PROJECT FINAL REPORT

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4.1 Final publishable summary report

Executive Summary

TALOS is an international research project co-funded from EU 7th Framework Programme funds in Security priority. The main objective of TALOS project was to develop and field test the innovative concept of a mobile, autonomous system for protecting European land borders. The conventional border protection systems are based mainly on expensive ground facilities installed along the entire length of the border complemented by human patrols. The system demonstrator developed within the TALOS project shows capabilities of being more versatile, efficient and flexible.

The complete system applies both aerial and ground unmanned vehicles, supervised by command and control centre. The ground platforms are both the watching stations and the first reaction patrols, which will inform the Control and Command Centre and an illegal immigrant about her/his situation, and undertake the proper measures to stop the illegal action almost autonomously with supervision of Border Guard Officers. It shall be emphasised that no other action than observing and detecting illegal entry attempts have been taken by vehicles, thus there is no risk to human health and life.

The most important features of the system are scalability, autonomous operation, mobility, adaptability and modular construction. Through its flexibility it should be easy to adjust the system to the local requirements such as border length and topographic conditions. Important role in the project is given to Border Guards from countries with EU external land border and FRONTEX agency in order to tailor system to end user needs and requirements.

TALOS project consortium gathered adequate resources to face the challenge. The system has been developed by experts working for 14 institutions from 8 EU member states (Belgium, Estonia, Finland, France, Greece, Poland, Romania, Spain) as well as 1 EU candidate (Turkey) and 1 associated country (Israel). A wide range of the necessary competencies has been ensured by composing the consortium of industrial companies, research institutions, small and medium enterprises (SMEs) and a technical university. Project budget summed up to nearly 20 million Euro, 13 million of which has been granted by the EC.

Main scientific and technological results were achieved in three basic TALOS subsystems - communication, Command & Control and UGV subsystem. Communication subsystem consisted of a new network architecture based on two types of building blocks (or types of network nodes): the TALOS Base Stations (TLS) and TALOS Remote Stations (TLR). It also included the study and simulation of robust and scalable algorithms for the construction of a heterogeneous topology network, for cooperative access and routing, cooperating data forwarding and signalling mechanisms. It has been confirmed that mobile WiMax technology in this application provides good performance in terms of coverage, capacity and latency and developed communication architecture allows proper planning, monitoring and control of the mission with a high degree of autonomy and very low intervention from the Commander/Operator. C&C subsystem consisted of Commander OCU, Operator OCU, UAV simulator, Static Sensor Tower simulator and 3D Maps/Terrain Model Generation Station installed in a single shelter. It has been proved that one operator can supervise two UGVs and cooperation between UGV and UAV systems can be performed through single C&C unit. In UGV subsystem main scientific work was done around following technological gaps - localization without GPS, traversability and path planning, UGV sensors data fusion, autonomous behaviour capability. During the TALOS system development, a significant progress has been made on most of the technological challenges. The system was successfully demonstrated, showing autonomous behaviour, path planning, low level control and sensors fusion. However, there are still

challenges to deal with mainly in terms of further development of algorithms for navigation without GPS or SLAM.

TALOS project is influencing European research by contributing to the exploration of the field of robotic perception (sensors processing / fusion), multi robot command and control as well as mobile communication. It is also promoting research in other fields: mapping and localization, artificial intelligence, low level vehicle control and robotic navigation.

Summary description of project context and objectives

The overall goal of the TALOS project was to prove the concept of a land border surveillance system based on unmanned vehicles by developing, testing and validating the technology demonstrator of the system.

Character of the eastern border of the European Union (EU) has changed diametrically in consequence of the EU extension in the recent years, when more than 10 countries, mainly from Central and Eastern Europe, have joined the Union. Nature of the new external EU border differs from the one before the accession. The frontier in its current shape extends between Finland in the North and Bulgaria in the South of Europe. It is diversified with regard to topographic characteristics, climatic conditions, as well as probability of occurrence and intensity of illegal activities. The borders of new member states, shared with the former Soviet Union countries, are particularly exposed to illicit trafficking. This part of the eastern EU frontier is a buffer between the relative prosperity of the West and the poverty of the former Soviet Republics. The average salaries on its West side are much higher than the ones on the East side. The border might be used as the Union's backdoor for illegal immigration and as an area of illicit activities, such as human trafficking and smuggling. European Union is aware of the challenges created by the new frontier. Border security mission is one of the priority security missions recognized by the European Security Research Advisory Board (ESRAB) and European Commission. FRONTEX with its headquarters in the capital of Poland is one of the agencies that were established in order to co-ordinate EU activities related with border protection. EUROSUR (European Surveillance System for Borders) is another initiative aimed at preventing and counteracting the illegal immigration.

Transportable Adaptable Patrol for Land Border Surveillance (TALOS) is a robotic system that addresses the problems of surveillance of the large land border areas, which is one of the capabilities critical for the border security mission recognized by the European Commission. The aim of TALOS was to help in detecting, tracking and preventing persons from crossing the land border illegally between the border crossing points. Its goals were in line with the concept of European Surveillance System for Borders (EUROSUR) and conclusions of the European Security Research Advisory Board (ESRAB). A prototype of the TALOS system, serving as a proof-of-concept, was designed, developed, tested and validated in a research project under the 7th EU Framework Programme.

To meet the requirements connected with the diversified nature of the Eastern EU land border, the system should have been adaptable, transportable and scalable. Designed TALOS system has these features thanks to use of mobile unmanned vehicles instead of a fixed surveillance infrastructure (sensor stations and fences). The vehicles are equipped with detection and observation sensors, controlled from a transportable command centre and supported by own independent wireless communication subsystem. They follow patrol routes defined by the officers in command centre and use sensors to detect activity within the border area. The officers are notified about each detection and are provided with the capability to observe the detected activity. Having gained the situational awareness the officers decide if the observed activity has to be interrupted. If so, a border guards patrol are dispatched and a specialized vehicle supports the apprehension. Overall TALOS concept is presented on Figure 1.

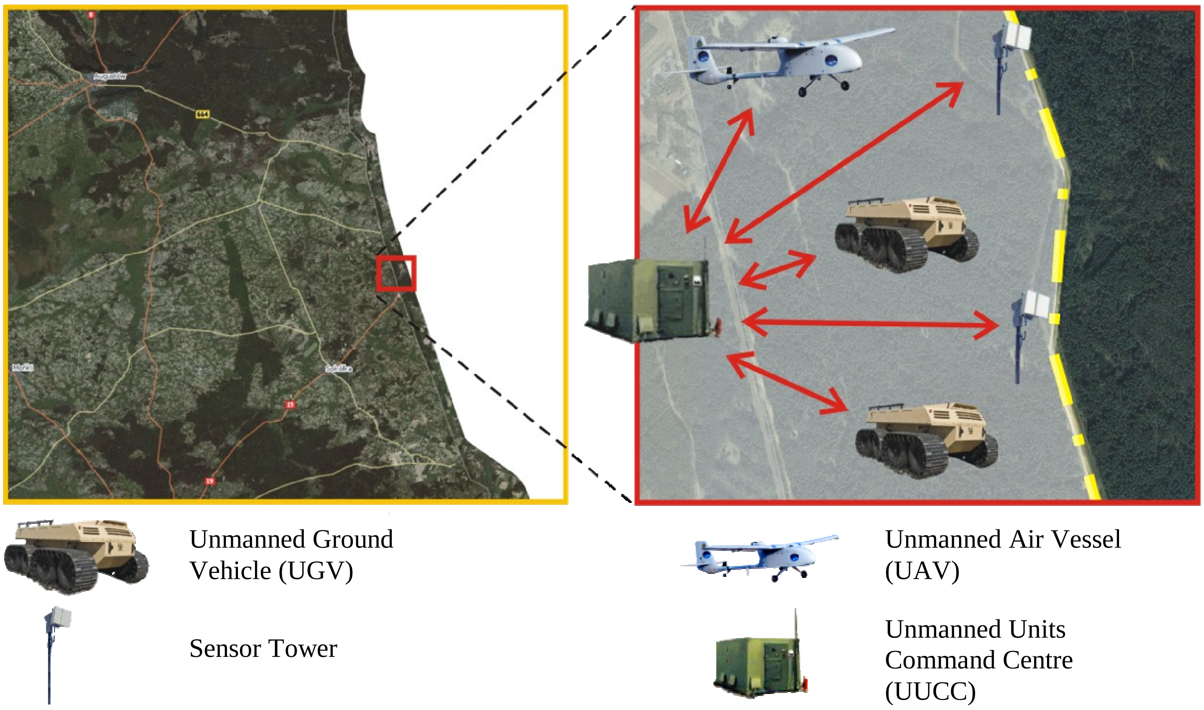


Figure 1 The concept of the TALOS system

The main benefits of this approach are:

- **Transportability** of the system – initiatives like CRATE (Centralized Record of Available Technical Equipment) and RABIT (Rapid Border Intervention Teams) have shown that EU member states are ready for sharing the equipment and personnel for border surveillance in case of emergency. TALOS system can be used in the same manner. The possibility of deployment in distant mission areas, unavailable in case of systems based on static infrastructure, give chance to effective utilization of the system.
- **Adaptability** of the system – the intended versatility of the system demanded a design, which allows the high degree of adaptability, with regard to topographic conditions, intensity and probability of illegal operations in the border section. TALOS system is easily configurable to meet the requirements of a particular mission area, by selecting an accordant set of unmanned vehicles to be deployed. Selection of number and configuration of the vehicles provide adaptability both to the length of the border section and the specific of illicit activity. Availability of different types of unmanned platforms enables the maximum adaptation to the terrain conditions. The system can also be scaled on a higher level of command, by adjusting the number of Unmanned Unit Command Centres, supervising and controlling the operation of unmanned units, and commanded by a transportable Theatre Command Centre;
- **Semi-autonomous operation** – autonomy of the vehicles patrolling the border is the key success factor of the concept behind the TALOS system. A system can be used for effective surveillance of large areas only when a minimum engagement of the operator is ensured. This is connected with the effectiveness of the system, both in terms of engagement of human resources and economy. Autonomy of the Unmanned Ground Vehicles (UGVs) in TALOS system was a particular challenge. The vehicles are going to operate in a complex and variable environment. To meet this challenge vehicles use precise terrain models, laser scanners and state of the art navigation modules.

While introducing advantages over systems based on static infrastructure (fences and static sensors) TALOS aimed to maintain their high effectiveness. The system should allow the Border Guards to react to trespassing within minutes. The vehicles can engage or trace illegal immigrant before the arrival of manned forces. This ensures the person not being left unattended since he/she has been detected by the sensors.

TALOS architecture

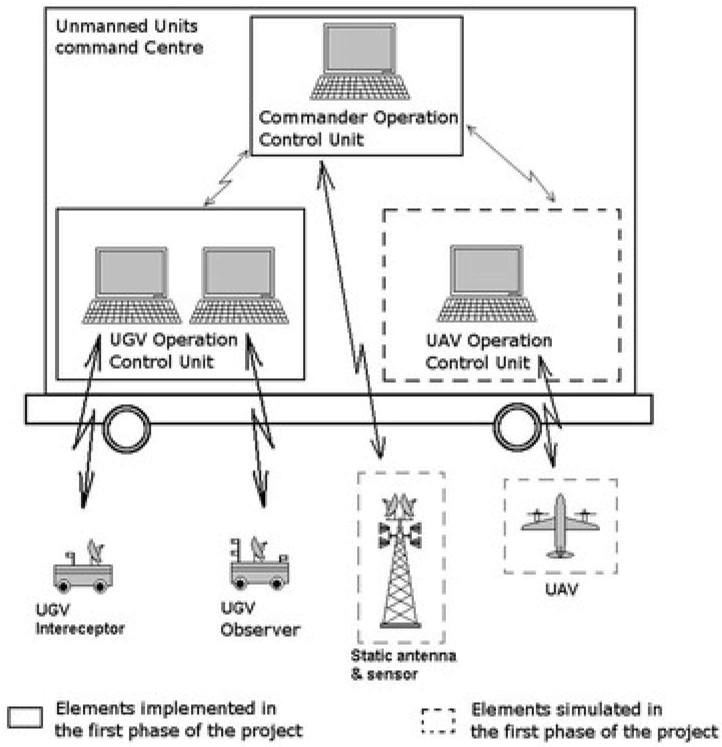


Figure 2 The architecture of the TALOS system

Demonstrator of the system is composed of the Unmanned Unit Command Centre (UUCC) and two Unmanned Ground Vehicles (UGVs). Unmanned Air Vehicle (UAV) and transportable Sensor Tower will be integrated into the system in future. In the first phase of the project communication with these elements has been simulated. Proposed architecture of the TALOS system is presented on Figure 2.

The Unmanned Units Command Centre (UUCC) is used to control and monitor the operation of the Unmanned Units. Mission commander and operators of the unmanned vehicles are seated at the Operator Control Units (OCUs). These allow Border Guard officers to plan the surveillance mission, control the vehicles and provide also an operational awareness in the mission area. The commander is presented with a visualization of the mission area, including position of the system elements, patrol routes and data from all the sensors, on different map layers. Personnel operating the UGV's and UAV's OCUs have the possibility of viewing the information from sensors carried by the vehicles, as well as planning vehicle routes and operating the vehicles manually.

Commands and data flow between the command centre and system's end units are ensured by the communication network. Wireless network for TALOS system is implemented in MESH architecture. The main goal of its design is the network reliability, which is crucial to the whole system's performance.

Unmanned Ground Vehicles (UGVs) were designed to constantly patrol the border section. Vehicles are equipped with long-range detectors of moving vehicles and people, as well as sensors allowing the operator to recognize the detected subjects. They are controlled from the UUCC: either 'driven' by the operator, using a steering wheel, pedals and joysticks or, in semi-autonomous mode of operation, being ordered to drive from one point in the mission area to another without 'hands-on control'. The latter was made possible owing to state-of-the-art navigation systems and advanced mechanisms of obstacle detection and avoiding.

Two types of vehicles have been implemented: the Observer, used for patrolling the given section, and the Interceptor, used for engaging the illegal immigrant before arrival of the Border Patrol. The Interceptor enables communication of the operator with the trespasser by means of a microphone and loudspeaker.

Unmanned Air Vehicle (UAV) will be responsible for the aerial surveillance and can be used as communication node in particular situations. The TALOS demonstrator does not contain the UAV. In order to make TALOS system ready for future UAV integration, the interaction of UAV OCU (console for UAV management) with other subsystems has been simulated by the computer in UUCC.

Sensor Towers can be deployed in places requiring ceaseless surveillance 24/7, or in places not accessible to the vehicles. The towers can be used both for sensor placement and as communication nodes. They can be transportable together with the whole system. In the 1st phase of TALOS, data flow between the towers and other subsystems were simulated. The towers will be implemented in future project phases.

Innovation Aspects

The main innovation that the consortium introduced in TALOS multidisciplinary project are as follows:

- **Scalability** - its ability to easily change the system scale due to changes in the requirements and local conditions such as border size, topography, density of surveillance elements etc. Another system feature is its adaptability behaviour, changes in the security scenario of a specific border or area, due to new intelligence information or update in immigrant's behaviour, threat assessment, designated means, etc.
- **Autonomous capability based on sets of rules (artificial intelligence)** - programmed in the computers of the UGV's and the Command & Control system. This sets of rules are actually a translation of procedures used by the border guards in the daily routine and emergency operations. These rules should be modified from time to time, to adapt the system to the new tactics.
- **Mobility/transportability** - The whole system is easily transportable installed in standard containers (20 ft and 40 ft), transported on trailers for fast deployment in selected border zones (according to intelligence). The system can move in convoys to the designated location, where possible (ground access), can be airlifted by helicopters to locations not accessible and is transportable by air in C-130 aircraft (or alike) to provide air deployment, within the country and between countries, all over Europe. The Command Centres, the UGVs and UAVs are being installed in containers and mounted on trailers, the Sensor Towers (transmitters), are also mounted on trailers. Once reaching the designated deployment area, the trailers are disconnected from the towing Trucks, located, fixed in place, levelled etc., and system components are connected with all the necessary command cables, power supply cables, support equipment, etc.
- **Tactical Learning/Adaptation behaviour** - During development process, system was adapted to local operational requirements, operators were consulted, and their needs implemented in system mission planning module. The TALOS system is designed having

Man-in-the-Loop. It enables voice engagement of the immigrant. System uses adaptive artificial intelligence to implement various tactical techniques, in the specific patrol scenario, area of operation, border topography, etc.

- **No need for fixed infrastructure or fences** - TALOS system owing to its mobility and transportability do not require any fixed infrastructure. Sensors and cameras can be installed on UGVs. All UGVs and UAVs, including their supply and maintenance equipment are or will be stored in their own containers, as well as all crew equipment, dormitories, kitchen, toilets, supplies etc. After deployment, the containers can be camouflaged, and from there platforms can be launched to perform surveillance tasks (automatically) and return for refuelling, servicing and maintenance.
- **Enables response to an illegal entry attempt in minutes** - system will respond to an illegal entry attempt in the matter of minutes, not hours.
- **Usage of "green" energy** - the energy in remote locations (where it is impossible to connect to standard power lines) could be coming from the natural sources e.g. solar panels (sunny area), wind towers (windy area), water wheels (near to rivers). At the demonstration the generators were used while none other sources of energy were available.

Main TALOS Scientific and Technological results

TALOS project scientific and technological goals has been set in three main technological work packages, that developed simultaneously three main subsystems of TALOS project. This are:

- Work package 4 – Communication Subsystem
- Work package 5 - C&C Subsystem
- Work package 6 - UGV Subsystem

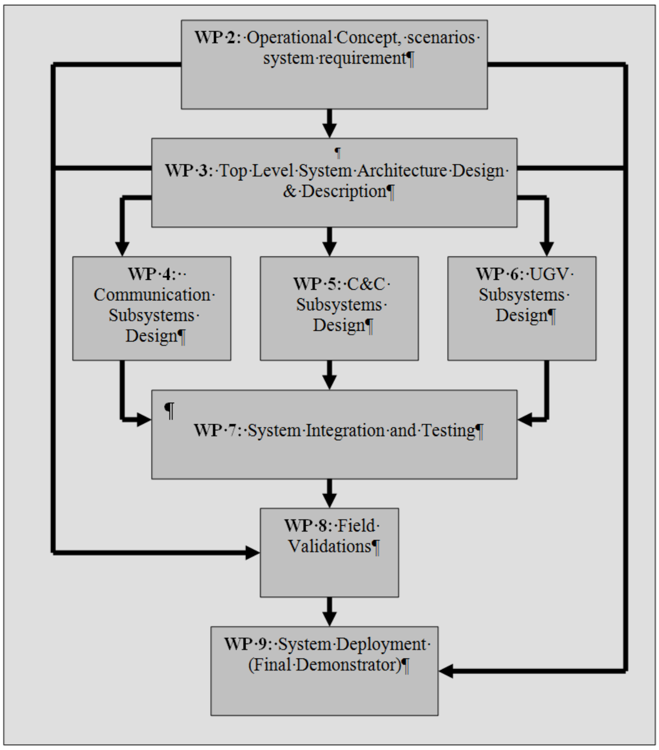


Figure 3 Work packages links

Although the final project results were obtained by integration and demonstration of developed subsystems according to previously specified requirements and architectural design, the scientific and technologic achievements has been obtained within the core work packages itself. It is noteworthy that the innovative efforts in technological domain has been limited by the objectives and requirements resulting from both initial description of work and ongoing cooperation with end-users representatives.

Communication Subsystem

Objectives for the communications subsystem

The main objective proposed in the description of work for the communications subsystem work package was to design, implement, integrate and test the communications subsystem for the TALOS system. This objective included the proposal of a new network architecture based on two types of building blocks (or types of network nodes): the TALOS Base Stations (TLS) and TALOS Remote Stations (TLR). The objective also included the study and simulation of robust and scalable algorithms for the construction of a heterogeneous topology network, for cooperative access and routing, cooperating data forwarding and signalling mechanisms. It is important to clearly differentiate between the TALOS final system (Target System) and the part that has been implemented for the demonstration (Demo System). Since during the phase I of the TALOS project only three communications nodes have been implemented (the UUCC and two UGVs), they are directly connected and routing and mesh protocols development have a low impact on the performance of this communications network. The scope of the work done in the design and implementation of the TALOS Demo Communications Subsystem has followed a more practical approach, while the scope of the work regarding the TALOS Target System (mesh network and heterogeneous topology) has followed a more theoretical approach, studying in depth the available technologies and performing simulations.

High level architecture description

The infrastructure of the TALOS communications systems is based on several local area networks (LANs) connected through wireless links and forming an Heterogeneous Wireless Network (HWN), the TALOS network (TALOSNet). Each node of the TALOSNet contains a LAN: UGV, UAV, Static Sensor Tower, Unmanned Unit Command Centre, Theatre Command Centre and Headquarters. At the end of the demonstration phase of the project, only the following nodes have been implemented: patroller/interceptor UGV, observer UGV, Unmanned Unit Command Centre (UUCC) and escort vehicle. Each of them will have a local network (UUCCLAN and UGVLAN), and the communication among them is redundant, with three different subsystems (networks) wirelessly connecting the nodes: primary system, backup system and safety system. Each of them is based on a different technology and a communications control subsystem decides which subsystem to use depending on the scenario conditions: lost of coverage, emergency situation, etc. The proper configuration of the switches that control each LAN has been a key point in the success of the network switching scheme. For the hardware part of the communications subsystem, COTS components (transceivers, antennas, encoders, etc) have been used, reducing as much as possible the development of hardware equipment. On the other hand, the software part of the communications subsystem is mainly composed of modules specially designed and implemented for the TALOS project.

Primary Communications subsystem

The primary communications subsystem is based on the WiMAX technology. This technology, in its 802-16e specification (Mobile WiMAX) supports mobile communications in a Non-Line Of Sight environment, which is appropriate for the TALOS scenarios. It offers enough bandwidth for the data that needs to be transmitted: up to four video channels; two data channels with radar, UGV and commands/mission information; and two voice channels. A commercial Base Station from manufacturer Alvarion has been used, operating in the 3.5 GHz bandwidth. The main challenge with this subsystem was the proper configuration of the base station and UGV terminal equipment. The WiMAX Mobile architecture is initially intended to provide high capacity in the downlink, but we have managed to configure it in a way that allows greater capacity in the uplink, required for transmitting the video and payload data from the UGVs to the UUCC. Also proper configuration has been established for providing multicast support, allowing to see the video streaming on several computers in the shelter while minimizing the load of the datalink and maintaining the Quality of Service Parameters, specially the latency, which is critical for teleoperation of the vehicles.

Backup Communications subsystem

For the Backup Communications Subsystem the CDMA@450 cellular network infrastructure provided by TP (Orange Labs) has been used. The advantage of using this network is that it complements well the characteristics of the primary subsystem, allowing to have coverage on areas where the primary subsystem shall fail. Theoretically, the performance specifications of this network shall be enough fulfil the requirements of the TALOS backup subsystem.

But in fact the use of this network has been very challenging. The first challenge comes from the fact that the network provides access to the public internet network. In order to provide secure and seamless connection between several LANs using the public part of the network, a complex architecture based on IPTunelling has been implemented, including support for multicast traffic encapsulation and data streams control and filtering. The second challenge comes from the usage of the commercial network of TP, which is operating normally with their customers. Both in the integration area and demo area, the load of the network was very high, and the capacity we had available was far from the maximum specified, and not enough for transmitting video. We have performed tests only with monitor and control traffic, which proves the viability of the architecture if the bandwidth is enough, but not with video traffic. One of the main issues to solve in next stages of the TALOS system development is to substitute this CDMA450 network by an alternative radio technology. Several options have already been considered and studied.

Safety Communications subsystem

The safety communications system has been used in the demo phase of the project for safety (not operational) purposes only. It links the UGVs with an escort vehicle so if the UGV lost control, the vehicle will be in charge of regaining control over the UGV or stopping it. Since the escort vehicle is close to the UGV, a low range technology has been used: standard WiFi modems and antennas (integrated in the modems), working on the 2.4GHz band, offering up to 54Mbps and a range in the few hundreds of meters. Emergency FM transceivers have been used for the effective stopping of the vehicles.

Switching and networking

The complete networking architecture is based on IP protocol, and standard Layer 2 switches have been used for the interconnection of equipment in the LANs. Those switches have some Layer 3 capabilities that have been enough for the proper configuration of the traffic routing in the Demo scenario. But due to the complexity of the network and the required routing capabilities, it is recommended to substitute those switches by full layer 3 routers in the next stages of development of the TALOS system.

Communications Monitoring and Control Software

The other big task of the work performed in the communications subsystem has been the development and integration of the different modules that compose the Communications Software. This software can be divided, taking into account its main purpose, into three main blocks:

- Planning/Simulation: The NPT tool developed by VTT has been tailored to fit the TALOS needs, including the simulation of coverage areas for different radio technologies in a preoperational stage, providing coverage raster maps that can be included in the database and used in the mission planning. The tool also includes the capability to obtain real time measurements of the QoS parameters from the vehicles, which helps to improve the simulation models and predict in real time coverage changes.
- Monitoring: several modules have been developed, by VTT and TTI, for monitoring in real time the performance of the network in use. This info is distributed to other modules which use it for effective controlling the network.
- Control: the modules in this block have been in charge of the proper configuration and control of the network, making the handover and transition from primary to backup network according to the monitored parameters as well as the coverage predictions from the planning tool.

The main challenge has been the coordination for the development and integration of the different modules by different partners (mainly VTT and TTI) as well as the access to the performance data from several sources and hardware equipment. This has implied the development of an ad-hoc protocol for the exchanging of information of the different modules.

Conclusions

The main conclusions of the technological results obtained during the project in the communications area are the following:

- The Mobile WiMAX technology is suitable as primary communications subsystem of the proposed architecture, with good performance in terms of coverage, capacity and latency.
- The CDMA450 technology may be suitable as backup communications subsystem, but the use of a commercial cellular network is not acceptable as performance cannot be guaranteed in terms of capacity and latency.
- The networking, switching and routing configuration is critical in the proper operation of the communications subsystem, and layer 3 routers are preferred over layer 2 switches for this task.
- The developed software allows proper planning, monitoring and control of the mission from the communications point of view, with a high degree of autonomy and very low intervention from the Commander/Operator.

C&C Subsystem

Objectives for the Command and Control (C&C) subsystem

The objective stated in the description of work is to design, implement, integrate and test the Command and Control (C&C) subsystem for the TALOS system. In the 1st phase of the program, the aim is to develop Unmanned Unit Command Control which consists of Commander OCU, Operator OCU, UAV simulator, Static Sensor Tower simulator and 3D Maps/Terrain Model Generation Station installed in a single shelter. However, high level system design work is done for whole TALOS system.

High level structure of C&C can be represented as given in below figure:

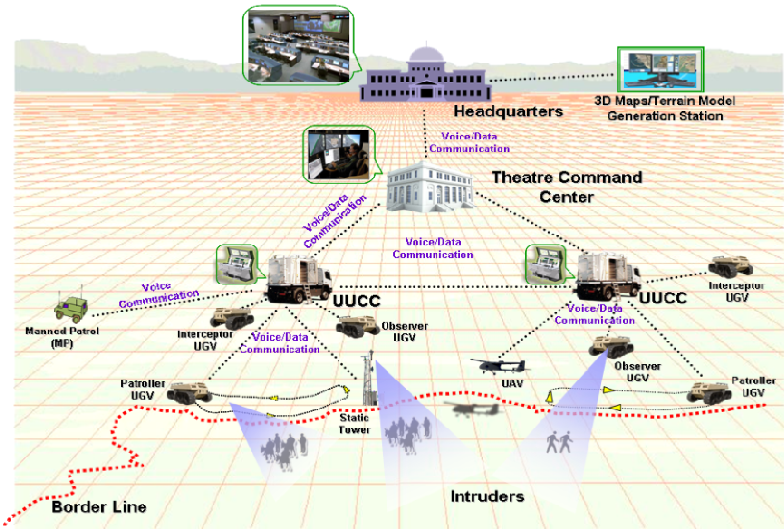


Figure 4 High Level System Structure of TALOS

C&C Subsystem Description

TALOS aims to use unmanned systems to support border guards' operations with help following of functionalities provided by UCCC:

- Situational awareness of mission area
- Tactical map
- Surveillance
- Event notification / sensor track data
- Mission planning and execution
- Teleoperation of UGVs
- Remote control and status monitoring of unmanned systems and payloads/sensors
- Tasking of unmanned subsystems
- Logging and replay
- Transportable/mobile

The information gathered from unmanned systems is collected at UCCC, necessary actions are taken and the reports about the situation are transferred to higher levels in the hierarchy.

Figure 5 C&C Shelter

UCCC is the key node where border guards are interacting with TALOS system. There are two places for operators in UCCC: Commander OCU and Operator OCU. The key functionalities and differences are summarized below:

Figure 6 Commander OCU and Operator OCU in UCCC

Commander OCU

- Mission Planning and Execution
- Operational area situational awareness
- UAV, Sensor Tower remote control / status monitoring
- UGV remote control / status monitoring
- Intrusion management using radar and detection sensors
- Operational area surveillance using visual sensors

Operator OCU

- Mission Planning and Execution
- Operational area situational awareness
- UGV teleoperation
- UGV remote control / status monitoring
- Intrusion management using radar and detection sensors
- Operational area surveillance using visual sensors

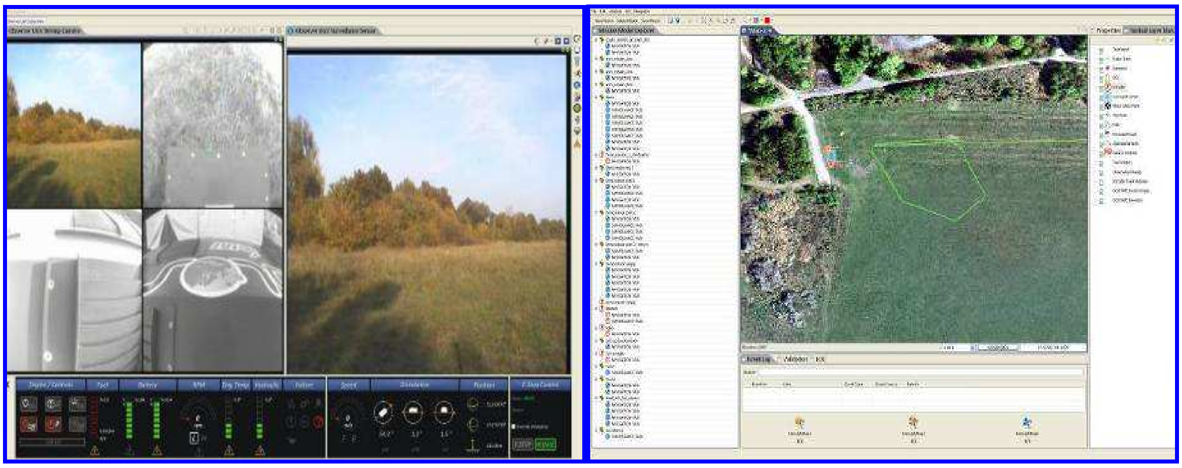


Figure 7 OCU Displays

In result of Command and Control development in TALOS project following components has been provided:

UCCC Mission HW

- Commander and UGV Operator Control Unit (OCU) Console
- Simulators Computers
- 3D Maps/Terrain Model Generation Station
- World Model Knowledge Store (WMKS)
- Network Video Recorder (NVR)
- Communication Subsystem

UCCC Supporting HW

- Emergency Stop
- Real-Time Kinematics (RTK) GPS Reference Station
- Printer
- Power Generator
- UPS
- Antenna Mast
- Shelter
- Air Conditioning Unit
- Other Auxiliary Equipments

C&CCommander /UGV Operator Control Unit (OCU) Software

- Multimedia Component Software
- Tactical Map Component Software
- World Model Knowledge Store (WMKS) Software
- Operator/Message Logging-Replay Software
- Time Synchronization Software
- 3D Visualization and Terrain Map Generation Software
- UAV System Simulator Software
- Sensor Tower Simulator Software

Detailed Description of UCCC Functionalities

- Teleoperation

UGVs are able to be controlled from a distance. Operator OCU is able to control one unmanned system at a time. Since the Operator OCU is responsible of multiple unmanned systems, the operator is able to switch teleoperation between these systems.

- Remote Control

Remote control is the activity of controlling an unmanned system and the payloads (i.e. radar, electro-optic sensors, acoustic sensors, etc.) from remote (C4I), other than teleoperation. Remote control includes the configuration of a payload, direction of a sensor, zooming in and out of an electro-optic sensor, control data mode, etc. Commander OCU and Operator OCU control the payloads on the UGV at a fixed location or on the move according to the operational requirements.

- Status Monitoring

Status monitoring is the activity of periodic information update from the unmanned units and payloads/sensors to the UCCC. Status monitoring is the opposite of Remote Control in the context of data flow; e.g. Status information can be general information such as location of unmanned units or device specific information presented to both Commander OCU and Operator OCU.

- Observation

Both Commander OCU and Operator OCU in the UCCC are able to observe the border area using the sensors on Unmanned Units. Sensor data is supplied to the UCCC for intrusion detection by means of a communication infrastructure, which requires supporting high data rates communication such as video, audio, etc.

- Multi-Unit Operation

A border sector may contain more than one unmanned unit. Since Operator OCU is able to teleoperate only a single unmanned unit at a time, switching between unmanned units is possible. Switching between operators and unmanned units are smooth not to loose control of unmanned unit during switching. A single operator may monitor more than one unmanned unit.

- Logging / Replay

The sensors data is stored at C4I level. The previously received sensor data arrived from UGV/UAV and static sensor towers are stored in C4I to be used later.

- Transportability / Deployment

Transportability/Deployment is the concept of displacement and installation capability of a system. UUCC is designed to be transported with standard shelter.

- Interoperability

IP protocol is used as the network infrastructure. JAUS protocol is used at application level for interoperability between system nodes (i.e. UCCC, UGV etc). Components & ICD are defined in accordance with the JAUS standard where applicable.

Functional nodes of the TALOS project are defined in accordance with the JAUS standard as JAUS subsystems, nodes or components. The communication between these nodes complies with JUDP (JAUS UDP) standard.

- GIS

There are some GIS utilities used for spatial analysis. These utilities are shown below:

  - Import/Export of GIS data in standard format
  - Line of sight (LOS) analysis
  - Distance measurement
  - Cross section analysis
  - Highest point analysis
  - Filter mechanism (Layer management)
  - Interactive graphic editing (Addition, deletion, moving and changing the geographic position of features)
  - 3D Image visualization

Results of GIS analysis are shown on the tactical map. GIS is capable of handling high resolutions maps displayed on one or more screens.

- Tactical Map

Tactical map data includes static geographical properties such as elevation data, obstacle data, and vector data such as routes, waypoints and areas (forbidden zones, etc.). Data can be entered, updated or deleted manually or can be obtained from other external sources such as unmanned units.

Tactical map also includes dynamic data such as position, direction, speed of intruders and unmanned units. Information about the intruders is supplied by the UGV or is entered manually by the operator with the help of observation cameras. Position history of intruders and system components is logged and displayed on tactical map. In case of losing the intruders, the track history that is kept can be displayed on the operator screen and according to the last speed information of the intruder a circle is marked that shows the possible intruder location.

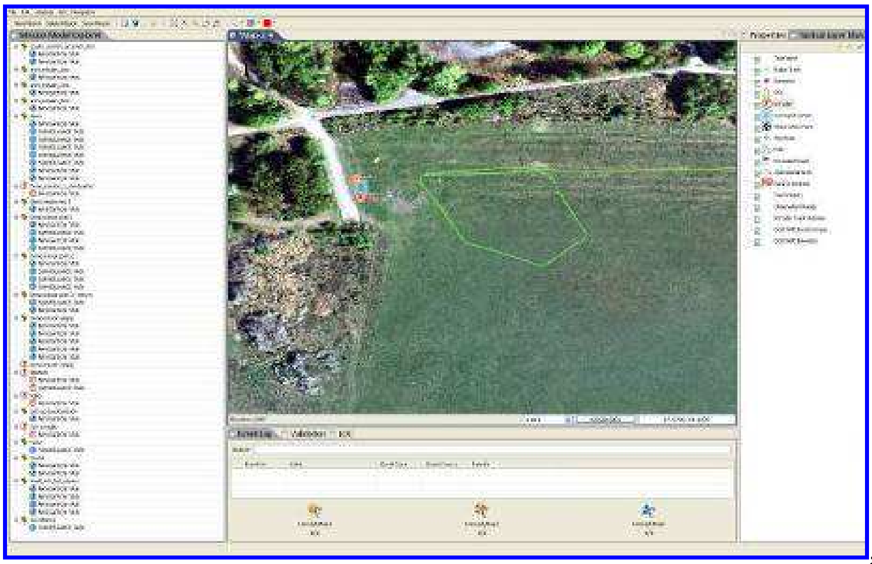
,

Figure 8 Tactical Map

Triggers can be defined on the map for specific areas (e.g., forbidden zones, endangered area, etc.) on the tactical map. If the trigger is activated (e.g., UGV enters forbidden zone) the operator is alerted.
Data displayed on the tactical map can be filtered, i.e. friendly units only, intruders only, etc., by the operator for better evaluating the situation.
Paths used mostly by the intruders can be marked by the commander on the tactical map. Also system can log the track history of the intruder paths during operation and display the track history if required.

- Terrain Map

The terrain map is composed from existing map data which is updated and complemented from high resolution satellite imagery (0.5 meter resolution, vegetation layer also from 5 - 10 meter resolution satellite imagery). Recent aerial imagery and laser scanning data is used whenever available. The terrain map is updated also from UGV sensor information and ground measurements.
The terrain map consists of the following layers:

- Elevation model
- Road network
- Buildings
- Water areas, lakes and rivers
- Vegetation layer, including height of vegetation: lawns, agricultural areas
- Stand wise forest parameters for dense forest: mean density of forest , mean height of trees, mean tree type proportion (coniferous /deciduous)
- Single tree parameters for passable forest: tree type (coniferous/deciduous), height, diameter
- Soil type
- Environmental elements: natural monuments, animal's habitat, water sources, natural/wildlife reserve,
- Fences
- Endangered areas

The terrain map data is collected using standard GIS formats and stored in a standard GIS database (some well known spatial databases are ESRI ArcGIS, PostGIS, etc.)
In addition to the map layers, the visualisation database includes mobile real time data:

- Unmanned units locations

  - Sensor locations
  - Patrolling routes
  - Planned routes
  - UGV fuelling facilities, C4I trailers, other static BG posts
  - Real time imagery and measurements from UGV/UAV and static towers

Part of the mobile data will be transferred also into the main GIS database.

- Mission Planning

Mission planning is performed by the Commander OCU. A mission consists of multiple tasks. A task consists of one or more actions performed by one unmanned unit. Commander OCU and Operator OCU are informed about the maximum time of continuous movement of the Observing Unit and Patrolling/Intercepting Unit by the help of planned path and average fuel consumption.

- Mission Execution

Mission execution is the activity of executing a planned mission. Missions consist of tasks which can be executed in sequence or in parallel. These tasks have to have a clear definition of its starting and ending conditions. Mission assignment, mission status update and mission reporting capabilities are supported by the messaging infrastructure.

- Mission Rehearsal

Mission rehearsal is the activity of validating the planned mission. Rehearsal gives feedback to the operator about the duration of the mission, sufficiency of the resources etc. to complete the mission.

- Reporting

Reporting is the activity of supplying mission specific information to a higher level of command. In TALOS system, reporting is identified between unmanned units to UUCC, UUCC to Theatre Command Center and Theatre Command Center to Headquarter.
Reporting is performed by the unmanned units during task execution (obstacles, intruders, events) and after each task completion (mission report). The difference between status monitoring and reporting is that status monitoring includes more device specific information where reporting includes mission specific information.

Conclusions

The main conclusions of the technological results obtained during the project in the command and control area are the following:

- The idea of two OCU configured to be operated by commander and operator has proven its possibility to follow the protocol and procedures whereas all functionalities and easy to use common interface is provided.
- Data sharing and gathering techniques are intensively helping with planning, commanding and operating complicated robotic system like TALOS.
- Developed system is possible to integrate into existing data sharing and commending techniques as well as into existing procedures of Borders Guards routine.
- The developed software allows proper planning, monitoring and control of the mission from the commander and operator point of view, with a high degree of autonomy letting he Commander and Operator to work in a comfortable way.

UGV Subsystem

Objectives for the UGV subsystem

The main objective proposed in the description of work for the Unmanned Ground Vehicle (UGV) subsystem work package was to design, implement, integrate and test the UGV subsystem for the TALOS system.

The second objective was to designed, implement, integrate and test different system modules, such as mapping, localization, path planning, low level control and payloads.

It is important to clearly differentiate between the TALOS final system (Target System) and the part that has been implemented for the demonstration (Demo System).

The scope of the work done in the design and implementation of the TALOS Demo UGV Subsystem has followed a more practical approach, while the scope of the work regarding the TALOS Target System has followed a more theoretical approach, studying in depth the available technologies and performing simulations.

The project was facing the following technical gaps :

- Localization without GPS
- Traversability and path planning
- UGV sensors data fusion
- Autonomous behaviour capability

UGV Subsystem Description

Two Unmanned Ground Vehicles were developed and used in the TALOS System Demonstrator to provide the reliable information on the application of autonomous platforms for border line protection.

The UGV subsystem is composed of a tracked platform of high mobility, integrated with a set of payloads, allowing it to perform autonomously the tasks assigned by the operator via the UUCC operator panels. The payloads for both vehicles include:

1. High and low level computers, responsible for steering the platform, controlling the sensors and executing autonomous mission;
2. Navigation devices, primarily based on precise Global Positioning System (DGPS, RTK) providing horizontal accuracy (RMS) of 0.01 m, that is aided by Inertial Navigation System (INS) providing in real time the attitude, azimuth and velocities of the vehicle, as well as acceleration and angular rates in three axes;
3. 3D laser scanner, with a 360 degrees horizontal field-of-view and a 26.8 degrees vertical field-of-view, providing environmental mapping used for obstacle avoidance;
4. Safety sensor, ie. laser scanner located on the front-side of the vehicle to prevent the UGV from colliding with dynamic obstacles;
5. Driving sensor, ie. day/night camera installed on a two axis pan/tilt platform, additionally allowing to detect and support recognition of the objects.

Figure 9 TALOS UGVs

The vehicles were differed, according to the TALOS system design into two roles: Observer and Patroller/Interceptor. Both of the vehicles were based on the same platform: TAGS vehicle. The difference is in some of the payloads and capabilities resulting thereof.

- **UGV Observer**

UGV Observer role is to monitor the area under observation (near border line), to detect objects (people or vehicles) trying to illegally cross the border, track them and provide the accurate data to the Border Guards system operators, sufficient to early recognize the threat.
The Observer has the following specific payloads:

- Surveillance Camera – MiniPOP – day and night camera with high zooming capability, visual tracking and precise control. Provides sufficient data to recognize a person/vehicle from a long distance (over 1 km).
- Radar– A Doppler radar, to detect moving objects in the scanning area. It can easily detect people or vehicles.

- **UGV Interceptor**

Role of the UGV Interceptor is to track and interrogate people trying to illegally cross the border. That mission is enabling UGV Observer to continue scanning of the area under observation. Owing to that capability the TALOS system is not vulnerable for multiple threats at the same time.
The Interceptor has the following specific payloads:

- Interrogation System – composed of a microphone and a loud speaker, allowing the communication with the individual recognized as suspicious by the operators, until the manned patrol arrives.

High level architecture description

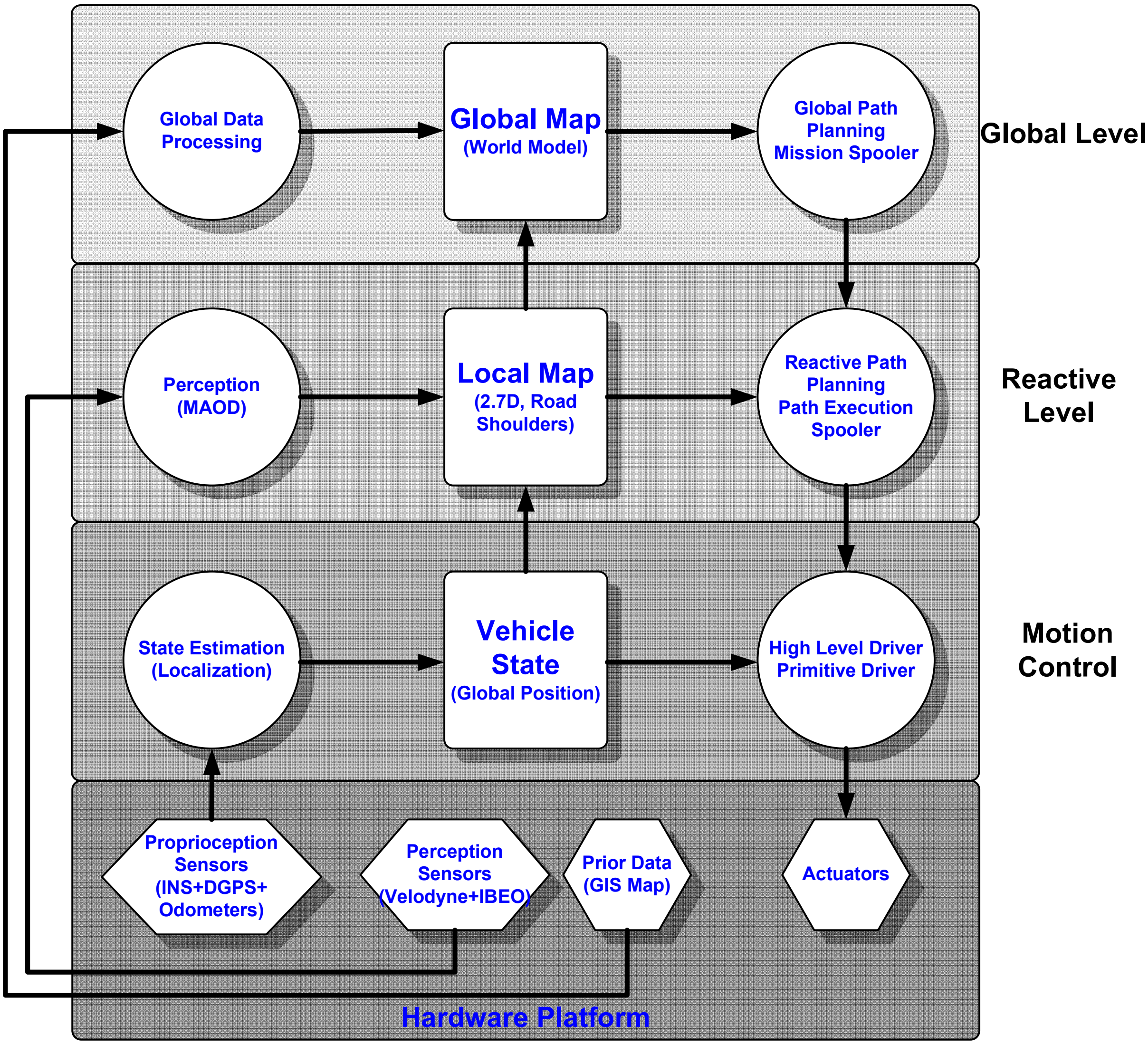
The UGV subsystem was built according to the following guidelines:

- JAUS Compliance

The system architecture design is based on JAUS reference architecture framework and follows its rules.

- UGV interchangeability
  UGVs designed to be convertible from one type to another (observer to patroller/interceptor and vice versa).
- Open Architecture
  The UGV system architecture provides an open and flexible design in order to support future growth and changes. Examples of that may be changing/adding external sensors without the need in changing internal interfaces, changing in algorithms without affecting software design etc.
- Three Layer Architecture

  The UGV architecture is based on 3-level architecture concept:



Each layer involves a sensory/data interpretation component, a world model, and a planning/control component.
In addition to the population of world models by sensor and external data, world model information flows upward in the model hierarchy and it is abstracted and/or reduced in precision as a result.

Command information flows downward and is elaborated and increased in precision as a result. Each layer has its own dedicated source of information, which is unknown below it. Each layer influences the behaviour of a single contended resource—the vehicle—through such mechanisms as:

- Hierarchical control: lower levels elaborate and follow higher level commands;
- Arbitration: deliberative elements must resolve disagreements arising from conflicting simultaneous goals such as obstacle avoidance and waypoint seeking;
- Exception handling: faster elements deal with exceptions quickly and propagate them upward.

When higher layers are present, they provide commands, which are elaborated and executed by lower layers. However, each layer has the capacity to control the vehicle independent of the layers above it to generate respectively the behaviours of (dense) waypoint following, obstacle avoidance, and global path planning. Each layer has the authority to ignore the commands passed to it in order to respond quickly to an exception or emergency.

Vehicle autonomous control

In order to perform autonomous control, the Sub-System Commander component has been developed. It performs the following tasks:

- UGV Control
- Emergency control
- Mission Management

The Subsystem Commander is able to receive high-level missions from C2 and perform them autonomously, according to the applicable rules/constrains. It builds the mission plan that parses the missions to UGV components. It activates all needed subsystems according to the mission objectives at any given time.

The SSC detailed functions are:

- Preparing the UGV components for the mission to be executed
- Running the system processes that realize the mission
- Handling exceptions during the mission execution
- Mission advance control
- Mission constrains management - for example, lowering the maximum velocity due to certain pre-programmed conditions, such as GPS blackouts or critical system failures
- Reports Handling - preparing and sending reports to C2.

Localization

For the UGV localization, the "Method and system for automatically guiding an unmanned vehicle", European patent EP 1 899 778 B1 is used.

The method is based on determining vehicle position by navigation sensors fusion – inertial navigation system, DGPS and odometers.

During TALOS UGV development, numerous changes and improvements were made to the original algorithm.

Mapping

During TALOS UGV development, a real time data fusion module was developed. The module receives and processes mapping sensors raw data to create a "Logical Sensor Maps" and then combines them to a one unified map. Two laser mapping sensors were used - 3D Velodyne HDL-64E laser range finder and IBEO LUX laser range finder.

Road detection algorithms were developed, since road detection is a pre-requisite for UGV. Before abiding traffic rules, even road recognition and obstacles avoidance is challenging, as there are many

possible features defining roads, such as pavement (asphalt) or road borders such as sidewalks, ditches, fences, vegetation or walls.
In addition, a lot of work has been done on SLAM algorithms, but they are still immature. IAI is continuing working on this issue in other projects and has achieved a significant progress.

Low Level Control
The Vehicle Control System (VCS) was developed by 'VTT Technical Research Center of Finland'. The VCS goal is to implement vehicle control.
The VCS consists of two components:

- Waypoint Driver

The Waypoint Driver is responsible for determining the actual trajectory and speed of the UGV during the movement. The optimization algorithm is used to minimize the curvature of the path while staying as close as possible to the waypoints in the local path.

- Primitive Driver

The Primitive Driver is responsible for interface with the UGV mechanical systems.

Path Planning
UGV has two planning systems – global and local.
The global path planning is based on expert system, which has the ability to analyze the following parameters in order to create a global path:

- Area topography
- Mobility limitations (vehicle kinematics and dynamics)
- Vehicle traversability (mobility due to ground conditions)
- Environmental conditions (weather, visibility...)

The local planning system is able to plan and update in real time the actual vehicle path. The global path plan have to be adapted to changes that occur in the environment (e.g., detection of obstacles not previously stored in the World Model), errors in the position and orientation of the vehicle (off-plan drift), the presence of smooth areas not explicitly represented in the road network, and the like. For reasons such as these, the a priori plan must be under constant scrutiny to determine whether and how it must be updated.

The goal of the local path planner is to enable the UGV to drive at maximal possible speed while avoiding obstacles and staying inside the global path plan corridor.
The concept of its operation is as following:

- Combining the global path waypoints that are in close proximity of the vehicle, the Environmental Map and the actual road center and boundaries
- Combining close obstacles (that UGV can not pass between them) to one obstacle
- Looking for areas, which indicate the collision of a path segment to be driven by the vehicle with newly found obstacles
- Once a potential collision course is detected, executing a dynamic (re)planning process that attempts to rapidly replace an appropriate number of pre-planned path waypoints with a new set of path waypoints that:
    - Avoids the obstacle (takes into account clearance issues with potential obstacles)
    - Traversable by the vehicle
    - Is legally drivable by the vehicle (subject to several kinematics and dynamic constraints including maximum lateral acceleration, maximum steering angle, maximum steering rate and maximum deceleration
    - Reconnects with the pre-planned route as soon as practical
    - Never takes the vehicle outside of the current boundary constraints
    - Takes advantage of relevant a priori data (e.g., road network)

- Minimizes the performance cost of the new path segments

Conclusions

During the TALOS system development, a significant progress has been made on most of the technological challenges. The system has been developed from scratch and was successfully demonstrated, showing autonomous behaviour, path planning, low level control and sensors fusion. However, there are still challenges to deal with, such as SLAM. As stated above, IAI is working continuously to overcome said challenges and has made serious progress.

Potential TALOS project impact

The project will make its main socio-economic impact through blazing a trial in application of the advanced robotic technologies not only in the security sector, but also in other branches of European industry. The approach adopted in the project provides a clear illustration of how robotic technology will allow the core and associated EU members to enhance both the skill set of their workforce, and improve overall productivity. In the proposed application it is possible to envisage the transition of assistance vehicle drivers into operators and high-level controllers of fleets of unmanned vehicles, thus facilitating an advance in their underlying competencies.

In the field of border security TALOS is paving the path to surveillance equipment of new generation. Systems based on the TALOS concept will not only be efficient, fast and reliable - TALOS is also another step on the way to cost effective security solutions. Cost effectiveness can be achieved by providing the capability of moving the system from one area of operation to another, and adapting it to the operational conditions existing there. Moreover, initiatives like CRATE (Centralized Record of Available Technical Equipment) and RABIT (Rapid Border Intervention Teams) have already shown that the EU member states are ready for sharing the equipment and personnel for border surveillance in case of emergency. TALOS is a solution to be used in the same manner. Although the project is research in its nature, the demonstration of its result, planned for the end of the project is expected to work as a catalytic agent for further development and implementation of systems based on the concept.

TALOS is influencing European research by contributing to the exploration of the field of robotic perception (sensors processing / fusion), multi robot command and control as well as mobile communication. It is also promoting research in other fields: mapping and localization, artificial intelligence, low level vehicle control and robotic navigation. The research will trigger spin-offs in the academic and industrial community. The prototype of the system will serve as a platform for introducing and evaluating new ideas. The demonstration will unveil technology gaps, thus it will enable to provide guidance for future research.

Main dissemination activities and exploitation results

TALOS Project public website is available at: www.talos-border.eu
Responsible for site's content: PIAP (aspronska@piap.pl)
Webpage administrator: WUT (mzasuwa@meil.pw.edu.pl)

TALOS webpage has been developed at the project beginning (2008) and updated regularly. In 2011 - after the recommendation from the EC - its layout and some parts of the content were modified, in order to stress the non-military character of the project.

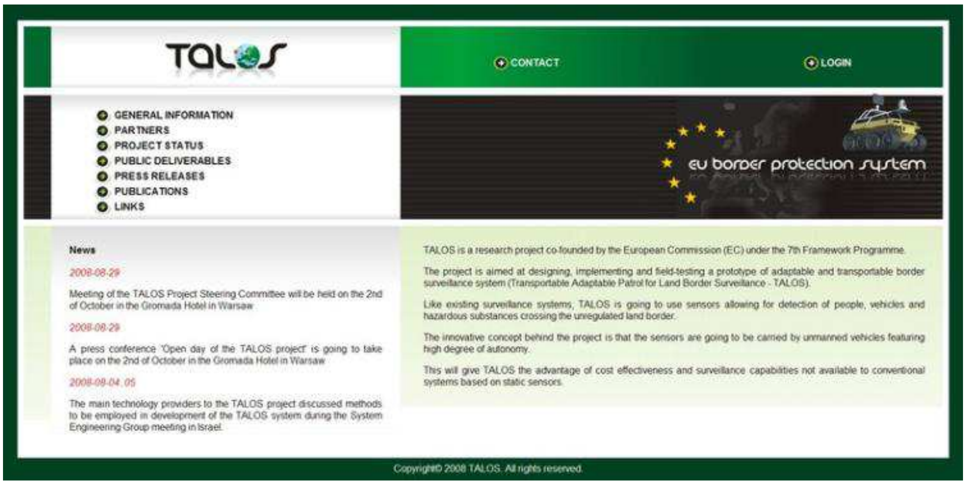


Figure 10 TALOS webpage (Main page) version 1

Figure 11 TALOS webpage (Main page) version 2

Furthermore, project logo, diagrams or photographs illustrating and promoting the work of the project (including videos, etc…), as well as the list of all beneficiaries with the corresponding contact names can be submitted without any restriction.

A) TALOS logo - has been developed at the beginning of the project (2008)

Figure 12 TALOS Project logo (full colour and black-and-white version)

B) TALOS leaflet - has been developed in two colour/content versions. 1st version was printed at the beginning of the project (2008). In 2011 - after the recommendation from EC the layout and some parts of the content were modified, in order to stress the non-military character of the project.

Figure 13 TALOS leaflet - version 1

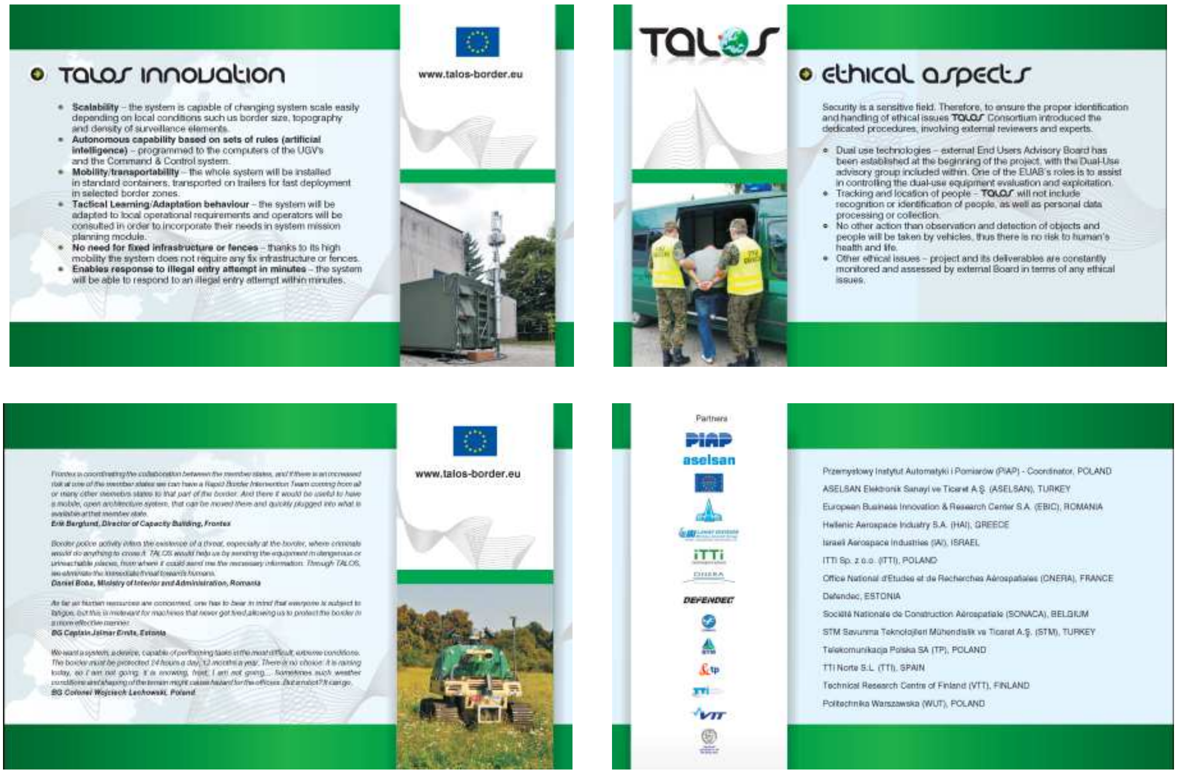


Figure 14 TALOS leaflet - version 2

C) TALOS poster (roll-up) has also been developed in two colour/content versions. 1st version was printed at the beginning of the project (2008), for the purpose of the 1st Project Workshop with End-Users, and illustrated various project-related events (workshops, review meetings, conference stands etc.). In 2011 - after the recommendation from EC the layout and some parts of the content were modified, in order to stress the non-military character of the project.

Figure 15 TALOS poster - version 1 and 2

D) TALOS dissemination movie

The dissemination movie has been developed in three basic versions and an additional one - in a form of a documentary.
First version of the dissemination movie was released in 2009, on the request of EC/REA representatives present at the first Project Review Meeting, to be shortly shown at the project stand during the SRC'09.
Second version was produced in 2011, according to recommendations from the Project Officer, in order to stress the non-military character of the project, and included the footage from the EUAB 8/3rd Workshop meeting, which covered the Demo in field presentation.
Third version has been produced as the final one at the end of the project.
Along with the third version a documentary version has also been produced, in order to show the project history and project works in a more detail.

E) List of all beneficiaries with the corresponding contact names

Partner	Acronym	Contact
Przemysłowy Instytut Automatyki i Pomiarów PIAP	PIAP	Mariusz Andrzejczak Email: mandrzejczak@piap.pl Aleksandra Bukała Email: abukala@piap.pl
ASELSAN Elektronik Sanayi ve Ticaret A.S	ASELSAN	Sami Duman Email: duman@aselsan.com.tr
European Business Innovation & Research Center S.A	EBIC	Simion Dascalu Email: Simion_Dascalu@Yahoo.com
Hellenic Aerospace Industry S.A.	HAI	Athanasios Poulakidas Email: Poulakidas.Athanasios@haicorp.gr
Israel Aerospace Industries	IAI	Yael Ben Dror Email: ylibson@iai.co.il
ITTI Sp. z o.o.	ITTI	Andrzej Adamczyk Email: andrzej.adamczyk@itti.com.pl
Office National d'Etudes et de Recherches	ONERA	Jean-Claude Krapez Email: Jean-Claude.Krapez@onera.fr
Defendec Inc.	DEFENDEC	Jaanus Tamm jaanus.tamm@defendec.com
SONACA S.A.	SONACA	Robert Delogne Email: Robert.Delogne@sonaca.com
STM Savunma Teknolojileri Mühendislik ve Ticaret A.S.	STM	Özlem DENGİZEK Email: ozlem@stm.com.tr
Telekomunikacja Polska S.A.	TP	Jarosław Noskowski Email: Jaroslaw.Noskowski@telekomunikacja.pl
TTI Norte S.L.	TTI	David Gutierrez Email: dgutierrez@ttinorte.es
VTT Technical Research Centre of Finland	VTT	Ari Virtanen Email: ari.virtanen@vtt.fi
Politechnika Warszawska (Warsaw University of Technology)	WUT	Janusz Narkiewicz Email: jnark@meil.pw.edu.pl

4.2 Use and dissemination of foreground

According to Description of Work the Exploitation and Dissemination Plan was prepared at M30. TALOS is an integrated project, so at this stage of the project execution the Partners had already the clear view of prospective project results exploitation and dissemination.

During the whole project duration the public awareness of project status and prospects was achieved by updated web page and project presentations at various conferences, meetings and other fora. Two movies of project concepts and results were prepared and distributed among interested entities and placed on the project web site.

The project scientific results were presented at three important conferences: NavSup 2010, EuroGNC 2011 and EuroNav 2012. There was one paper published in referenced journal, and at least two are planned to be published based on the latest conference presentations. The Consortium presented system capabilities at two filed demonstrations for End User Advisory Board and other interested audience. The demonstrations proved the system existing capabilities and gave opportunities for discussing further developments and extension of applications. Many Partners declared further dissemination activities of project results after its completion.

The TALOS project offers a novel, innovative concept for border protection, based on autonomous ground and air vehicles, which will pave the way for further research and implementation of the system. The main features of the TALOS system are adaptability, scalability, transportability, semi-autonomous operation and autonomy from logistic point of view. The system may be deployed in any type of land border with and without ground infrastructure. The scalability allows to tailor the system to the type of terrain and the size of the protected area.

The trans European dimension of the project is reflected by the Consortium composition, which groups the research teams from countries from the "old EU", like Belgium, Finland, France, Greece and Spain, "new EU", like Estonia Poland and Romania and the "associated countries" like Israel and Turkey. Awareness of the TALOS project results in such a variety of countries makes good prospect for prospective commercialisation of the system.

TALOS system exploitation plan was based on the consortium expertise supported by End User Advisory Board (EUAB) and also by the opinions of other prospective users of the system met at various places, where TALOS system was presented. The respective Partners declared further use of project results in terms of commercially exploitable knowledge, improving scientific and technological quality, prospective product development. Also application of project results in education and in personnel skills development were envisioned.

Consortium is aware that complete TALOS system may be too complex solution for some of Border Guards across Europe. But the whole system and many technologies (subsystems or even specific solutions) developed in the TALOS project may be exploited by respective individually or in collaboration with other consortium members.

TALOS system is based on three main subsystems:

- Command, Control, Communication and Computer Centre (C4 ISR)
- Unmanned Platforms
- Communication.

The key challenges for C4 ISR subsystem in TALOS were coordination and control of different unmanned platforms. These required controlling and coordinating of data flow, effective planning based on open system architecture and well defined interfaces as well as use of 3D terrain models and maps.

In C4 ISR the examples of ***commercially exploitable knowledge*** are:

- Clock Synchronization Software (EBIC)
- 3D immersive visualization for complete situational awareness of unmanned systems (STM),
- Developing of add-ons and plug-ins for open-source GIS software to achieve new functionality and better integration (STM),
- Tree mapping from remote sensing imagery to realistic terrain visualisation and visibility calculations (VTT).

In terms of ***improving scientific and technological quality*** for C4 ISR Partners declared achieving

- Electro-optical and infrared (EO/IR) performance modelling and simulation (ONERA)
- Climatological / environmental impact studies on EO/IR sensors performances (ONERA)
- Optimization of advanced EO / IR sensors to meet customer requirements (ONERA)
- Tight integration with sensor data coming from unmanned systems (STM)
- Interface to JAUS middleware (STM)
- Improvements on easy of use characteristics of GIS tactical map module especially by giving a great situational awareness to the operator who also has a teleoperation responsibility (STM)
- Knowledge on patterns for more efficient data exchange between two distinct open source software namely WorldWind and uDIG (STM)
- Integration of Open Scene Graph (OSG), Open Dynamics Engine (ODE), Joint Architecture for Unmanned Systems (JAUS) and PostGIS/PostgreSQL database in virtual TALOS model (VTT, Defendec)

Prospective product development for C4 ISR

- Clock Synchronization Software (EBIC)
- Command post (shelter) integrated to an existing C2 system (HAI)
- 3D simulator for optics systems (ONERA)
- GIS supported command control systems including mission planning and execution (STM)
- Various security systems (STM)
- Situational awareness and resource management supported by desktop GIS software focusing on disaster management concept (STM)
- Strategy Computer Games (STM)
- Surveillance Systems (STM)
- A reusable GIS library with 2D and 3D capabilities (STM)

Specific for C4 ISR ***personnel skills and qualifications*** are

- Improving knowledge on climatological / environmental database and software (ONERA)
- Improving knowledge on advanced EO / IR technologies (ONERA)
- Experience on developing EO /IR sensors modelling (ONERA)
- Experience on working on an European project (ONERA)
- Experience on developing simulators (ONERA)

- Experience on developing software with different partners (ONERA)
- Experience on developing Software based on Eclipse RCP (Rich Client Platform) (ONERA).
- Discover of JAUS architecture (ONERA)
- Experience on using JAUS protocol to implements interoperability between subsystems (ONERA)
- Discover of OpenSceneGraph Library (ONERA)
- Experience in developing a user library base on OSG to generate 2D and 3D Images for simulators (ONERA)
- Knowledge on JAUS Architecture (STM).
- Experience on applying JAUS Reference Architecture in Command & Control of unmanned systems. (STM)
- Experience on development of 3D GIS Applications (STM)
- Effective Eclipse RCP development ability (STM).
- Experience on using uDIG as underlying desktop GIS infrastructure (STM).
- Experience on using GeoTools and JTS libraries and GDAL Tools (STM).
- Experience on setting up and using GeoServer. WMS concepts and advanced knowledge on performance improvements by tiling and caching (STM).
- Experience on setting up PostGIS/PostgreSQL database, interface description and testing (VTT)

The key challenges for **Unmanned Ground Vehicles (UGV) subsystems** in TALOS were localisation (especially without GPS, development of SLAM algorithms), path planning, data fusion and autonomous behaviour.

In Unmanned Ground Vehicles (UGV) subsystems the examples of ***commercially exploitable knowledge*** are:

- Virtual model for autonomous ground vehicle operation: training for UGV control, telecommunications network planning, mission/route planning and rehearsal, area recognition (VTT)
- New methods and algorithms for navigation sensors integrations (WUT)

In terms of ***improving scientific and technological quality*** for Unmanned Ground Vehicles (UGV) subsystems Partners declared:

- Improvement of laboratory equipment, software and procedures for mobile platforms navigation (WUT)
- Improve Engineering design abilities for robotics & autonomous surveillance systems (WUT)
- Vehicle control software (VTT)

Prospective product development for Unmanned Ground Vehicles (UGV) subsystems

- Support of new multisensors systems (WUT)
- Path planning (VTT)

Specific for Unmanned Ground Vehicles (UGV) subsystems application of project results in education and improvement of ***personnel skills and qualifications*** are

- Cooperation in development of Mobile Robots Excellence Centre in order to organize place for students for conducting experiments and writing thesis, based on the equipment developed in project as well as the test site created for project needs (PIAP)
- Experience transferred to university syllabuses (WUT).
- Theoretical knowledge, programming and hardware operation skills (WUT)
- Promoting the personnel's technological skills in the following disciplines: Project management, System Engineering, Software, Mechanical Engineering, Electrical Engineering (IAI)

The key challenge for **Communication subsystem** in TALOS was ensuring reliability, security, quality of service, performance, scalability, network management, compatibility of the radio end-systems and integration with external applications..
In communication subsystems the examples of ***commercially exploitable knowledge*** are:

- Software for probing QoS parameters in the transmission channel (ITTI)
- Software for switching among data streams in order to ensure reliable video streaming based on QoS measures of radio connections (ITTI)
- CDMA EV-DO standard based services with increased performance of (TP)
- Architecture design, deployment, management and exploitation of WiMAX networks for providing wideband communications (TTI)
- Handover algorithms for different radio access networks (TTI)

In terms of ***improving scientific and technological quality*** for communication Partners declared achieving

- Deeper knowledge about Qt programming (ITTI)
- Capability of handling of MPEG streams for programming purposes (ITTI)
- Better understanding of CDMA related issues (TP)
- Development of simpler handover algorithms for using them in scenarios where full Mobile IP protocol support is not required (TTI)
- Optimization of WiMAX Mobile Networks for rural NLOS scenarios (forests) (TTI).
- Enhancements to network planning of WiMAX and CDMA450 networks (VTT)
- Enhancements to real-time monitoring of WiMAX and CDMA 450 systems and use of application level QoS information (VTT, TTI)

Prospective communication ***product development*** may be

- Proxy server for nearly seamless switching of video streams transmitted through several and different radio interfaces (ITTI)
- Client-server software for nearly seamless switching of video streams transmitted through few different radio interfaces (ITTI)
- Intelligent & seamless handover tool (TTI)

Specific for communication area ***personnel skills and qualifications*** are

- Improving understanding of modern mobile systems (ITTI).
- Programming in Qt (ITTI).
- Handling video streams for programming (ITTI).

- Programming tools for QoS measurement (ITTI).
- Deeper knowledge about Qt programming (ITTI)

Participation in TALOS project led to **increased productivity of Partners** in the field specific for their expertise and activity (see Table below):

Partner	Increase of partner productivity / effectivity
Industrial Research Institute for Automation and Measurements (PIAP)	Application of best practices learnt during the project to improve project management skills for large projects
ITTI Sp. z o.o. (ITTI)	Experience from the project ITTI will use in other security projects. Experience in modern mobile systems. Elaboration of development process for IT solutions, especially in the domain of video streaming and probing of QoS in the radio transmission channel. Qt programming language. Open-source applications that can be developed in Windows OS. Experience in making project split among several partners. Software development using open-source tools and languages
Telekomunikacja Polska S.A. (TP)	The task is to provide backup facilities rather than contribute to the increase in productivity/ efficiency.
Warsaw University of Technology (WUT)	Improving education process at university level. Improving process of student participation in the research
Israel Aerospace Industries Ltd. (IAI)	The responsibility on work packages / interface to other work package leaders clears and improves the importance of communication based on engineering language (Design reviews / gating / development process) and provides a very good demo of dependent and the efforts to help partners.

Section A (public)

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[1] (if available)	Is/Will open access[2] provided to this publication?
1	*Compass deviation revisited*	*J.Narkiewicz, M. Żugaj*	*Annual of Navigation*	*No 16, 2010*	*Polish Academy of Science*	*Gdynia,Pl*	*2010*	*pp 75-89*	ISSN 1640-8632	no
2	Accelerometers application for rate sensing of rigid moving platform	J.Narkiewicz M.Szafrański	EuroGNC 2011	Conference CD	DGLR	Munich, D	2011			no

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
1.	Conference	HAI	9th Homeland & Corporate Security Conference & Expo –	16-17.03.2010	Athens, Greece	Scientific Community, Industry, Civil Society, Policy makers, Medias	900	International

[1] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).
[2] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

			EXPOSEC 2010					
2.	Fair, presentation	HAI	1st International Defence & Security Fair – DEFENSYS 2010	28-31.10.2010	Thessaloniki, Greece	Scientific Community, Industry, Civil Society, Policy makers, Medias	1000	International
3.	Conference	HAI	Electronic Monitoring Services for Identification and Control of Borders	24.01.2011	Athens, Greece	Scientific Community, Industry, Policy makers	200	Greece
4.	Presentation	HAI	Border Surveillance	02.02.2011	Athens, Greece	Civil Society, Policy makers	15	Greece
5.	Conference, poster	HAI	10th Homeland & Corporate Security Conference & Expo – EXPOSEC 2011	12-13.04.2011	Athens, Greece	Scientific Community, Industry, Civil Society, Policy makers, Medias	600	International
6.	Presentation	HAI	TALOS day	3.05.2011	Schimatari Viotias, Greece	Civil Society, Policy makers	15	Greece
7.	Conference, poster	HAI	11th Homeland & Corporate Security Conference & Expo – EXPOSEC 2012	28-29.02.2012	Athens, Greece	Scientific Community, Industry, Civil Society, Policy makers, Medias	400	International
8.	Conference		European Conference on Nanotechnologies	26 February 2010				
9.	Conference	ONERA	6th Future Security Research Conference	Sept. 5-7 2011	Berlin (Germany)	Scientific Community, Industry, Military, Civil Society, Policy makers	1000	65 countries
10.	Workshop	ONERA	Robots in the battlefield	Nov. 9-10, 2012	Guer (France)	Military	100	France
11.	Workshop	ONERA	Global Security Workshop, WISG 2012	January 24-25 2012	Troyes (France)	Scientific Community, Industry	450	France
12.	Workshop	ONERA	Borders and technology	April.19-20, 2012	Marseille (France)	Military, Policy makers	50	Europe

13.	Conference	ONERA	Infrared Imaging Systems: Design, Analysis, Modeling, and Testing Conference	April 23-27 2012	Baltimore (USA)	Scientific Community, Industry	6700	All
14.	Workshops	ASELSAN	NATO IST-072: Trust & Confidence in Autonomous Systems Workshop	18-21 November 2008	FL, USA	Industry		Turkey, UK, USA, Canada, Netherlands
15.	Fair	ASELSAN	IDEF International Defence Industry Fair	27-30 April 2009	Istanbul, Turkey	Policy Makers, Industry	50.000 visitor	45 countries from all over the world.
16.	Fair	ASELSAN	IDEF International Defence Industry Fair	10-13 May 2011	Istanbul, Turkey	Policy Makers, Industry	50.000 visitor	122 countries from all over the world.
17.	Conference	ASELSAN	SAVTEK	23-25 June 2010	Istanbul, Turkey	Scientific Community, Industry		Turkey
18.	Press Releases	ASELSAN	Hürriyet Newspaper	05 April 2009	Turkey	Medias	480.000 reader	Turkey
19.	Press Releases	ASELSAN	Hürriyet Newspaper	04 July 2012	Turkey	Medias	400.000 reader	Turkey
20.	Press Releases	ASELSAN	HaberTurk Newspaper	04 July 2012	Turkey	Medias	225.000 reader	Turkey
21.	Other: Project website www.ttinorte.es/en/?page_id=340	TTI	TALOS System	Since September 2011	TTI company website	Industry		Worldwide: two versions. Spanish and English
22.	Conference	VTT	European Conference on Nanotechnologies	26 February 2010				
23.	Publication	VTT	Virtual model for land border surveillance by mobile robots, in Scientific	2009	Otaniemi, Finland	Industry, VTT marketing	300	International

			activities in safety and security, yearly review magazine					
24.	Article published in the popular press	VTT	in Helsingin Sanomat, daily newspaper	2010	Finland	Civil society	380 000	Finland
25.	Article published in the popular press	VTT	Can a robot act as border guard? In Tekniikka ja Talous, weekly magazine	8 October 2010		Industry	96 000	Finland
26.	Presentation	VTT	3D terrain data pipeline to create content for virtual reality environments, in Remote sensing days 2010	4-5 November 2010	Espoo, Finland	Scientific community, Industry	180	Finland, Sweden, Norway, Denmark, Iceland
27.	Presentation	VTT	In Conference of Border Security, Technologies and Human rights, arranged by DETECTER project	11-12 May 2011	Turku, Finland	Scientific community, Industry	100	International
28.	Presentation Publication	VTT	Simulation models in the concurrent development of a land border surveillance robot system, at AutomationXIX seminar	15-16 March 2011	Helsinki, Finland	Industry, Scientific community	300	Finland
29.	Conference		European Conference on Nanotechnologies	26 February 2010				
30.	Flyers and posters about TALOS Project was distributed in IDEF 2009 9th International Defence	Turkish Armed Forces Foundation	IDEF '09 9th International Defence Industry	27-30 April 2009	Istanbul, Turkey	Industry, Civil Society, Policy makers, Medias		

	Industry Fair.	under the auspices of the Ministry of National Defence	Fair					
31.	TALOS Project has been introduced by STM Project Manager in one of the panels of IT Solutions in Defence Industry	International Conference	Bilişim Zirvesi 2009	7-11 October 2009	İstanbul, Turkey	Scientific Community (higher education, Research)		
32.	STM participated in the poster session of the FOSS4G conference with TALOS Project.	International Conference	FOSS4G 2010 (Free and Open Source Software for Geospatial)	6-9 September 2010	Barcelona Spain	Scientific Community (higher education, Research)		
33.	TALOS project presentation has been distributed by TÜBİTAK, Turkish FP7 National Contact Point	International Conference and Exhibition	ICT 2010	27-29 September 2010	Brussels,Belgium	ICT 2010 is organised by the European Commission and hosted by the Belgian Presidency of the European Union. Researchers from all parts of Europe and beyond presented their latest work in upstream ICT innovation as well as close-to-market projects. There were participants from research institutes, ICT companies, universities, public authorities and non-profit organisations.		
34.	TALOS project posters were displayed.	The Info Day was conducted by Turkish Undersecretariat of Defense.	"European Initiatives On Security Research And Technology For Industry" Info Day	23th November 2010	Ankara, Turkey	Industry, Policy makers		
35.	Brochures of TALOS Project were distributed.		IDEX 2011 (The International Defence	20-24 February 2011	Abu Dhabi, United Arab Emirates	The International Defence Exhibition and Conference (IDEX) is		

			Exhibition and Conference 2011)			the largest defence and security event in the Middle East and North African region.		
36.	Brochures of TALOS Project were distributed.	International Fair	IDEF '11 10th International Defence Industry Fair	10-13 May 2011	İstanbul, Turkey	Industry, Civil Society, Policy makers, Medias		
37.	Brochures of TALOS Project were distributed.	International Exhibition	DSA Exhibition	April 2012	Kuala Lumpur, Malaysia	One of the biggest Defense Exhibition in Far East Region.		
38.	Conference The Future of Aerospace – Unmanned Vehicles & Systems	WUT	Systems for ground and flying robots	27 October 2011	Torino, Italy	Industry, Scientific	60	EU, USA, others
39.	Conference EuroNav 2012	WUT	Talos Navigation Research Electric Car	25-27 April 2012	Gdańsk, PL	Scientific, Industry	40	EU, USA, others
40.	Conference EuroNav 2012	WUT	Novel Approach to Odometer Technology	25-27 April 2012	Gdańsk, PL	Scientific, Industry	40	EU, USA, others
41.	Expo&Conf.	EBIC	BSDA2008	24 - 26 Sept.2008	Romania, Bucharest			
42.	Conference	EBIC	GSA GNSS	18 - 22 Feb. 2009	Belgium, Brussels			
43.	Competition Conference	EBIC	ESNC2010	18 - 19 May 2010	Germany, Munich			
44.	Expo&Conf.	EBIC	BSDA2010	13 - 15 April 2010	Romania, Bucharest			
45.	Expo&Conf.	EBIC	AEROSPACE DAYS - 2011	12 - 13 Oct. 2011	France, Paris, Orly-Airport			
46.	National Forum RTD	EBIC	Sustainable Innovation	31 May 2012	Romania, Pitesti, Arges			
47.	EC Infoday FP7 Call	EBIC	INFODAY FP7 2012	09 July 2012	EC in Romania, Bucharest			

Section B (Confidential[3] or public: confidential information to be marked clearly)
Part B1

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[4]:	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)
COPYRIGHT	YES	31 May 2012	Not Available	Mobile Network Clock Synchronization Software	EUROPEAN BUSINESS INNOVATION & RESEARCH CENTER S.A.

[3] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[4] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

Part B2

Type of Exploitable Foreground[5]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[6]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
Software Product	TALOS Tactical Map Software	No	No	Software Product	Information Systems		-	STM
Software Product	uDIG based GIS Library	No	No	Software Product	Information Systems		-	STM
Software Product	Screen Logging and Replaying Application	No	No	Software Product	Information Systems		-	STM
General advancement of knowledge	Vehicle control software	No		Vehicle control software	C.29 - Manufacture of motor vehicles, trailers and semi-trailers	-	-	VTT
General advancement of knowledge	Path planning software	No		Path planning software	C.29 - Manufacture of motor vehicles, trailers and semi-trailers	-	-	VTT
Commercial exploitation of R&D results	Virtual model for autonomous ground vehicle operation: training for UGV	No		Talos Virtual model	C.29 - Manufacture of motor vehicles, trailers and semi-trailers J.61.2 - Wireless telecommunicat	2015	Licencing is planned for 2014	VTT

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.
[6] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

Type of Exploitable Foreground[5]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[6]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
	control, network planning, mission/route planning and rehearsal, area recognition				ions activities R.93 - Sports activities and amusement and recreation activities			
Commercial exploitation of R&D results	Tree mapping from remote sensing imagery to realistic terrain visualisation and visibility calculations	No		Tree mapping software	J.61.2 - Wireless telecommunications activities F.42 - Civil engineering R.93 - Sports activities and amusement and recreation activities	2015	Licencing is planned for 2013	VTT
General advancement of knowledge	A tool for network planning of WiMAX and CDMA450 networks	No		Enhancements to NPT software	J.61.20 - Wireless telecommunications activities	-	-	VTT
General advancement of knowledge	Real-time monitoring of WiMAX and CDMA 450 systems and use of application	No		Enhancements to NPT and QosMet softwares	J.61.20 - Wireless telecommunications activities	2013 (TTI part)	-	VTT TTI

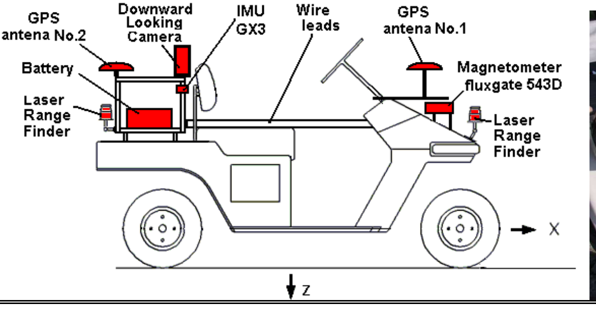
Type of Exploitable Foreground[5]	Description of exploitable foreground	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Exploitable product(s) or measure(s)	Sector(s) of application[6]	Timetable, commercial or any other use	Patents or other IPR exploitation (licences)	Owner & Other Beneficiary(s) involved
	level QoS information							
Advancement of knowledge	*New algorithms for integration of sensors in navigation systems*	*YES*	*Until published*		*M72* Scientific research and development			*WUT*
General advancement of knowledge	Electric car with integrated navigation sensors	NO		Field test laboratory for navigation systems algorithms	*M72* Scientific research and development			*WUT*
Commercial exploitation of R&D results	New Mobile Network Clock Synchronization Software	YES	31 May 2012	IT product as new software	1. Robotics 2. Transport 3. Space 4. Aeronautics 5. Agriculture 6. Environment	*2012 - 2020*	*COPYRIGHT Licences is planned for 2012 - 2020*	*Beneficiary EBIC (owner/producer)*

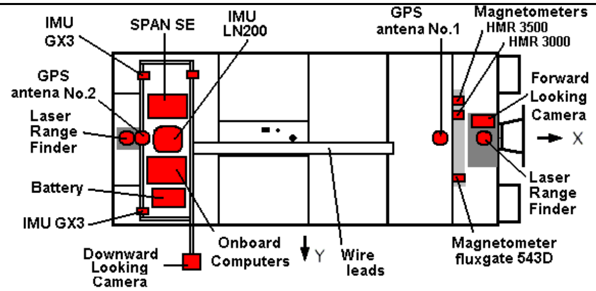
Additional template B2: Overview table with exploitable foreground

Description of exploitable foreground	Explain of the Exploitable Foreground	Owner & Other Beneficiary(s) involved
TALOS Tactical Map Software	This software includes TALOS specific properties and functionalities. It has custom layers with their domain specific behavioral and visual properties. Visualization and tracking of unmanned vehicles with providing their real time location, direction, speed, track history information on the map. Visualization and tracking of radar signals and manual fusion of them to identify intruder entities. Mission and tasks can be displayed on the map and their geospatial properties can be edited by using the map windows. The software can evaluate the incoming sensor data in point of their geospatial aspects and can generate alerts to the mission planning and control software, such as approaching to a dangerous zone or entering to/exiting from an operation area. It also uses JAUS specific messaging infrastructure for communicating with a geospatial database. By thinking these properties of the software, it’s possible to say that this software can be reused and improved to be used in a future mission planning and control system for unmanned vehicles based on TALOS concepts. It is also possible to use this software as a sample prototype for developing a GIS software for other domain areas such as unmanned systems, security, disaster management, search and rescue operations, transportation, logistics, vehicle tracking/navigation and fleet management.	STM
uDIG based GIS Library	This software uses uDig as the base GIS framework. Main properties are visualization and editing of the geospatial static or moving objects on a 2D map, visualization of raster images by communicating with WMS servers compatible with OGC standards. An extensible layer management and periodic map update infrastructure and geospatial analysis functionality are included in this software. This software uses an OSGi framework based on Eclipse RCP for service oriented communication with other software plugins. By thinking of this features, it’s possible to say that this software can be reused and integrated with or within any other host software developed by using Java and OSGi framework. So, it can be used in a wide range of domain areas such as unmanned systems, security, disaster management, search and rescue operations, transportation, logistics, vehicle tracking/navigation and fleet management. This GIS library development also involves the development of a 3D map visualization module based on NASA WorldWind. But, because of resource limitations, this module couldn’t reach to enough stability. So, in the future this software can be the base library or a sample prototype for designing and developing an improved GIS library with 3D support.	STM

Description of exploitable foreground	Explain of the Exploitable Foreground	Owner & Other Beneficiary(s) involved
Screen Logging and Replaying Application	This software can be used as a screen recorder for capturing all the mission planning and execution processes as video data. This data can be used as training or mission debriefing purposes. Since this software is not so specific to TALOS system and not dependent to any other TALOS software, it can be used for any area requiring the capturing the operator console displays during a session and replaying the session at any time after its finish.	STM
Vehicle control software	The vehicle control software is a real-time linux based closed loop system to the low level control of the UGV. The main part is the waypoint driver to steer the UGV by given waypoints. Potential users are the work machine manufacturers.	VTT
Path planning software	The path planning software calculates the optimal route from a terrain grid with cells weighted by the properties of the terrain, land cover, elevation, soil etc. Further development is needed to integrate all relevant parameters to the grid cells and test the optimal weights to the parameters.	VTT
Virtual model for autonomous ground vehicle operation: training for UGV control, network planning, mission/route planning and rehearsal, area recognition	TALOS Virtual model includes the 3D terrain map, virtual tactical components, a UGV model with realistic dynamics model and radio propagation models. It was built to assist in system development phase for distributed software development, interface testing and the testing of UGV dynamic behaviour, before the deployment of the real UGVs. In preoperation phase it is used in new area recognition, the planning and rehearsal of missions, radio network planning (NPT software), personel training for UGV control and steering (ODE software) , and route planning and rehearsal. During operation the virtual model keeps track and monitors the motion of the real UGV's by JAUS messages from TALOS PostGIS/PostgreSQL database. The 3D visualisation of the virtual model is developed on OpenSceneGraph modules. Besides TALOS border guarding application, the virtual model could be used in training and rehearsal in other applications where UGV's are used, for instance in mapping of disaster or other dangerous areas. Further development could include the correlation of the imagery taken by cameras and scanners installed on the TALOS UGV to the 3d terrain map to enable non-GPS based navigation (to fix the drifting error generated by sensors that are using relative positioning). This information could be used also to refine or even generate new 3D terrain maps along the	VTT

Description of exploitable foreground	Explain of the Exploitable Foreground	Owner & Other Beneficiary(s) involved
	UGVs' path.	
Tree mapping from remote sensing imagery to realistic terrain visualisation and visibility calculations	The environment or the terrain of the virtual model was targeted to be as realistic as possible and correspond to the real operation (demonstration) environment. The tree mapping software of VTT was enhanced to TALOS requirements to create as accurate locations of the trees as possible to the virtual model. It estimates the tree locations and tree parameters from remote sensing imagery. Potential end users are all parties requiring realistic 3D terrain maps and visualisations over large area, because the tree layer is changing constantly and need frequent updates with automatic methods: municipalities, forest industry, recreational area administrators and users, defence, wireless system operators.	VTT
A tool for network planning of WiMAX and CDMA450 networks	The radio network of the operation area is planned by the NPT software. It calculates the radio coverage map based on basestation location, parameters of the telecommunication system and the 3D terrain map of the area. Different scenarios are calculated to select the optimal basestation location and parameters. The resulting radiocoverage map is then used in route and mission planning.	VTT
Real-time monitoring of WiMAX and CDMA 450 systems and use of application level QoS information	The QoSMET software is used for real time quality monitoring of the data transmission and alarm for radiocoverage limits. Further development is needed in the handover functionality and the down scaling of the traffic in case of limited bandwidth. QoS monitoring could be used more efficiently to prioritize traffic and to cut-off low priority connecti	VTT TTI
New algorithms for integration of sensors in navigation systems	The new algorithms for integration of navigation sensor measurements were developed concerning mainly: application of accelerometers for rate sensing, on-line monitoring of magnetic deviation of magnetic compasses and magnetic course correction, odometer technology for non-flat surfaces, supporting odometer and GPS measurements by vehicle model, laser range measurements and obstacle avoidance. The algorithms may be available / extended to other types of mobile platforms like sea vessels, ground and air vehicles. For research purposes the navigation sensors were placed on WUT electric cart used for field measurement.	*WUT*

Description of exploitable foreground	Explain of the Exploitable Foreground	Owner & Other Beneficiary(s) involved
Electric car with integrated navigation sensors	 The cart (fig) is equipped with sensors (fig) acquired during TALOS project such as two antenna GPS receiver integrated with high INS unit, four low cost INS sensors, two magnetoresistive magetometers, one flux gate compass, two laser range and direction sensors (in front and rear of the),looking-down camera operating in visible light with autonomous visual signal processing system . Some sensors were multiplied for investigation of signals redundancy. There are two on-board computers for signal processing and integration. The cart may be controlled by operator or remotely.  	*WUT*

Description of exploitable foreground	Explain of the Exploitable Foreground	Owner & Other Beneficiary(s) involved
	  The main application of the vehicle after TALOS will be research projects in unmanned vehicles and for education purposes as mobile laboratory for students lecturing, projects and thesis.	
New Mobile Network Clock Synchronization Software	New Mobile Network Clock Synchronization Software	EBIC (owner/producer)

4.3 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A	**General Information** *(completed automatically when **Grant Agreement number** is entered.*
Grant Agreement Number:	218081
Title of Project:	Transportable Autonomous patrol for Land bOrder Surveillance
Name and Title of Coordinator:	Dr Eng Mariusz Andrzejczak

B Ethics	
1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***YES***
2. (tick box) :	***YES***
RESEARCH ON HUMANS	
• Did the project involve children?	
• Did the project involve patients?	
• Did the project involve persons not able to give consent?	
• Did the project involve adult healthy volunteers?	
• Did the project involve Human genetic material?	
• Did the project involve Human biological samples?	
• Did the project involve Human data collection?	
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	
• Did the project involve Human Foetal Tissue / Cells?	
• Did the project involve Human Embryonic Stem Cells (hESCs)?	
• Did the project on human Embryonic Stem Cells involve cells in culture?	
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	
• Did the project involve tracking the location or observation of people?	
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	
• Were those animals transgenic small laboratory animals?	
• Were those animals transgenic farm animals?	
• Were those animals cloned farm animals?	

• Were those animals non-human primates?	
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	
DUAL USE	**YES**
• Research having direct military use	Yes
• Research having the potential for terrorist abuse	Yes

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	3	4
Work package leaders	2	9
Experienced researchers (i.e. PhD holders)	8	73
PhD Students	0	16
Other	39	121

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**22**
Of which, indicate the number of men:	22

D Gender Aspects

5.	**Did you carry out specific Gender Equality Actions under the project?**	X ○	Yes No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
X	Design and implement an equal opportunity policy	○	○	○	X	○
X	Set targets to achieve a gender balance in the workforce	○	○	○	○	X
❑	Organise conferences and workshops on gender	○	○	○	○	○
❑	Actions to improve work-life balance	○	○	○	○	○
○	Other:					

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

○ Yes- please specify

X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

○ Yes- please specify

X No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

○ Yes- please specify

X No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

○ Main discipline[7]: 2.3

○ Associated discipline[7]: 1.1 | ○ Associated discipline[7]: 2.2

G Engaging with Civil society and policy makers

11a	**Did your project engage with societal actors beyond the research community?** *(if 'No', go to Question 14)*	X ○	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

X No
○ Yes- in determining what research should be performed
○ Yes - in implementing the research
○ Yes, in communicating /disseminating / using the results of the project

[7] Insert number from list below (Frascati Manual).

11c	**In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?**	○ X	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- X Yes- in framing the research agenda
- X Yes - in implementing the research agenda
- X Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- X Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise Environment External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy Research and Innovation Space Taxation Transport	

13c If Yes, at which level? ○ Local / regional levels ○ National level X European level ○ International level	

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?			**2**
To how many of these is open access[8] provided?			**0**
How many of these are published in open access journals?			**0**
How many of these are published in open repositories?			**0**
To how many of these is open access not provided?			**2**
Please check all applicable reasons for not providing open access:			
X publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[9]: ……………			
15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*			**0**
16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).		Trademark	**0**
		Registered design	**0**
		Other	**1**
17. How many spin-off companies were created / are planned as a direct result of the project?			**0**
Indicate the approximate number of additional jobs in these companies:			**0**

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

X	Increase in employment, or	X	In small & medium-sized enterprises
❑	Safeguard employment, or	X	In large companies
❑	Decrease in employment,	❑	None of the above / not relevant to the project
❑	Difficult to estimate / not possible to quantify		

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*

[8] Open Access is defined as free of charge access for anyone via Internet.
[9] For instance: classification for security project.

Difficult to estimate / not possible to quantify	X

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

X Yes ○ No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes X No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

X	Press Release	X	Coverage in specialist press
X	Media briefing	X	Coverage in general (non-specialist) press
X	TV coverage / report	X	Coverage in national press
X	Radio coverage / report	X	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
X	DVD /Film /Multimedia	X	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

X	Language of the coordinator	X	English
X	Other language(s)		

Question F-10: Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]