponds to a proportional decrease in potential

damage costs. The expected economic savings resulting from this vulnerability reduction include:

Lower probability of asset damage (e.g. tanks, piping, control units);

- Reduced losses due to operational downtime or emergency shutdowns;
- Decreased costs for incident response and containment (e.g. firefighting water, clean-up operations, environmental remediation);
- Mitigated liability and reputational risks.

While site-specific monetary values were not disclosed, the Business Plan (Action B6 – [D13]) provides scenario-based estimates linking the use of SECURDOMINO to avoided losses in the range of several hundred thousand euros per site, depending on plant size and stored substances. The financial projections also indicate that the system could reach break-even within 3 to 5 years, depending on the level of regulatory uptake.

In addition to avoided losses, the SECURDOMINO system contributes to:

- Optimised risk assessment and inspection workflows, reducing the workload for competent authorities and consultants;
- Improved resource allocation, as risk hotspots can be identified and addressed more efficiently;
- Training value, by supporting internal staff development and operator awareness on integrated safety-security (ISS) risks.

6.4.3. **Social benefits**

The main social benefit produced by the LIFE SECURDOMINO project is the reduction of risk to human life and health in the areas surrounding the demonstration sites. The 40% decrease in vulnerability achieved at all three DEMO sites—validated through expert elicitation in Action D1 [D6] and confirmed under Action C1 [D21]—translates directly into a reduced probability of accident escalation and its consequences on nearby communities and an eventual risk reduction of more than 20% [D15]. In particular, in each DEMO site, the 3D modelling of the plant, integration of real-time data, and implementation of the software enabled the early identification of critical scenarios, allowing better preparedness and mitigation.

Beyond accident prevention, the project contributed to the promotion of a culture of risk awareness and integrated safety-security among operators, public authorities, and external stakeholders. Through training, public events, and networking with other EU projects (Action D3), the project engaged a wide audience, improving the collective understanding of intentional threats and domino effects in industrial environments.

In summary, the project enhances social resilience by strengthening the capacity of sites and institutions to anticipate, withstand, and respond to complex risk scenarios, with long-term benefits for the safety of workers, local communities, and emergency responders.

6.4.4. **Replicability, transferability, cooperation**

The SECURDOMINO tool has been designed from the outset as a modular and replicable solution for integrated safety-security (ISS) risk assessment in industrial contexts. Its architecture allows adaptation to different site layouts, regulatory environments, and user needs, making it suitable for replication beyond the original demonstration sites.

The replication strategy, fully developed under Action B7 [D19], confirms the feasibility of applying the tool to at least 247 additional Seveso and non-Seveso sites across the EU over the next five years (total 250 sites). This includes industrial facilities

in sectors such as chemicals, energy, water treatment, logistics, and food processing, which share vulnerability to external intentional events.
Replication is based on a standardised 4-step methodology: (i) 3D reconstruction of the site (e.g. via drone); (ii) assignment of digital hazard sources to plant components; (iii) integration with real-time data (optional); and (iv) implementation of the SECURDOMINO software for dynamic risk analysis and domino simulation.
To facilitate future replication, the project produced:
A comprehensive Handbook and Guidelines [D16], a Business Plan [D13] defining the service structure and commercialisation options; a Replication and Adaptation Plan [D19], including a cooperation protocol and roadmap.
While the current market for ISS tools remains limited, due to the lack of mandatory security assessments under the Seveso Directive, the project engaged with the LIFE Close-to-Market (C2M) initiative to prepare the transition to market. As noted in the C2M checklist, the innovation lies in addressing a gap not yet covered by standard tools used by consultants, public authorities, or Seveso operators.
Replication potential is therefore strongly linked to future policy evolution and the uptake of ISS principles in inspection protocols. Nevertheless, the groundwork has been laid: trained partners, ready-to-use documentation, and working tools are available for application in new sites.

6.4.5. **Best Practice lessons**

The implementation of the LIFE SECURDOMINO project allowed the consortium to identify and consolidate a set of technical and institutional best practices that can support future replication of the methodology in Seveso and non-Seveso sites.
From a technical standpoint, two key lessons emerged:
1) The use of MATLAB for algorithm development, combined with MATLAB Coder to convert routines into C/C++ code, proved to be the most time-efficient and scalable approach for implementing quantitative models in the SECURDOMINO software. This process enables rapid updates and facilitates the future integration of additional models (e.g. for new substances or scenarios).
2) The development of a practical workflow for 3D reconstruction of industrial facilities using drone technology was essential for building site-specific models. The two-stage approach—preliminary photogrammetry followed by local refinement (either through closer drone flights or camera inspections)—demonstrated its adaptability even under severe flight restrictions (e.g. ATEX zones, airport proximity, Seveso constraints). This procedure is now transferable to a broad range of industrial environments.
The institutional best practice particularly referred to digital inspections of Seveso plants. Thanks to the involvement of ARPAT, SECURDOMINO was integrated into actual site inspections as a digital support tool. This experience positions Tuscany as a leading example of how digital ISS assessment tools can be effectively introduced into existing regulatory practice. The integration of real-time risk visualisation, drone-acquired data, and model-based assessment represents a paradigm shift towards digital inspections, aligned with broader EU goals of digital transition and resilience.

6.4.6. **Innovation and demonstration value**

SECURDOMINO introduced and validated an innovative and demonstrative approach to risk assessment in high-hazard industrial facilities, by developing a systematic methodology for ISS evaluation and demonstrating it in real operational environments. The core innovation lies in combining quantitative modelling, real-time site data, 3D

representation, and performance assessment of safety-security barriers, in a single modular platform.
At the time of proposal, no such tool or methodology was available on the market, and security risks—especially those related to intentional events such as sabotage or terrorism—were not explicitly addressed in standard safety analyses under the Seveso framework. This was confirmed by the regulatory analysis [D7] and by the industrial survey [D6], both showing that security is either treated separately or not formally considered in most European Seveso sites.
The innovative character of the approach is reinforced by the fact that the barrier modelling framework and performance assessment methodology developed in SECURDOMINO has been recognised by the scientific community. The methodology was peer-reviewed and published [AD1], with specific reference to the modelling of cascading effects and the integration of security degradation scenarios. This validates the scientific and technical relevance of the project results.
From a demonstration standpoint, the tool was successfully applied in three operational sites, covering different regulatory contexts (Italy and the Netherlands) and plant typologies (storage terminal, manufacturing facility, logistics site). The demonstration confirmed the applicability of the method even in the presence of flight restrictions (e.g. ATEX, proximity to airports), partial access to process data, and site-specific layout and barrier configurations.
The interface developed in SECURDOMINO builds on an earlier prototype used in harbour contexts, but introduces key innovations in logic, usability, and integration with drone-based inspection and 3D simulation. The demonstration provided practical evidence of the feasibility, robustness, and added value of the approach, especially for authorities and operators seeking digital tools for risk-informed inspections and land use planning.

6.4.7. **Policy implications**

The LIFE SECURDOMINO project addresses a critical policy gap in the current European risk governance framework, by demonstrating that intentional external threats—such as sabotage, terrorism or cyber-attacks—are not systematically integrated into the existing Seveso-III (2012/18/EU) Directive, despite the increasing vulnerability of industrial facilities and the evolution of the EU security landscape.
The project contributes to policy by:

- Providing a concrete operational methodology for integrating safety and security (ISS) risk assessments;
- Demonstrating the technical feasibility and added value of ISS analysis through three real industrial applications;
- Raising institutional awareness on the absence of binding requirements for security scenario analysis in the current Seveso framework.

The regulatory analysis (Action B3 – [D7]) confirms that no formal link exists between the Seveso Directive and Directive 2022/2557 on the resilience of critical entities. As a result, intentional external events are often addressed in an ad hoc, non-harmonised manner—if at all.
This gap is also reflected in the project's industrial survey (Action D1 – [D6]), where:

- 74% of respondents considered security a relevant concern;
- 60% reported insufficient regulatory guidance or internal capacity;
- 45% adopted site-specific, voluntary mitigation measures.

To support future policy evolution, the project has delivered a White Paper [D14] on Safety-Security Integration, which includes definitions of ISS scenarios, security

barriers, and domino chains, modelling approaches for scenario quantification, proposals for integration in inspection routines and land-use planning.
The following recommendations are formulated based on project results and stakeholder engagement:
a) *At EU level*: Promote a revision of the Seveso Directive to explicitly include intentional external events, in coordination with Directive 2022/2557.
Encourage the adoption of digital tools for integrated S/S risk analysis and real-time visualisation, supporting the digital transition in risk governance.
Develop guidance documents and technical annexes for Member States and competent authorities to operationalise ISS concepts.
b) *At national/regional level*: Encourage Member States to introduce ISS risk screening criteria in inspections and Safety Reports. Fund the testing of digital ISS methodologies (such as SECURDOMINO) through pilot actions or national guidance.
Recognise regional experiences—such as the digitalised inspections supported by ARPAT in Tuscany—as good practice.
c) *For industry and Seveso operators*: Promote voluntary integration of ISS analysis in Safety Management Systems (SMS). Provide training materials, such as the SECURDOMINO Handbook and open repository, to support implementation. Encourage cross-sector collaboration to strengthen preparedness and barrier performance.

7. Key Project-level Indicators

Social and technical indicators were uploaded on the website https://webgate.ec.europa.eu/eproposalWeb/kpi/module. The export of the KPI module is reported in the additional documentation [**AD3**]. For the sake of clarity they are grouped into 1) "technical" indicators, i.e., related to the potential impact associated with the decrement of vulnerability to ISS domino effects; and 2) "social" indicators, i.e., related to the performance of communication actions, involvement of population, and economic aspects. The KPIs are discussed in the following.

7.1.1. Technical indicators

The technical performance of the LIFE SECURDOMINO project was assessed through a set of LIFE Key Performance Indicators (KPIs), selected and monitored via the LIFE KPI webtool (https://webgate.ec.europa.eu/life/kpi/module) as part of Action C2. These indicators cover aspects such as territorial coverage, population affected, hazardous substances, emissions, and resource use, with reference values established during the project and final values recorded in September 2025.
Compared to the original proposal and mid-term data, the final results confirm a positive impact across all indicators, thanks to the full implementation of the SECURDOMINO system in all three demonstration sites. Unlike the previous reporting period—when implementation was limited to DEMO2—the final assessment reflects the completed application of the tool in all DEMOs, with vulnerability reduced by 40% in each case, as validated through expert elicitation and documented in Action C1 [D21].
The KPI values were updated accordingly:
Indicator 1.5 (project area) now reflects the total surface covered across the three sites;
Environmental indicators (5.1.1, 6.1, 8.1) were adjusted based on updated inventories of hazardous substances at the DEMO sites and the expected 40% reduction in release probability due to vulnerability mitigation;

Indicator 2.3.5.3 (water consumption) decreased as a result of reduced firefighting demand, linked to earlier detection and prevention capacity;
All updated values are based on conservative assumptions, validated via the expert-based methodology and impact modelling described in Action C1.

7.1.2. Social indicators

The final values (September 2025) are shown in Table 7.1.2, where each indicator is presented with its original baseline snapshot (July 2022). These are the main outcomes achieved:

- *Website and online visibility*: The project website reached 141,057 visits by September 2025, well beyond the mid-term number of 12,369. This strong growth reflects sustained interest over time and suggests effective dissemination and outreach efforts.
- *Publications & media presence*: By the end of the project, 7 technical/scientific publications were released, and 7 articles in printed media were published — confirming that the project succeeded in amplifying its visibility beyond the consortium and reaching a broader audience.
- *Events and networking*: The number of events and dissemination actions rose to 9, including conferences, workshops, and networking meetings. Networking with other EU and LIFE projects expanded to 5 active collaborations, demonstrating the capacity of the consortium to build partnerships and cluster with other initiatives.
- *Stakeholder engagement*: The survey [D6] reached 450 respondents, meeting the project's target and confirming broad stakeholder involvement. This supports the representativeness of awareness raising effort.
- *Employment and capacity building*: The project generated 1.65 Full-Time Equivalent (FTE) positions across the consortium, reflecting concrete socio-economic benefits and the creation of specialized professional capacity in integrated safety-security risk assessment and software development.
- *Training / education impact*: Over 100 individuals were trained during specific SECURDOMINO workshops [D18], strengthening the project's legacy in capacity building and knowledge transfer to practitioners, authorities, and industry stakeholders.

Table 7.2.1. Summary of the social indicators

KPI	Baseline	End of project effective	End of project planned
10.1.2. Supervisory/enforcement bodies involved	0	21+1=22	21+1=22
non-governmental organisations (NGOs) and other stakeholders in project activities	0	6	5
Public bodies	0	55	29
11.1. Website	0	141.057	30.000
11.2. Other tools for reaching/raising awareness of the general public. Nr. publications made	0	13	10
Number of discrete Project Reports drafted	0	3	3
Number of events/exhibitions organized	0	11	9
Number of patents submitted	0	0	0
Number of articles in print media (e.g. newspaper and magazine articles)	0	21 (online)	20
Other distinct media products created (e.g. different videos/broadcast/leaflets)	0	7	4
Number of different displayed information created (posters, information boards)	0	9	7

11.3. Surveys carried out regarding awareness of the environmental/climate problem addressed (only mandatory for information and awareness projects)	0	450	100
12.1. Networking	0	139	115
Jobs	0	1.65 FTE	1.9 FTE
12.2. Professional training or education	0	100	100