SIXTH FRAMEWORK PROGRAMME
PRIORITY 2
INFORMATION SOCIETY TECHNOLOGIES

Contract for:

SPECIFIC TARGETED RESEARCH OR INNOVATION PROJECT

Annex I - "Description of Work"

Project acronym: **AWARE**
Project full title: **platform for Autonomous self-deploying and operation of Wireless sensor-actuator networks cooperating with AeRial objEcts.**
Proposal/Contract no.: 33579
Related to other Contract no.: *(to be completed by Commission)*

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1. Project Summary

The general objective of the project is the design, development and experimentation of a platform providing the middleware and the functionalities required for the cooperation among aerial flying objects, i.e. autonomous helicopters, and a ground sensor-actuator wireless network, including mobile nodes carried by people and vehicles. The platform will enable the operation in sites with difficult access and without communication infrastructure. Then, the project considers the self-deploying of the network by means of autonomous helicopters with the ability to transport and deploy loads (communication equipment and nodes of the ground network).

To reach the above mentioned main goal, the project has the following technical objectives:

1) Develop a scalable and self-organizing ground sensor network;
2) Develop the architecture and middleware required for the cooperation of the heterogeneous objects including aerial vehicles, static sensor-actuator nodes, and mobile nodes carried by ground vehicles and people;
3) Develop network-centric functionalities for the system operation, including the development of perception techniques and the reliable co-operation based on the explicit consideration of the main sources of failures in the network operation;
4) Develop new cooperation techniques for tasks requiring strong interactions among vehicles and between vehicles and the environment, such as lifting and transporting the same load with several UAVs.

In order to verify the success in reaching the objectives, the project considers the validation in two different applications: Filming dynamically evolving scenes with mobile objects and Civil Security/Disaster Management. Three general experiments in a common scenario will be conducted in order to integrate the system and test the functionalities required for the above validations.

The expected results and techniques will be transferable to many potential applications involving wireless networking of heterogeneous objects.

2. Project objective(s)

2.1 Project context and goals.

This project is devoted to the design, development and experimentation of a platform providing the middleware and the functionalities required for the cooperation among aerial flying vehicles and a ground sensor-actuator wireless network with mobile nodes. The platform will offer the self-deploying, self-configuration and self-repairing features by means of the cooperation of autonomous helicopters. These features are very relevant in natural and urban environments without pre-existing infrastructure or when this infrastructure is damaged or even completely destroyed. Two validation scenarios are considered: Filming, and Disaster Management/Civil Security applications. The consortium consists of seven complementary partners, with four outstanding institutions that are playing an important role in several European initiatives in the field, and three companies (including one SME) with significant industrial capabilities, that will exploit the results in different sectors: Filming, Disaster Management and Civil Security.

In recent years significant progress in autonomous aerial vehicles [33] and wireless sensor networks [17] has been experienced. The aerial and remotely piloted vehicles are now able to be coordinated for missions such as the detection and monitoring of events [34]. On the other hand, wireless sensor networks with static nodes have been developed and also experimentally applied for detection and monitoring activities [11], [27]. However, static wireless sensor networks have important limitations as far as the required coverage and the short communication range in the nodes are concerned. The use of mobile nodes could provide significant improvements. Thus, they can provide the ability to dynamically adapt the network to environmental events and to improve the network connectivity in case of static nodes failure. Moreover, mobile nodes with single-hop communication and the ability to recharge batteries, or refuelling, have been proposed as data mules of the network saving energy in static node communications [37].

However, in many scenarios, the motion of the mobile nodes installed on ground vehicles or carried by persons is very constrained, due to the characteristics of the terrain or the dangerous conditions involved. These scenarios can be found in civil security and disasters, but also in other applications such as cinematography and documentary filming, particularly in dangerous sites (fires, volcano eruptions, and other risky scenarios). In these scenarios, the use of aerial autonomous and remotely piloted vehicles is very suitable. The cooperation of these aerial vehicles with the ground wireless sensor network offers many potentialities.

It should be noted that flight endurance and range of the currently available low cost unmanned aerial vehicles is very constrained. Moreover reliability and fault-tolerance is a main issue in the cooperation of the aerial vehicles. Furthermore, these autonomous vehicles need communication infrastructure to cooperate or to be tele-operated by humans in emergency conditions. Usually this infrastructure is not available, or the required communication range is too large for the existing technology. Then, the deployment of this communication infrastructure is a main issue. In the same way, in most wireless sensor networks projects, it is assumed that the wireless sensor network has been previously fully deployed without addressing the problems to be solved when the deployment is difficult. Moreover, it should be noted that, in the operation of the network, the infrastructure could be damaged or simply the deployment is not efficient enough. Then, the problem is the repairing of the coverage or the connectivity of the network by adding suitable sensor and communication elements.

The implementation of a system integrating UAVs, mobile ground nodes, and the wireless sensor network requires the development of an appropriate middleware that facilitates the communication allowing the topology changes and simplifying the application development in particular scenarios.

Detailed studies of the state of the technology have been conducted in the framework of the Embedded Wisents IST Coordination Action. These studies are: Applications and Application Scenarios, Paradigms for Algorithms and Interactions, Vertical System Functions and System Architecture and Programming Models. These studies, point out that currently there are no available technologies to deal with the above scenarios. This proposal will contribute to fill the identified gaps by providing technologies required for these applications.

2.2 Project objectives.

The general objective of the project is the design, development and experimentation of a platform providing the middleware and all the functionalities required for the cooperation of aerial flying objects, i.e. autonomous helicopters, with a ground sensor-actuator wireless network, including ground mobile nodes carried by persons and vehicles. The platform will enable the operation in sites with difficult or impossible access and without communication infrastructure. Then, the project considers the self-deploying of the network by means of autonomous helicopters with the ability to transport and deploy loads (communication equipment and nodes of the ground network).

The project presents the following innovations:

i) It will develop an unprecedented self-organising platform for the reliable fault-tolerant cooperation, over a wireless network, of a team of heterogeneous objects involving aerial objects, static ground sensors, and ground mobile nodes carried by persons and vehicles, in a dynamically evolving scenario. Furthermore, the wireless network will have special purpose actuators such as pan and tilt devices for pointing cameras or even to generate actions on the environment (i.e. fire extinguishers). Reliability and fault tolerance will be addressed by exploiting redundancies in objects and functionalities. No other platform with all the above mentioned characteristics has been identified.

ii) The project will go beyond telecommunication ad-hoc networks. It involves the middleware and the cooperation of aerial objects, mobile nodes carried by persons and ground vehicles, and static nodes.

iii) The project addresses the dynamic adaptation of the network and the repairing of the coverage and connectivity by using a fleet of autonomous helicopters. Only preliminary studies involving the deployment of sensor nodes by means of a single helicopter can be found.

iv) It will implement new cooperative fault-tolerant network-centric aerial/ground-based perception techniques for object and event recognition providing reactivity to changes in the environment. This represents a natural extension of the previously developed cooperative perception tools based on aerial sensing. In this project the ground nodes will be considered and a fully distributed network-centric approach will be adopted.

v) It considers the self deploying of the network by means of autonomous helicopters with the ability to transport and deploy loads (communication equipment and nodes of the ground network). This is a unique feature that has not been identified in any other project. In fact, the joint transportation of a load by several helicopters has been considered in simulation only for two helicopters, but never has been addressed for more than two helicopters and never has been implemented. The joint transportation is justified due to the strong payload limitation of individual low cost UAVs, and the very high cost of helicopters with sufficient payload capacity required to transport the entire infrastructure needed to deploy the network.

To reach the above mentioned main goal, the project has the following supporting technical objectives:

1. Develop a scalable and self-organizing ground sensor network integrating mobile nodes and including not only low energy and light sensors (motes) but also cameras and other sensors with higher energy requirements. This objective will be addressed in Workpackage WP3 “Ground wireless sensor network” of the Workplan.
2. Develop the architecture and middleware required for the cooperation of the heterogeneous objects including aerial vehicles, static sensor-actuator nodes, and mobile nodes carried by ground vehicles and persons. The middleware will make the communication among these heterogeneous nodes transparent even if its topology changes. Such a middleware adds a level of abstraction in order to simplify application development. This objective will be addressed in the Workpackage WP2 “Architecture and Middleware” of the Workplan.
3. Develop network-centric functionalities for operation. The project will include the development of perception techniques required for the operation of the network, including surveillance, localisation and tracking. Furthermore, reliable co-operation strategies based on the explicit consideration of the main sources of failures in the operation of the network will be considered. Thus, reliability tools based on the use of multiple UAVs and the sensor network will be developed. Particularly, the UAV communication breakdowns and GPS degradation will be considered by exploiting redundancies in communication and environment perception. This objective will be addressed in the Workpackage WP5 “Functionalities for the operation” of the Workplan.
4. Develop new cooperation techniques for tasks requiring strong interactions between vehicles and between vehicles and the environment, such as lifting and transporting by means of the cooperation of several UAVs carrying the same load. This objective will be addressed in the Workpackage WP4 “Self-deployment with co-operative UAVs” of the Workplan.

The relation between the above technical objectives and the Workpackages is also shown in Table 7.1 of section 7.

In order to verify the success in reaching the objectives, the project considers the validation in two different applications:

1) Filming dynamically evolving scenes with mobile objects. Particularly cooperative object tracking techniques by using the cameras in aerial objects cooperating with cameras on the ground will be applied. Furthermore, this activity will involve sensors carried by mobile entities (people, vehicles …) to obtain measures that could also be displayed in the broadcast picture.
2) Disaster Management/Civil Security, involving exploration of an area of interest, detection, precise localisation, deployment of the infrastructure, monitoring the evolution of the objects of interest, and providing reactivity against changes in the environment and the loss of the required connectivity of the network. It will include actuators, such as fire extinguishers, to generate actions in real-time from the information provided by the sensors.

Three general experiments, one every project year, in a common scenario will be conducted in order to integrate the system and test the functionalities required for the above validations. These experiments will involve the wireless ground sensor network with mobile nodes, the UAVs, the middleware, the network-centric cooperation of the UAVs with the ground sensor network, and the self-deployment functionality.

Then, the project will be driven by two very innovative applications. Furthermore, it will develop and combine a number of cutting edge technologies, such as the development of the middleware, self-deployment strategies, and the network-centric cooperation methods. The expected results and techniques seem transferable to many potential applications involving wireless networking of heterogeneous objects.

Figure 2.1 illustrates the approach.

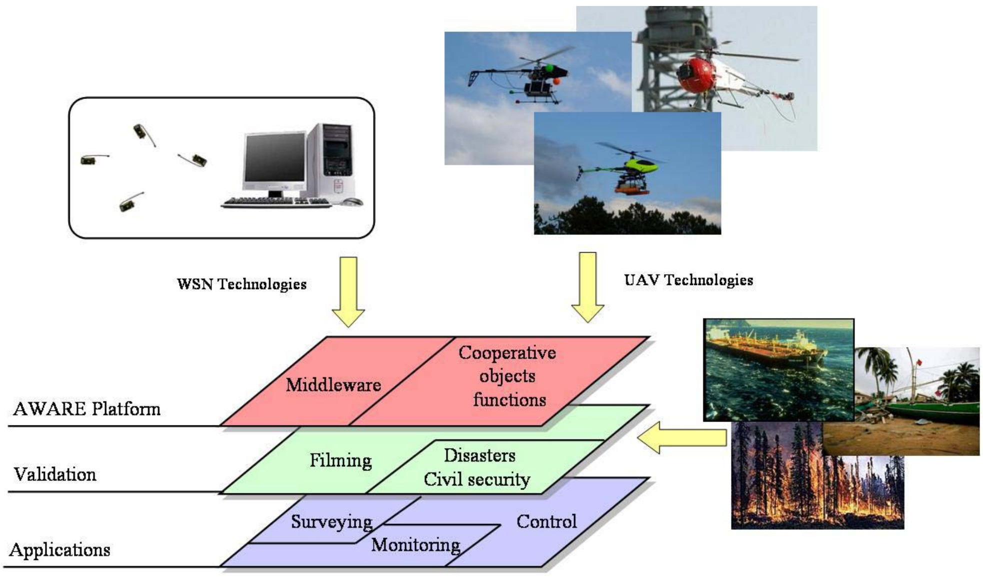


Figure 2.1: AWARE Technologies.

AWARE will enable the integration of the results produced in successful European projects recently concluded. Thus, the IST 2001-34304 COMETS project [34], concluded last June 30, led by the coordinator of this proposal with the participation of another partner, has been the first European project on the coordination and control of multiple heterogeneous UAVs. In AWARE the concepts and architecture of COMETS will be used. However, a different decentralized network-centric approach will be adopted (see section 7 for details). Furthermore, some national projects on the cooperation of aerial and ground autonomous vehicles have been carried out in Spain and Germany being led by the AWARE partners. This is the case of the CROMAT Spanish project led by the coordinator of AWARE or a German DFG project on joint lifting and transporting loads by means of several helicopters where the theoretical issues have been developed and the feasibility of the joint transportation has been demonstrated by means of a laboratory experimental setup. In AWARE an outdoor system for the autonomous self-deploying will be developed, including the development of a new distributed embedded control system for the cooperation of the helicopters (see section 7).

As far as WSN are concerned, the Eyes IST-2001-34734 project has been led by one of the AWARE partners. In this project, significant results on energy efficient sensor networks have been produced. This partner is also the leader of the Dutch project Smart Surrounding (15 large research groups) devoted to investigate, define, develop, and demonstrate the core architectures and frameworks for future Ambient Systems. The same partner is coordinator of the Dutch project CONSENSUS on fundamental and distributed aspects of distributed collaboration algorithms. Another partner of AWARE has been involved in the project CarTALK 2000 dealing with the interaction between vehicles, whose main target was to develop cooperative driver assistance systems and self-organizing ad hoc radio networks with very high dynamic topologies. Another European initiative is the above mentioned Embedded Wisents Coordination Action on WSN and cooperating objects [29]. This action, in which three AWARE partners are actively involved, has deeply analysed the state of the technology and will produce the European Road Map.

The above projects and the current state of the technology that will be further analysed in section 5 define the baseline of AWARE. This project is a unique opportunity to benefit from their results of in an ambitious joint effort that will go beyond the state of the technology producing a platform with unprecedented capabilities.

2.3 Assessment of Project Progress.

Self-assessment procedures of the project will be applied by the Consortium to verify the progress towards the achievement of its goal and final success. It should be noted that the Project management (see section 6) includes the development and implementation of the Quality Management System for monitoring project development, review Deliverables and conducts audits processes.

The general Milestones of the project defined in section 7 can be also used as external Milestones. The Table M1 indicates these Milestones and the expected results.

Table9.1: Milestones and expected results.

Milestone	Date	Expected result
Milestone 1	T0	Kick-off meeting.
Milestone 2	T0+6	Specification review.
Milestone 3.	T0+12	First critical review: Design, simulations and first year experiments
Milestone 4	T0+24	Second critical review: Developments and second year experiments
Milestone 5	T0+32	Integration review: Subsystems and integrated platform.
Milestone 6.	T0+36	Final platform and final experiments

The project starts with the Kick-off meeting, which is the first Milestone (M1) of the project. The second Milestone (M2) is defined by the Specifications with the Deliverables D3, D4 and D5 in t0+6. At this point the development tasks will be launched.

The general yearly experiments will provide important inputs and will be also associated to Milestones of the project. Then, after the first and second general experiments, the project will have critical reviews that define the Milestones M3 (t0+12) and M4 (t0+24). Milestone M5 (t0+32) is defined by the integration of the system (Deliverable D27), two months later than the completion of the Workpackages WP3 Ground Wireless Sensor Network, WP4 Self-deployment with co-operative UAVs, and WP5 Functionalities for the operation and their corresponding Deliverables.

The final Milestone M6 is at the end of the project, after the final experiments.

The success criteria of the project are the fulfilment of the project objectives formulated in section 2 of this Annex. Then, as far as the general objective of the project is concerned, AWARE will be a success if it concludes with a platform providing the middleware and functionalities required for the cooperation of aerial vehicles between them and with a wireless ground network, including mobile nodes carried by persons and vehicles. Furthermore, the project includes the development of the self-deployment ability by means of autonomous helicopters transporting sensor nodes. Then, the project will be a full success if the following criteria, related to the four supporting technical objectives in section 2, are fulfilled:

- Development and validation in the experimentation scenario of the architecture and middleware making the communication between UAVs and ground static and mobile nodes fully transparent.
- Development and validation in the experimentation scenario of the ground sensor network. A number of nodes will be mobile, transported by people and vehicles. Furthermore, the integration of nodes transported by UAVs should be possible. This network should be able to support the cooperative functionalities.
- Development and validation in the experimentation scenario of a self-deployment system based on the lifting and transporting of loads (i.e. sensor nodes) by means of at least two helicopters carrying the same load.
- Development and validation in the demonstration scenario of functionalities for the co-operation. The functionalities will include surveillance, localisation and tracking. Moreover, tools to improve the reliability in case of communications breakdown and GPS degradation will be also developed.

An additional success criterion will be the assessment about the relevance of the platform for filming applications, and Disaster Management/Civil Security applications.

Finally, a success criterion will also be the development of the dissemination and exploitation activities described in the Workplan.

The progress towards the achievement of the above objectives will be based on the fulfilment of the activities described in table 9.2.

Table 9.2 Progress towards the achievement of the objective of the project

	T0+6	T0+12	T0+24	T0+36	Partners
WP1	- Definition and implementation of Coordination mechanisms. - First Intermediate Report - Milestones M1 and M2	- Activity Report. - Management Report. - Milestone M3.	- Intermediate Report - Activity Report. - Management Report. - Milestone M4.	- Intermediate Report. - Activity Report. - Management Report. - Final Report. Milestones M5.and M6	Responsible: AICIA. Others: TUB, FC, UT, USTUTT, SE.
WP2	Platform specification				Rsponsible: SELEX. Others: AICIA,

					TUB, FC, UT, USTUTT, ITU.
WP2		Design of the middleware and communication	- Implementation of middleware for WSN shown in simulation (t0+18) - Implementation of middleware for WSN, using actual hardware	- Implementation of integrated UAV-WSN system, shown in simulation (t0+30). - Integration document, describing the system with actual hardware (t0+32) - Validation using actual hardware	Responsible: USTUTT. Others: AICIA, TUB, FC, UT, SE, ITU
WP2		- Design of UAV cooperation techniques.	- UAV cooperation techniques. - Cooperation between 2 UAVs shown in simulation (t0+18). - Simulation of co-operation of 3 or more UAVs.		Responsible: AICIA. Others: TUB, FC, USTUTT,
WP3	- Ground Sensor Network/nodes Specification - Overall architecture	- Design of protocols - Providing support for mobility and heterogeneity, adaptability - Simulation of some protocols	- Implementation of Protocols - Initial implementation of integrated mobile and static network	Assessment and evaluation of integrated network	Responsible: UT. Others: AICIA, USTUTT,
WP4	Self deployment system specification	Simulation Environment (SE).	- Algorithms for control and coordination of multiple helicopters in order to transport loads (sensor nodes) as well as to sense the environment. - Algorithms implemented and tested in SE. - Flight experiments with multiple indoor helicopters - Flight experiments (demonstration) with one outdoor helicopter which transports load (sensor node).	- System composed of multiple autonomous helicopters for self deploying, self organization, self repairing and filming. - System integrated into the architecture using middleware.	Responsible: TUB. Others: AICIA, UT
WP5	Functionalities specification	- Design of tools. - Proof of concept simulations. - Preliminary experiments of object tracking.	-Algorithms for cooperative functionalities (t0+18). - Simulations of tracking and surveillance algorithms considering UAVs and WSNs - Field experiments of tracking and surveillance.	- Software that implements functionalities and reliability tools (t0+30). - Integrated experiments with UAVs and wireless sensor networks .	Responsible: AICIA. Others: TUB, FC.

		- UAV first updating	- UAV second updating	- UAV final updating	Responsible: FC. Others: TUB
WP6	Scenario specification	Preliminary filming experiments with UAV and ground cameras.	- Filming experiments with two UAVs and ground cameras. - Filming experiments with WSNodes	- Final filming experiments with the integrated system.	Responsible: FC. Others: AICIA, TUB, UT, USTUTT, SE, ITU.
WP6		- Preliminary Disaster Management/Civil Security (DM/CS) experiments with UAVs.. - Preliminary DM/CS experiments with WSNodes	- DM/CS experiments with UAVs and ground cameras. - DM/CS experiments with WS nodes.	Final DM/CS experiments with the integrated system.	Responsible: ITU. Others: AICIA, TUB, FC, UT, USTUTT, SE.
WP7		Presentation on preliminary exploitation plan results: - Analysis of work done in WPs. - Requirements analysis. - Results from User Group interactions. -Exploitation road-maps. - Status of requirements and constraints.	First exploitation plan: - Exploitation roadmaps - User requirements for different scenarios - Technical requirements and constraints on technological output - Dependencies on concurrent activities. - Outputs into other WP's	Final exploitation plan: - Exploitation roadmaps based on product, technology, capability and marketplace information. - User requirements for different scenarios. - Technical requirements and constraints on technological output. - Input from WP2-6 - Plans for future work to support exploitation activities.	Responsible: SELEX. Others: AICIA, TUB, FC, UT, USTUTT, ITU.
WP8	Project Web site and Project presentation.			- Final Web site - Final dissemination plan	Responsible: AICIA. Others: TUB, FC, UT, USTUTT, SE, ITU.
WP8	General dissemination plan	Update of Dissemination Plan	Update of Dissemination Plan.		Responsible: USTUTT. Others: AICIA, TUB, FC, UT, SE, ITU.

On the other hand, the measurable criteria related to dissemination and exploitation are:

1) Criteria for scientific and academic dissemination:

- Number of papers in journals and conference proceedings.
- Number of oral presentations and posters in conferences and workshops.

- Number of Master Thesis and PhD Thesis related to the project.
- Number of references to the project in the scientific/technical literature

These numbers will grow during the project life. Furthermore, the project will generate papers presentations and Thesis after its completion. It is difficult to provide precise figures. However, we can estimate about 20 related papers, 20 presentations and 8 Thesis.

2) Criteria for commercial and general public dissemination

The project will produce brochures and a DVD with the result of the experimentation. The original footage will be DV and/or HDV available for General Media dissemination after approval from the partners.

Furthermore, the following criteria will be considered:

- Number of web hits
- Mass media contributions
- Contacts demanding information.

Again it is difficult to provide figures, but thousands of visits to the Project main site and related sites of the partners can be estimated. The number of mass media contributions including newspapers, radio, TV and electronic journals could be between 5 and 10.

3) Exploitation and contributions to standardization related criteria.

AWARE is a pre-competitive project and then the objective is not to produce final products for exploitation. However, the project will generate results that will be used in commercial products and technology demonstrators. These results will be components and technologies suitable for exploitation as described in section 5.1 of this Annex.

Other exploitation related criteria are:

- Interest of potential end users of the developed technologies.
- New projects, and particularly application projects, based on the technologies developed in AWARE.

The potential contribution to standards is described in the section 5.2 of this Annex. The main contribution will be to conduct experiments, components testing and validations that could provide information valuable for future standardization activities, which are not considered in the Workprogramme.

Finally, it should be noted that AWARE is a project with a very strong innovation component and then involves risks. The fulfilment of the project scientific/technical objectives is considered as the main issue and will require strong efforts from the partners. The distribution of efforts between the different Workpackages reflects this fact. It is believed that if these objectives are fulfilled the dissemination and exploitation will be achieved even if their final completion will be after the project ending. Thus, the above figures should be considered only as rough indicators and could be revised during the project execution.

3. Participant list

List of Participants

Partic Role*	Partic. no.	Participant name	Participant short name	Date enter Project *	Date exit Project **
CO	1 (coordinator)	Asociación de Investigación y Cooperación Industrial de Andalucía	AICIA	T0	T0+36
CR	2	Technische Universität Berlin	TUB	T0	T0+36
CR	3	Flying-Cam	FC	T0	T0+36
CR	4	University of Twente	UT	T0	T0+36
CR	5	Universität Stuttgart	USTUTT	T0	T0+36
CR	6	SELEX sensors and airborne systems	SELEX	T0	T0+36
CR	7	ITURRI	ITU	T0	T0+36

*CO = Coordinator
CR = Contractor

** Normally insert "month 1 (start of project)" and "month n (end of project)"
These columns are needed for possible later contract revisions caused by joining/leaving participants

4. Relevance to the objectives of the specific programme and/or thematic priority

The project is within the scope of the ***2.5.3 Embedded Systems*** strategic objective.

Table 4.1 compares this strategic objective with the contribution of the project.

TABLE 4.1: Contribution of the project to the Embedded Systems objective.

OBJECTIVE	CONTRIBUTION
2.5.3 Embedded Systems. To develop the next generation of technologies and tools for modelling, design, implementation and operation of hardware/software systems embedded in intelligent devices. An end-to-end systems vision should allow to build cost-efficient ambient intelligence systems with optimal performance, high confidence, reduced time to market and faster deployment.	The project contributes to this objective by providing technologies and tools for the co-operation over wireless networks of hardware/software systems embedded in heterogeneous objects. Thus, wireless sensor-actuator networks, including ground mobile nodes carried by persons, and aerial objects will be integrated. The platform that will be developed in the project will minimise the required infrastructure deployment and external intervention to become operative. Thus, the project considers the self-deploying of the wireless network by means of autonomous helicopters with the ability to transport and deploy loads (communication equipment and nodes of the ground network), as well as the ability to repair the network connectivity. These unique features minimise the deployment requirements and allows the operation in sites with difficult or impossible access and without communication infrastructure. Particular attention will be also devoted to improve the reliability and confidence through the cooperation of low cost systems.

Table 4.2 compares the call with the contribution of AWARE:

OBJECTIVE	CONTRIBUTION
2. Middleware and platforms for building secure, swarming and fault-tolerant Networked Embedded Systems where diverse heterogeneous physical objects co-operate to achieve a given goal. While the developed technology must be generic (e.g. regarding computational and programming models, architectures, semantics, new APIs, operating systems, secure kernels etc.), it should be driven by an entire class of ambitious future applications, covering not only information handling but also perception and control (e.g. smart homes, civil security, air and highway traffic management). *o Middleware for wireless objects, from mobile devices to cars, which aim to hide the complexity of the underlying infrastructure while providing open interfaces to third parties for application development.* *o Scalable and self-organising platforms that offer services for ad-hoc networking of very small objects and for mastering the complexity through perception techniques for object and event recognition.* *Key issues include: new computing paradigms which are network-centric and not necessarily device-specific; data networking which goes beyond traditional node-centric approaches; dynamic resource discovery and management; advanced control which makes the system reactive to the physical world and semantics which would allow object definition and querying for data and resources without any need for unique identifiers.*	The project will contribute to this objective by the design, development and experimentation of a platform providing the middleware and all the functionalities required for the cooperation, over a wireless network of diverse heterogeneous objects: aerial flying objects, i.e. autonomous helicopters, static ground sensor-actuator nodes and ground mobile nodes carried by persons and vehicles. The platform will be generic but driven by two future applications: disaster management/civil security and filming/cinematography. Thus, the validation for both applications is considered in a Workpackage of the project. The Architecture and Middleware of the platform will play an important role and is also the subject of another Workpackage of the project. The platform involves the development and implementation of new cooperative perception techniques, including object and event recognition, and advanced control technologies, including techniques that make the system reactive to the physical world from the information provided by the perception system. New distributed network-centric approaches for co-operative perception and control of the actuator nodes are considered in the project.
1. Concepts, methods and tools for System Design that master system's complexity by allowing cost-efficient mapping of applications and product variants onto an embedded platform; while respecting constraints in terms of resources (time, energy, memory, etc.), safety, security, and quality of service. *o Model-based system design, validation and testing. The aim is to achieve interoperability at the semantic level of the models and tools.* *o Design methods, programming models and compilation tools for reconfigurable architectures. The aim is to master the heterogeneity and facilitate the use of these architectures.* *Key issues include: developing more effective language representations; component-based and modular design that allows for integration and for scalability and interoperability of heterogeneous components, including the mixing of different communication and timing models; verification of functional correctness through formal methods.*	Correct handling of the energy resources in the wireless sensor nodes and the hardware on-board the UAVs is very relevant for the project. Furthermore, real-time constraints and strict safety requirements are needed for the UAV control and cooperation, and particularly for the lifting and transporting loads by means of UAVs. The architecture and middleware will be designed taking into account scalability and interoperability of heterogeneous components.

As a summary, it can be seen that the AWARE project is mainly devoted to the focus "Middleware and platforms for building secure, swarming and fault-tolerant Networked Embedded Systems where diverse heterogeneous physical objects co-operate to achieve a given goal", but it has also relations with the topics mentioned in "Concepts, methods and tools for System Design".

Relations to other issues in the call.

- SME targeting.

The partner FC is a SME. This company will exploit the results of the project and will contribute to the dissemination between other SMEs. Furthermore, the ITURRI group has **several industrial SMEs** that will benefit from the result of the project. Moreover many SMEs are supporting members of AICIA. One of the main objectives of this Association is the **technology transfer** to companies in general and to the SMEs in particular. Finally it should be noted that the Universities involved also have many collaborations with SMEs. The Dissemination and Exploitation WPs of the project will target specifically developers and vendors SMEs by including them in the User Group in order to achieve better interoperability of complementary tools and to increase integration of the tool chain in the future application of the AWARE platform.

- Complementarities with other R&D initiatives.

The project will also address the coordination with other initiatives in the framework of the European Research Area, including IST initiatives such as the EUREKA ITEA (1998), and the MEDEA programme to establish a long term vision for micro and nano-electronics. In fact, the AWARE platform will benefit from the developments in Microsystems to be used in the ground motes and also in the UAV on-board equipments.
The Dissemination Workpackage also includes activities related to the definition of links with on-going research in Europe in the framework of the European Research Area. Thus, other related national and international initiatives related to AWARE will be specifically addressed following the Dissemination Plan defined in this Workpackage. Moreover, the project will profit from the resources and results obtained in National projects (see section 8.3). The relation with the Embedded Wisents Coordinated Action is also clear: three partners of AWARE are also partners of this Coordinated Action.

- International cooperation.

The international cooperation will be also addressed in the Dissemination Workpackage. Particularly, taking into account the existing initiatives (see Section 5) and existing contacts, the interaction with the following institutions have been planned: University of Southern California (USC), University of California at Berkeley (UCB) and Carnegie Mellon University (CMU) (USA), Advanced Telecommunications Research Institute Kyoto, Toshiba and Mitsubishi R&D Corporate Centres (Japan), ETRI and the Korea Ministry of Information and Communications (Korea), and CSIRO ICT Centre (Australia).

- STREP Instrument.

Finally, it should be noted that this project fits perfectly in the STREP instrument category. In fact, AWARE involves challenging objectives exploring emerging technologies and alternative approaches, opening new prospects in the field, as pointed out in section 1. Some of the objectives involved in the project have been never achieved yet.

5. Potential Impact and contribution to standards.

5.1 Potential impact

Solving societal problems.

The enormous potential of wireless sensor networks (WSN) for delivering benefits to our society has been pointed out by many studies. Applications include environmental monitoring, agriculture, wildlife biology, public safety, structural engineering and manufacturing among others.
Civil Security and the protection in case of natural or human-made disasters are today main concerns of our society. Recent terrorist attacks pointed out the limitations of current existing technologies to protect people. On the other hand, for example, Southern Europe countries suffer from forest fire devastation every year, with high social, ecological and economical costs. In spite of R&D efforts, there is still a real need to develop systems for surveillance, early detection, localisation, monitoring and contribution to the fire extinction. Thus, the need of European systems to protect people and to save lives in case of disasters is evident. On the other hand, the impact of the media industries in today's society is clear. Particularly, documentary filming has an important effect on the public opinion; for example, filming of environmental disasters could also contribute to the public awareness.
In these scenarios, both the ground WSN and flying sensors, on board UAVs, are very valuable. Thus, for example, the fire fighters in urban or forest environments could carry micro-cameras but also chemical and biological sensors to detect the level of contaminants. In case of a fire, NOx and COx sensors could be used to monitor the danger due to the inhalation of the smoke. The multi-hop networks are also valuable to transmit the sensor information between members of the brigade and finally to the vehicles that could be linked to control centres. On the other hand, small UAVs with cameras and other sensors are very valuable to collect information in dangerous and inaccessible locations. A team of aerial systems could be used in co-ordination with ground means to locate victims of a fire, accident or terrorist attack and to help the rescue. UAVs offer several advantages when compared to conventional piloted means such as preventing pilots from flying in dangerous conditions, the ability to fly close to obstacles and the minimization of potential damages. Moreover, the infrastructure self-deployment, which is a characteristic offered by AWARE, could be very important because the lack of pre-existing communication infrastructure could be a main issue in forest environments and also in urban environments when the existing infrastructure is destroyed or damaged by the disaster. Moreover, the ability to dynamically adapt the network to the requirements of the situation deploying new nodes to increase the coverage, or to repair the connectivity of the network, is also very valuable.
The middleware and cooperation strategies to be developed in the project will open many opportunities for monitoring the full disaster scenario by integrating all the information to guide the operational forces to mitigate its effect or even to generate automatically actuations such as the activation of fire extinguishers.

Reinforcing competitiveness.

The potential impact of WSN technologies points to opportunities in technology innovation, increased productivity and strategic advantage. *ON World* conducted an extensive market study over six months with 147 companies, pointing out that WSN will have a profound impact on many markets and estimated 7 billion US dollars ($) sales by 2010. Furthermore, the July 2005 report [15], based on interviews with 103 technology companies and 44 end users, estimated that 1 million WSN nodes could be deployed worldwide in 2005, with mesh deployments to increase > 300 percent between 2004 and 2005.
On the other hand, the potentialities of UAVs are mobilising important R&D efforts, mainly in the USA. USA maintains the leadership in UAV technologies fuelled by military and other government

funding. The market for UAVs performing reconnaissance and surveillance missions, is expected to be worth 10.6 billion $ over the next ten years, according to Forecast International [9]. Other analysis estimates market's total value, about 9 billion $ with more than half generated by procurement of payloads and ground control stations. According to the portal *SPACEDAILY,* the current worldwide UAV expenditures is about 2 billion $ in 2005 and the European military UAV budget was expected to reach around EUR 5.5 billion between 2003 and 2012.
However, the civilian application of UAVs requires not only low cost vehicles but also infrastructure, platforms and systems to integrate them. The integration with ground WSNs could have an important impact in the development of new products. Europe owns technologies which can play an important role in the development of wireless networked embedded systems involving WSN and UAV technologies. However, the lack of integrated efforts could lead to a secondary position, when considering the efforts being developed in USA. The adoption of European architectures and communication components would favour the position of European IT companies in this new market. Special attention will be paid to the development of a common architecture and middleware for components, coming from different European manufacturers, on board vehicles interacting between them.

Work at the European level.

AWARE will enable the integration of the results produced in successful European projects recently concluded such as **COMETS**, **Eyes, Smart Surrounding** and **CarTALK 2000** (see Sections 1 and 8.3). Thus, the AWARE partners have been playing an important role in the development of the required technologies in Europe. AWARE represents a unique opportunity to integrate the results of previously successful IST European projects with other projects developed with national and private funds in which the partners have been also participating.

The interest on WSN and UAV technologies in Europe has grown in the last decade. However, the cooperative research activities at the European level are still scarce, and the funding is still very low when compared to the USA. Thus, urgent attention is required at European-level to compete in a field that could have strategic impact in the near future. Taking into account the current state of the technology in Europe, it is difficult for a single country to launch a project involving all the required partners. In most cases the partners can only afford limited disconnected issues. Critical mass in human and financial terms, scientific developments and industrial capabilities are strictly required to develop the project. Furthermore, this project requires a scenario suitable for experimentation in realistic conditions, which is not easy due to legal aspects, safety requirements and required coordination. All the above facts render particularly relevant the cooperation at the European level. This proposal represents a realistic approach to solve a problem with European dimension and has an important European added value establishing a critical mass by means of the synergies of different partners. Furthermore, the consortium (see section 8.3) minimizes the required resources by minimizing the overlapping and adopting a pragmatic approach to address the most important issues in the project.

Other National and International Activities.

The importance of sensor networks is highlighted by the number of recent funding initiatives, including the DARPA SENSIT program, military programs, and NSF Program. Other USA WSN projects related to security, surveillance and disaster scenarios are: Bio Watch for early warning of a mass pathogen release (anthrax, smallpox, and plague), Monitoring Volcanic Eruptions, and RISCOFF for forest fire detection.
Node mobility for ad-hoc and sensor networks has been studied by many researchers mainly in USA universities [6], [4], [21], [24], [12], [46] and [18]. The possibility of using the coordinated motion of a small number of nodes in the network to achieve efficient communication between any pair of other mobile nodes has been pointed out [5]. Mobile nodes can act as “data mules”, gathering data while they are near of fixed nodes; this strategy can have a number of advantages, such as reduced energy consumption, if the increased communication latency can be tolerated. Some research results on this approach can be found in [22], [16], [44] and [20]. On the other hand,

mobile nodes can benefit from the existence of static nodes for position estimation purposes. In [3],[28],[38],[40] the use of aircrafts as data sinks is proposed, although not implemented. Aircrafts would fly over the fixed sensor networks following a predictable pattern in order to gather data from them. Several wheeled robotic mobile nodes exist, mainly low cost small mobile robots such as MICabot (Univ. Notre Dame), CotsBot (Univ. Berkeley), Robomote (USC) and Millibots (CMU). Algorithms for planning the motion of the mobile nodes have been proposed and there are also reactive algorithms to guide the mobile node reacting to sensorial stimulus, such as the diffusion based technique to determine new sampling locations [32], and the random walk algorithm to guide the node to a focus of interest [8]. Most of the above mentioned algorithms have been only tested in simulation or in conditioned indoor environments. Thus, more experiments are needed. The joint project between USC, CMU, Dartmouth College and the Australian CSIRO studies the application of an autonomous helicopter for the deployment and repairing of a wireless sensor network. However, the deployment and repairing the connectivity by a team of autonomous helicopters working in parallel has not been addressed.
The coordination and control of multiple flying helicopters [10], [14] and [36] and the coordination of the helicopters and ground robots (pursuit-evasion games [43]) are researched in the BEAR project of the Berkeley Univ, which is also part of a recent initiative on wireless technologies. Research Programmes on Embedded Systems and wireless networked embedded systems in USA have devoted significant attention to UAVs (see for example [2] and [45]) and the cooperation of autonomous systems. USA universities also conduct significant research on the guiding of mobile entities (persons or robots) by using the information from wireless sensor networks. The so-called probabilistic navigation algorithm is used to guide a mobile robot assuming neither a map nor a GPS is available. This algorithm was applied to guide a mobile robot in an indoor environment. The potential field guiding algorithm can be used to guide across the network along a safe path, away from the type of danger that can be detected by the sensor [1], [25]. In [7] an algorithm for path computation and following is proposed and applied to guide the motion of an autonomous helicopter flying very close to the sensor nodes deployed on ground.
In Asia, a significant effort to integrate ubiquitous network and robot technologies exist. Thus, the concept *network robot* denotes a framework to integrate these technologies developing autonomous systems embedded in our daily environments. Examples include a five year project funded by the Japanese Ministry of Internal Affairs and Communications [19] by combining multiple robots with ubiquitous networks. Here the term “robot” is very wide and, in addition of “visible robots”, also comprises the so called *Unconscious type robots* [13], which are sensors and actuators embedded in the environment (roads, rooms, equipment, …). Toshiba [39] is also developing ubiquitous and multi-robot applications including the development of flexible middleware, such as the network script named Flipcast, which provides cooperation between ubiquitous devices and robots. In Korea, ETRI and the Korean Ministry of Information and Communication are developing the so-called *Ubiquitous Robotic Companion* (URC) and the Context Aware Middleware for URC system [26].
However, the planning of multiple heterogeneous autonomous aerial and ground systems interacting with WSNs has not been properly addressed in all the revised literature. Furthermore, the concept of self-deploying network by using the transportation of the required infrastructure by means of the autonomous helicopter has never been addressed. It should be pointed out that the research on lifting and transportation of loads by means of two helicopters (twin lift) has been also conducted in USA Universities (see for example Georgia Institute of Technology [31], Arizona State [26], [35]). However, this research work has been done only in simulation. Thus, lifting and transporting loads by real UAVs have never been demonstrated. However, the German project conducted by TUB mentioned above is addressing the transportation by more than two helicopters.

Innovation related activities.

Exploitation.

Besides the integrated AWARE platform, the expected results of the project will include: the Middleware, the architecture and protocols of the wireless sensor network with mobile nodes, the

sensor network self-deployment/self-configuration/self-repairing multi-helicopter system, a simulation environment for distributed embedded control system, the autonomous cooperative surveillance and tracking tools, and the tools to improve the reliability.
The three companies involved in the project assure the commercial exploitation of the project results in Civil Security, Disaster Management and Filming.

SELEX Sensors and Airborne Systems, a Finmeccanica company, is one of Europe's leading defence electronics companies which is 75% owned by Finmeccanica and 25% owned by BAE Systems and brings together the former Galileo Avionica in Italy and the UK based BAE Systems Avionics. SELEX provides world class capabilities in surveillance, protection, tracking, targeting, avionics and imaging systems, including sensors and UAVs. The company employs some 7,600 employees and has operations in England, Scotland, Italy, and USA. The middleware technologies developed in AWARE will be incorporated within the product development route maps for a number of SELEX products (see Figure 8.3.1) to enhance the integration capabilities currently disparate sensor systems: Unattended Ground Sensor systems, Mobile Surveillance units, Fixed surveillance applications, Passive Littoral surveillance systems, UAV payload applications. These systems may employ a range of sensing technologies including: Video, Acoustic, Seismic, PIR, and Chemical / Biological / Nuclear / Explosive / Barometric. The systems may be deployed in surveillance systems that will be used for automated monitoring of infrastructure health and security.
SELEX will market these wireless sensors and mobile systems to be used in Civil Security Applications. The exploitation of capabilities developed within the AWARE programme will be immediate and may start prior to the completion of the AWARE programme. It is expected that commercial products will be available between one to two years later and recoup the investment made by SELEX within 3-5 years.

Flying CAM, a SME world leader in cinematography using remotely piloted helicopters, has offices in Belgium, California (USA) and Hong Kong. The technologies to be developed in AWARE could have a significant impact in the products and systems for the Media industries to be produced and commercialised by the company. Thus, several helicopters with on-board cameras will be synchronised with the ground cameras to obtain several simultaneous views of the scene with different degrees of details (group of moving persons, bodies, faces…..). Furthermore, the project offers the opportunity to commercialise a completely new system for broadcasting of live events for TV Networks in which the broadcasted picture will display data obtained with the wireless sensors carried by persons or vehicles (see Fig. 7.1.2). Thus, for example, the speed, motion rhythm, or even heart beat of participants could be displayed together with the position correlation between competitors on related map at different scale, in competitions such as mountain-bike racing or rally car racing. In order to perform this functionality the middleware and cooperative functions of the proposed platform are required. Moreover, using the results of the project and its experienced personnel, Flying Cam will produce and market autonomous helicopters for tracking persons or vehicles in places where remotely pilots do not have good visibility conditions to guide the helicopters. Flying Cam produces and sells systems for filming. The price of the system with 2 helicopters with remote heads and camera and the ground equipment can be estimated in a total 500,000 EURO. Furthermore, the services of a turn key system ready to shoot (35 mm HDV) with 3-member crew could be estimated in 99,550 EUROS per week (111,800 in extreme conditions). It is expected that the investment in the project will be recovered within the five years after the project ending.

The **Protec Fire Company** of the **ITU group** manufactures integrates and sells equipped vehicles, protection systems and clothes for the Agencies in charge of Operational Disaster Management. They will install wireless sensors and actuator nodes in the vehicles (see Fig. 8.3.1). Moreover, they will incorporate to their helmets and clothes micro-cameras and tiny sensors to sense the environment and monitor the toxicity remotely (Fig. 8.3.1 and 7.1.3). The middleware will be used in these applications as well as to integrate the sensors and actuators and to implement cooperative schemes also produced in the project. Then, the company will market cooperative integrated

systems to satisfy the existing demand of the Agencies to protect the personnel working in the mitigation of these disasters and improve their efficiency. Protec Fire currently sells the Ges-Fire system for the management of the fire vehicles with a price of 4000-5000 euros/vehicle (total cost of the vehicle between 240000 and 600000 euros). If 10 mobile sensor nodes are considered for each vehicle (carried by fire fighters and the vehicle itself) the total market price of the instrumentation associated to the vehicle and associated persons could be 9000 euros/vehicle. Then, for a fleet of 5 vehicles with new functionalities such as the monitoring using visual and infrared cameras and the automatic pointing and activation of fire extinguishers, the market price of all the associated instrumentation will be 135000 euros. It is expected that the investment in the project will be recovered within the period of 4 years after the project completion.
Moreover, the involved universities have a long tradition cooperating with industries in national and international projects. Then, they will also contribute to exploitation activities. Furthermore, they will perform the academic exploitation in research and education activities.
To conclude it should be noted that SELEX will lead the task devoted to the specification of the AWARE platform (see section 7). This will assure the characteristics required for the exploitation of the platform to be developed in the project.

The User Group of the project will be constituted taking into account exploitation criteria. Thus, this Group will include: Agencies and Government offices in charge of Disaster Management and Civil Security, IT industries, including developers and vendors SMEs that will contribute to achieve better interoperability of complementary tools and to increase integration of the tool chain in the AWARE future application. The User Group will have members of at least all the countries of the partners.

5.2 Contribution to standards.

Currently, there is no a single standard covering the work to be done in AWARE. However, some existing standards are related. Thus, the increasing demand for mobility in data communications resulted in standards for wireless networking such as the IEEE 802.11 and the Europe´s HIPERLAN. The standards, and particularly the IEEE 802.11, have sped-up the adoption of Wireless Internet usage. Standards for interoperability between wireless sensors are still in the early stages. However, the commercial expectations created by WSN is forcing the WSN market for transitioning from networks based on proprietary platforms toward a standard-based environment with emergence of standards such as IEEE 802.15.4, ZigBee, SensorML and BACNet. The AWARE project will contribute to the testing of the current standards on WSN. The Work Programme includes the study of the state of the art of networking protocols, and the development of energy efficient MAC protocol supporting heterogeneous networks[41], [42]. It should be also noticed that the experiments on the use of mobile nodes with significant velocity and communication range requirements, such as UAVs, could impact the adoption of existing and new wireless communication standards. The testing and validation activities included in the Work Programme could provide valuable inputs.

The definition of standards may have an important impact on the commercial use of small UAVs. Interoperability of communication, command and control is a hot topic in the UAV domain, which is affected by the lack of suitable standards. The work in the AWARE project on the cooperation of multiple UAVs and WSNs will provide valuable information. Particularly, the testing and validation activities to be carried out in the project will generate information that could be useful for the definition of standards and regulations. It should be noted that the lack of regulations, involving the shared use of space by manned and unmanned vehicles, is one of the main barriers for commercial applications. The project will also contact the main bodies working in these regulations including the European Unmanned Vehicle Systems Association (EURO UVS). The results of the studies conducted by the UAV-NET and the UCARE network funded by the EC will be also considered.

The AWARE platform to be developed in the project will integrate WSN and UAV systems. Then, the project also offers a good opportunity to study the co-existence and synergies between the low-power networking standards such as IEEE 802.15.4 and Zigbee, and other standards like IEEE 802.11 and WiMAX (802.16d, e). The project will look to the application of standards and will analyse how standards, and their implementations, are subject to change incurred by the environment within which they are implemented. The AWARE platform could serve as a proof of concept for wide deployment of wireless networked co-operating heterogeneous objects including motes, cameras, UAV controllers and other devices. Then the project could provide guidelines for the future definition of standards for the integration and operation of these quite diverse objects.
The presence of SELEX in the Sensors, Communication and UAV communities, as well as in the standardisation Committees will promote the use of the guidelines obtained in AWARE in the standardisation bodies.

Furthermore, the ITURRI group also participates in standardisation activities in Associations for the improving of labour conditions and protection equipment. The experimentation activities to be carried out in the project will also provide valuable information for the development of standards in the protection of the operational people involved in Disaster Management and Civil Security activities, and particularly in fire fighting.

6. Project management and exploitation/dissemination plans

6.1 Project management

Project Management deals with both technical and administrative coordination, the intellectual property and other innovation-related activities arising in the project. Simultaneously, the management will maintain the external relations to the European Commission, to other European projects and to international standardization activities. Active support will be given and formal controls will be applied in order to assure efficient feed-back loops and a close inter-relation between partners. A clear definition of tasks and responsibilities including the control of it, and a work distribution that avoids excessive and unproductive interactions on the one hand, ensuring all the necessary communications between the partners on the other hand, will be established. The declared goal of project management is leading the **AWARE** project to scientific, organizational and financial success.

AICIA will undertake the responsibility for the management and coordination of the overall Project. AICIA is an association with more than 25 years expertise in both national and international R&D projects involving research institutions and industrial companies from many countries. AICIA has high project management capacity having participated in many European Projects (29 International projects in 2003), leading several of them and with significant coordination activities in many others.

6.1.1 Organisation and Decision Process in the Consortium

Figure 6.1.1.1 gives an overview of this management structure, which has been defined as a relatively simple taking into account the characteristics of the STREP project.

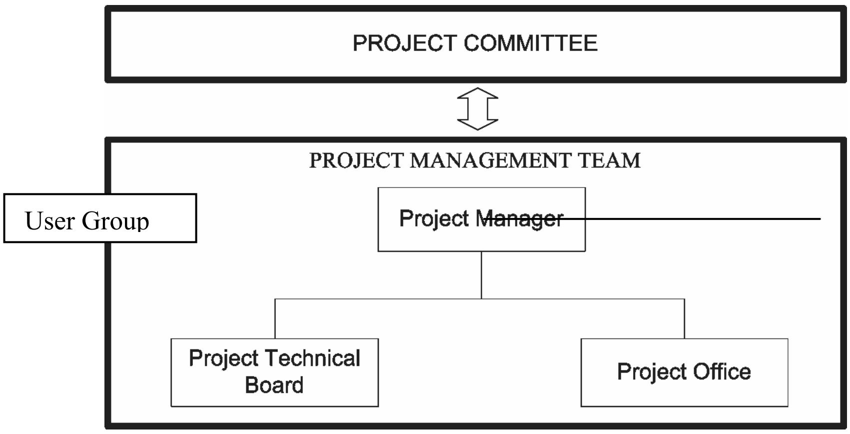


Figure 6.1.1.1: Management Structure.

The structure includes the **Project Committee (PC),** which is the ultimate decision body and the highest authority, and the **Project Management Team (PMT),** which is responsible for day-to-day management of the project. The figure also includes the **User Group** that will be constituted in the project (see Sections 5 and 7). This User Group will provide valuable information for the project development and the exploitation of the results.
The PC is the representation of every partner in the project; each partner has a single vote in it. These representatives will have sufficient authority within their organisation to take the corrective actions considered by the PC, including the resolution of the conflicts that could arise during the project. It is chaired by a representative of the coordinator. The PC will constitute itself with a

general project kick-off meeting within the first four weeks after the project start; this meeting is called by the Project Manager.

The **PMT** will be responsible to make technical and management decisions to the normal running of the project, set clear objectives, compares the progress of the project against milestones, and ensures that it is in line with its technical goals. The PMT will highlight and resolve any technical issues between contractors, where needed. In case of deviations from the project plan, the PMT will take corrective action. The PMT takes final responsibility for reviewing and approving deliverables and other external documents such as publications and standards contributions, and ensures that periodic progress reports are delivered on time. The PMT is finally responsible for financial management of the project. The PMT will meet every 4 months or more often if necessary.

The PMT comprises the Project Manager (PM), Project Technical Board (PTB) and Project Office (PO).

The **Project Coordinator**, AICIA, nominates the **Project Manager PM, Anibal Ollero.** He has a large experience with European projects, led the recently concluded successful project COMETS, and has an extensive R& D background, including successful industrial cooperation. The **PM** is responsible for both the administrative execution of the project as well as for the technical progress. The PM has the following administrative duties: 1) is the contact point between the Project and the Commission; 2) carries out reporting towards the commission; 3) has responsibility for project procedures and administration, including preparation and maintenance of the Project Handbook (including procedures for document control and approval) and the project archive (copies of all documents written in the project); manages the approval process for deliverables and other documents; is responsible for implementing decisions made by the PC and for communicating project status and results towards the PC. With respect to the technical progress of the project, the PM is responsible for the following issues: 1) maintains the overall technical vision of the project; 2) ensures a common approach on technical directions and solutions; 3) assists in building consensus in the case of disagreements; and 4) identifies potential problems with interactions between different WPs. The PM has overall responsibility for the management of the User Group and the coordination of any potential dissemination activities and standards contributions. The PM is aided in his work and can delegate parts of it (in particular, administrative duties) to the Project Office.

The Project Technical Board (PTB) consists of the **Workpackage Leaders** (WPL) and the PM who heads the Board. The WPL have extensive experience in the specialised activities that are proposed for each particular WP (see sections 8.3 and 7). The PTB form the actual technical guidance group of the project. Their task is to ensure that the objectives of the WPs are met and that interaction between WPs takes place in a suitable and timely fashion. The WPL coordinates the technical work within its WP in line with the overall project plan. The WPL is responsible of the following issues: 1) schedules the deliverables and their content and interrelationships, ensuring timely delivery of a high quality; 2) organizes WP meetings and other communication mechanisms when necessary; coordinates planning with related WPs and manages the exchange of information with them.

Project Office (PO). The PO provides administrative support to the project manager; they are installed by the project coordinator AICIA. The Project Office Leader (POL) will be **Prof. P. Moreu.** He is a very experienced colleague with more than 30 years of expertise in Project Management, R&D activities in Production Control and Quality Control, and collaborations with industries. **The POL** has together with the project manager the authority for implementing and verifying compliance with all quality evaluation policies and procedures related to the project. The list of Quality Assurance (QA) tasks includes: 1) Develop the QA Plan including QA project instructions, procedures, checklists (e.g., audit checklists, inspection checklists) and reports (e.g., deliverable report formats); 2) Monitor project development to ensure that initial project plan goals are met within time and budget; 3) Review internal and external deliverables following an internal review process prior to its delivery to the EC**,** for consistency, clarity, technical content, and adherence to the QA standards; 4) Conduct audits of processes prior to each development phase of the project and assure specifications for each phase.

6.1.2 Conflict Resolution.

When Project Management Team could not agree on any decision, the conflict will be solved at the PC level, by means of the following procedure. The PM will initiate a negotiation phase at PC level to settle the dispute. The PC will define the time schedule of this phase with a maximum duration of the negotiation of 20 days. If this fails and no solution is found, the PC will vote on the matter considering the simple majority of the votes given. If the result is tie, PM will have the casting vote.

Tools to improve communication.

The project Web site to be developed in the Workpackage 8 will be also used for the Management of the project. Then, general and particular E-mail list will be implemented and a CVS repository will be used to keep documents, common interest information, reports, etc.

6.1.3 Planning and Reporting

Each partner will submit each 6 months an activity report summarising the work done in each relevant WP and the resources spent, as well as on problems encountered and schedule changes, if any. Based on these reports the PM, assisted by the POL, will prepare the Intermediate Reports (months 6, 18, 36), the extensive yearly Activity Reports (months 12, 24, 36), and the yearly Management Report (months, 12, 24 and 36). These documents will contain the work undertaken, achievements, deliverables submitted (or delayed), deviations from plan and work for the following period, current level of expenditures of the partners and its concordance with the financial plan of the project. The PM will send the reports to the Commission. At the end of the project, the PM assisted by the WPL, will compose a consolidated Final Report addressing technical progress based on milestone achieved. The final report will emphasise on the implementation and exploitation of project results.

Reviews.

At project level, several reviews will be organised. Their purpose is to provide EC and the consortium with information on the status of the project: Kick-off (T0), Specification review (T0+6), First project critical review (T0+12), Second project critical review (T0+24), Integration review (T0+30), Final review (T0+36).

Meetings.

General Meetings will be organised at project level every 4 months, except other agreement of the PMB. Additionally, partners will have **special purpose integration meetings**, particularly in the second half of the project when more integration efforts will be required. These meetings have been very useful in previous projects. Moreover, internet integration meetings will take place to test in simulation the integration of some components.

6.1.4 IPR Handling

The consortium will actively review its IPR strategy in preparation of a Consortium Agreement (CA) prior to the start of the project, and through the duration of the project. As a point of departure, the consortium partners are jointly committed to the following set of principles:

- An open policy of sharing generated knowledge and developed technologies with a wider community

- A spirit of open collaboration and open sharing of results to facilitate the maximum synergistic impact within the partnership and in engagement with collaborators.
- While promoting openness, all generated knowledge assets including computer software, designs, processes and technical or business know-how shall remain the property of the authors or originators.

All existing IPR agreements, bound by contracts set up before start of this project, are being taken into account. Each Partner has committed himself to make the consortium aware of any possible earlier contractual binding as soon as the topic of concern will become an issue within the consortium activities. Each Party agrees to grant to the other Parties to use the pre-existing knowledge when needed to perform the activities in the Work Programme. These grants are strictly limited to such Party for its own needs of research and development in the project excluding any commercial use. Such licence does not permit the use of the software for commercial exploitation, business use, resale or transfer to any third party. An OEM license agreement will be needed for the parties to provide, sale or distribute products or components containing executable code of software belonging to one party.
If appropriate, patents will be applied to maintain the competitiveness of the consortium, and to protect the investment made by the European Commission and the partners in the project. This will be agreed on a case-by-case basis. As general principle each Party shall take appropriate actions to protect results developed by such Party under the Project by such rights as are available under such Party's national legal system and in accordance with applicable European legislation including without limitation copyright or any other similar statutory right, and to protect results to the extent reasonably possible as Proprietary information. The software shall be property of the Parties who carried out the work leading to the software. Where several Parties have carried out work generating a software, they shall have non transferable free user rights for the developed software for their own purposes. They can also agree among themselves different procedures on the allocation and the terms of exercising the ownership. The partners will identify in the CA potential results that could be used free of charge by each partner. If, in the course of carrying out work on the Project, employees and/or subcontractors of more than one Party jointly make an invention, design, or work, and if the features of such joint invention, design, or work are such that it is not possible to separate them for the purpose of applying for or obtaining the relevant patent protection or any other IPR, the Parties concerned may jointly apply for the relevant patent or other IPR.

6.1.5 Risk Analysis

Several risks can endanger the success of a European project. In general the risk management will help to achieve the ambitious goals of the project. The rules and regulations as defined in the Consortium Agreement and in the work plan form the framework for actions to be taken. The section 6 describes the actors; in the following table several risks are anticipated and corrective actions described. Any other risks will be handled in the same manner with full commitment to success.

Risk	Action
One or more partners are not able to fulfill their duties at all, in part or in time.	The Project Committee (PC) specifies a clear and fair time limit for improvement. In case of failure the conflict resolution procedure will be applied all consequences as described in detail in the consortium agreement.
One or more partners are not willing to fulfill their duties at all, in part or in time	The PC specifies a clear and fair time limit for improvement. In case of failure the conflict resolution procedure will be applied.
One partner withdraws from the project	The partner will be replaced as soon as possible with capacities from other partners and/or inclusion of a new partner.

A specific concept cannot be agreed upon within the consortium	Immediately a review process will be invoked. The recommendations will lead to corrective actions.
One or several of the project concepts will not be accepted by the User Group	An additional iteration loop will be started. Feedback from the User Group will be taken into account (time permitting).
A new technology appears which has not been foreseen during the conception phase of the project	The technology will be analysed and eventually partially or fully adapted.

Risks for Fulfilment of Project Objectives.

The partners will adopt specific measures to avoid global failure of the project and allow it to fulfill its main objectives despite the risk involved in the development.
The specification of the full system will confront with potential problems and conflicts between subsystems that can be detected early so that they can be resolved without putting the project's goals at risk.
Reliability and robustness against failures are main issues in the project concept. Thus, reliability in the hardware and communications are particularly addressed by means of hardware redundancies, software design and special purpose algorithms. Thus, a special challenge when developing the communication system is to add reliability and fault tolerance since the underlying platforms only support unreliable communication. This is especially true in the wireless sensor network where nodes fail frequently. Reliability is necessary to allow for cooperation of nodes at the application level. Otherwise, the algorithms employed there would have to deal with inconsistent data. Here special algorithms for reliable and timely communication with the presence of resource-constrained nodes will be developed.
It should be also noted that a main motivation of the repairing network feature of the proposed system is the consideration of the node failures or damages in the Disaster Management/Civil Security applications. The tasks 3.2 and 4.3 are devoted to provide the system with this feature. Furthermore, the task 5.4 is particularly devoted to the development of reliability tools in the co-operation.
The three general experiments will play an important role for the integration of the system. However, it has been observed in previous projects that these experiments were not sufficient for the full integration of the system. Therefore, special purpose integration meetings with simulated equipment will be implemented. The partners have expertise in these integration meetings that are also very valuable for the preparation of the general experiments. Additionally, internet integration meetings will be also implemented to test some functionality.

Contingency plans

In the following table the main sources of failures are analysed and the contingency plans presented.

Risk	Action
Failures in the hardware of autonomous aerial vehicles	The project will use relatively low cost aerial vehicles, and particularly autonomous helicopters. Hardware reliability is a main issue in these vehicles. However, the number of existing vehicles already developed by the partners, increases the robustness of the project because any possible failure of one of these vehicles will not hinder the other's work, and the project as such will still be able to demonstrate autonomy and cooperation with a reduced number of vehicles. Furthermore, it could be possible to substitute one autonomous vehicle by a remotely piloted vehicle.
Failures in the nodes of the wireless ground sensor network. It is well known that the low cost nodes may	Again the redundancy in nodes increases the robustness of the system. Furthermore, the above mentioned property of network repairing of the proposed system

fail frequently (especially in a disaster scenario).	provides inherent robustness to the system, and new nodes can be deployed by an UAV when necessary.
Failures in positioning of mobile objects. It is well known that GPS positioning is a source of failures, particularly transient failures due to the visibility of satellites, media transmission, and communication problems	Positioning functions based on environment perception have been developed and will be improved in the project. Furthermore, if environment perception using visible cameras is difficult, due for example to smoke, existing infrared on board cameras (radiation transparent to smoke) can be also used. Moreover, in case of failures of all the environment perception techniques, it could be possible to use the network information provided by the nodes. Thus localisation techniques using the signals transmitted by the fixed ground nodes and even their positioning information will be applied. Then, we will have triple redundant method to overcome the problem.
Failures in the software functionalities	If some functionalities were not possible to be achieved as targeted, partially degraded functions will be implemented from background software already owned by the partners. This includes teleoperation, perception and coordination functions that are already in operation (centralized mission planning and cooperative perception) that will be used with some improvements.

6.2 Plan for using and disseminating knowledge

Management of Knowledge.

The Consortium Agreement will clarify the protection of the partner knowledge prior to the project and to be used in the project and will also clarify the protection of the knowledge resulting from the project.

Dissemination.

The dissemination of the project results will follow a plan, which will be constantly updated. Dissemination will be targeted at the following main groups: potential end-users, IT industries with particular attention to SMEs, and Research community. Workpackage 8 will be devoted to all the activities related to Dissemination.

A User Group will be settled as indicated below (see paragraphs below). The User Group activities will be part of the Dissemination.

Presentations in Scientific Journals and Conferences will disseminate the project in the Scientific Community. Special Issues in Journals and Invited Sessions and Workshops in Conferences will be organized. The first version of the project Web site will be implemented in the first three months of the project. The Web site will be updated by loading information of the experiments, validations and public deliverables (see section 7 for details). The Web site will include the “Project Presentation” in the Deliverable “D1 (t0+3) First project Web site”

Presentations in magazines, fairs and major events will contribute to create awareness amongst the IT companies related to involved technologies (embedded systems, wireless communications, control, others).

Project brochures explaining the concepts and potential applications will be produced in the first three months of the project. Promotional videos will be generated with the results of the experiments.

The mandatory Deliverable “D34 (t0+36) Final Plan for using and disseminating knowledge” will include the above activities and the future Plan. This will be complemented with the Deliverable “D33 (t0+36) Final exploitation Plan”

In the section 6.3 dissemination activities related to the media and general public are considered.

The User Group.

A User Group of the project will be settled. The User Group will be constituted taking into account the targeted users of the technologies developed in the project. Then, the members will be

- Agencies and Government offices in charge of Disaster Management and Civil Security.
- Media industries.
- IT industries, including developers and vendors SMEs.
- Members of the Academia.

The User Group will have members of at least all the countries of the partners. A basic User Group will be defined in the first six months of the project. However, new members will be accepted during the whole project.

The User Group will provide valuable information for the following project activities:

- Specification of the system.
- Evaluation of the involved technologies and project results.
- Information for the Exploitation plan

The members of the User Group will be invited to special purpose meetings that will be held during the project. Particularly meetings will be organized in conjunction with General Project meetings hosted by the partners in different countries. Furthermore the members of the User Group will be invited to the yearly General Experiments.

The activities of the User Group will be managed in the Workpackage 8 of the project devoted to Dissemination. However, as mentioned above and also in the Section 7 of this Annex, the information obtained in the interactions with the User Group will be used in other Workpackages and particularly in the specification of the Aware platform in WP2 “Architecture and Middleware”, and in the WP7 “Exploitation”. Then these interactions will influence the Deliverables D3 “Specification Document”, D6 “General Dissemination Plan”, D14 “First Exploitation Plan” and D33 “Final Exploitation Plan”, and D34 “Final Plan for Using and Disseminating Knowledge”.

6.3 Raising public participation and awareness

The project will be disseminated not only in the Academia and professionals but also in the public authorities and the general public. Then, efforts will be devoted to increase the awareness of the project results and the involved technologies between the media and the general public.

The project Web site will have a public section devoted to enhance the visibility of the project by means of public information of crucial events, breakthrough research (expert and general public; economic, legal and social interests).

Project brochures and short videos will also contribute to increase the awareness. This could be translated to local languages by partners, eventually adapted to local point of view, and delivered to the local media.

Furthermore, the publicity of participation in major events will also contribute to attract the interest of media and general public.

The general experiments will have a significant role for the general press publicity of the project. Thus the media will be invited to attend experiments and particularly the final experiments of the project.

Personnel of Agencies in charge of Disaster Management and Authorities (Local, Regional and National) will be also invited to the presentation of the project and the final experiments.

All the above activities will be included in a plan for general press publicity of the project that will be developed during the first period of the project. This plan will be included in the release in month t0+12 of the Deliverable D6 “General Dissemination Plan” that will deal with raising public participation and awareness.

7. Workplan– for whole duration of the project

7.1 Introduction - general description and milestones

The Work-plan has been defined to fulfil the project objectives considering the expertise and previous achievements and complementary skill of the partners. More specifically the following facts should be emphasised:

- The partners have expertise in mobile co-operating objects over wireless sensor networks and static wireless sensor networks, including the development of middleware, architectures and co-operations strategies.
- The partners have and maintain important equipment resources to be used in the project including several aerial and ground autonomous vehicles, fire vehicles, cameras, sensors, and wireless sensor networks. The additional requested equipment is justified in Section 8.3.
- The consortium has expertise in the scenarios considered in the project and the organisation and execution of experiments.

Workpackage organisation.
The work-plan has been broken down according to the following types of activities:
Project Management: WP1.
Research and Development Activities: WP2, WP3, WP4, WP5.
Technological Development: WP6.
Innovation Related Activities: WP7 and WP8.
The summary of these WPs is the following:

WP1 Management.
This WP is concerned with the project management ensuring that all the objectives are fulfilled and, if necessary, adopting corrective actions. In this WP all the activities mentioned in Section 6 will be carried out. The WP has two tasks: Scientific and Technical Coordination and Administrative and Financial Coordination.

WP2. Architecture and Middleware.
This Workpackage includes the specification of the Platform from the definition of the scenarios considered in the project. This specification will provide inputs for the remaining tasks of the WP. Then the WP includes a task devoted to the Middleware for the integrated UAV-WSN, which will provide an additional level of abstraction that will simplify the application development by hiding the heterogeneity of the nodes and the dynamic changes of the network topology. The Black Board Communication System developed in COMETS for UAV communication will be adapted to the new properties required in AWARE (e.g., presence of a wireless sensor network) and integrated in the middleware. A task devoted to the definition of distributed UAV cooperation paradigms based on the developed communication services is included. Finally, a task for the integration and verification of the software platforms developed for the UAVs and the wireless sensor network will guarantee a consistent working platform.

WP3: Ground wireless sensor network.

Starting from the specification defined in WP2, the static ground sensor network will be designed, developed and implemented. Then, a task will be devoted to develop protocols supporting the adaptability of sensor nodes to environmental changes and available resources and services. The third task of this WP will be devoted to the integration of ground mobile nodes including nodes installed in ground vehicles and carried by persons. Finally, a task for the implementation and evaluation of the designed ground wireless sensor network is included.

WP4: Self-deployment with cooperative UAVs.

This WP is devoted to the design and implementation of the co-operating UAVs system required for self deployment, self reconfiguration and self repairing of the sensor network. The WP includes the development of the distributed embedded system for control and coordination of multiple autonomous helicopters as well as the development of tools for simulation and testing of embedded systems with the ability to transfer simulated systems to the real hardware automatically.

WP5: Functionalities for the operation.

The first task of this WP will be devoted to the hardware and software adaptation of the UAVs to be integrated in AWARE. The second will address the study and design of tools for autonomous cooperative surveillance and tracking, involving object and event recognition and localisation, and mobile object tracking by means of the UAVs, the ground cameras and the ground sensor network. Then, a task will be devoted to the implementation of these tools. Finally, a task is devoted to the improvement of the reliability of the system by means of explicit consideration in the operation planning of typical sources of failures, such as communication breakdowns and GPS degradation.

WP6: Validation.

This WP is devoted to the development of integrated experiments and validation activities looking to the application of the system in the Media industries and Disaster Management/Civil Security. The first task will be devoted to the specification and the execution of the general integrated experiments in a common scenario. The second one will address the validation in filming for the Media Industries from the results obtained in the experiments. The third task will address the validation for the Disaster Management/Civil Security applications also using the results obtained in the integrated experiments.

WP7: Exploitation.

This Workpackage is devoted to study the exploitation, with particular attention to the two above mentioned application fields: Media Industries and Disaster Management/Civil Security applications. The results of WP6 will be used in this WP. A User Group will be constituted taking into account the targeted users. The feedback from this Group obtained in the activities of WP8 will be also used for the Exploitation. Exploitation plans will be based on assessment of market prospects being updated at regular intervals. Academic exploitation will be also considered.

WP8: Dissemination.

This WP will be devoted to the dissemination of the project results. Dissemination will include the development of the project web site, project presentations in conferences, papers, brochures and videos. This WP also includes the meetings and presentations to the User Group during the entire project. Furthermore, it includes a plan for general press publicity of the project during the first period of the project.

Achievement of the project objectives.

The main goal of this project is the design, development and experimentation of a platform providing all the functionalities and middleware required for the cooperation of aerial flying objects, i.e. autonomous helicopters, with a ground sensor-actuator wireless network, including ground mobile nodes carried by persons and vehicles.

As mentioned in Section 1 the platform will enable the operation in sites with difficult or impossible access and without communication infrastructure.

The WPs presented have been defined to achieve all the supporting technical objectives mentioned in section 2. Table 7.1 illustrates the relation (grey squares) between these objectives and the particular research and development WPs: WP2, WP3, WP4 and WP5.

Table 7.1: Relations between objectives and Workpackages

	WP2	WP3	WP4	WP5
O1) Self-organizing ground sensor network				
O2) Architecture and middleware				
O3) Network-centric functionalities for the system operation				
O4) Self-deployment				

Detailed project Description.

Management WP1, led by AICIA, is a permanent activity that will be carried out during the whole project. The management tasks are described in detail in the corresponding section of this annex. This WP has two tasks the Scientific and Technical Coordination, and the Administrative and Financial Coordination.

The **Scientific and Technical Coordination** is devoted to define clear achievable objectives and motivate team members, monitor/coordinate scientific and technological objectives, and ensure the coherency of the different contributions, solving conflicts and technical discrepancies. This task includes the coordination of the WPs and monitoring the production of the Project Deliverables in the Project Technical Board (see section 6), the collection and synthesis of technical information from all partners to be used in the reports, and the preparation of the meetings, including the integration meetings and the Commission review meetings.

The ***Administrative and Financial Coordination*** includes the activities of the Project Office (see section 6) with the development and implementation of the Quality Assurance Plan for monitoring the project development, review internal and external Deliverables and conducts audits processes. This task also involves the monitoring of the project costs, the generation of the Project Reports for the Commission, the organization of the project meetings and the preparation of the minutes, the interfaces with the Commission and the Management of the Project Committee (see section 6). Finally, this task includes the implementation of the project management Services in the project Web site,

The project starts with the Kick-off meeting, which is the first **Milestone (M1)** of the project. In this meeting **WP2** “Architecture and Middleware” will be open by addressing the definition of the functional specifications taking into account the priorities imposed by the functionalities of the system and the Mission Scenarios. All the partners participate in this important Workpackage. WP2 is led by USTUTT, with significant inputs from SELEX and AICIA, which lead tasks 2.1 and 2.2 respectively. Thus, the industry partner SELEX will have an important role in the Specification of the platform favouring the future exploitation of the project results. AICIA will provide the expertise in UAV cooperation.

The main goal of the ***specification*** task **(2.1)** is to create a basis for the development of AWARE by describing in detail the functionality and interfaces of the system and its parts. To ensure consistency of the specification in this task we first define the structure of the specification document and outline the general guidelines about the content. The specification itself identifies dependencies between the subsystems, defines the interfaces for them, and ensures that each subsystem’s responsibilities are clear. So it is possible to develop the subsystems mostly independent of each other. In addition, when creating the specification, potential problems and conflicts between subsystems can be detected early so that they can be resolved without putting the project’s goals at risk. The results of this task will serve as the basis for further tasks against which their results will be evaluated. This task 2.1 will produce as Deliverable the specification document (D3) specifying each subsystem and the overall platform. All other documents created in this task (e.g., the guidelines for the specification) are internal to the project. The guidelines for the specification at t0+3 will open the activity in some tasks of WP3, WP4 and WP5. The generation of the Deliverable at t0+6 will define the second **Milestone** of the project **M2** in which the tasks 2.2 ad 2.3 will be launched.

The second task of WP2 (**2.2 *Distributed autonomous UAV cooperation***) addresses the design and implementation of schemes to enable autonomous interactions capabilities between the UAVs. This architecture is intended to provide mechanisms to achieve cooperative activities which are useful in WP5 (functionalities for the operation) and WP4 (self-deployment operations with UAVs).

At **M2** the third task (2**.3 *Middleware for the Integrated UAV-WSN system)*** will be started. The objective of this task is to provide the communication platform needed by the application and to design and implement a middleware that makes communication transparent. As Figure 7.1.1 shows, the middleware is used to integrate the UAVs and the wireless sensor network. It supports heterogeneous nodes (regarding hardware, software, resources) and deals with dynamic changes of the network topology (e.g., node failures, self-deployed nodes, mobile nodes). It hides such properties from the application by adding a level of abstraction so that the application does not have to deal with them. Where possible, the middleware integrates the blackboard communication system (BBCS) developed in the COMETS project. This system provides a shared memory abstraction using low-level communication primitives. Since the nodes cooperating in the network are heterogeneous, there is a large gap concerning their capabilities, especially between the resource-limited sensor nodes and less constrained UAVs. Therefore, the abstraction provided by BBCS has to be adapted to the new properties of AWARE and extended by the functionality offered by the middleware. The middleware has to make this difference transparent to the application while considering the resource limitations of the sensor nodes. For example, in sensor networks, communication has to be minimized because it consumes much of the limited energy resources. Therefore, the sensor network can only be indirectly integrated in the BBCS abstractions. Although some of the capabilities offered by the middleware could be added to an application, such an approach is not practical because it would increase the complexity of the application significantly. Furthermore, they would be tightly coupled to the application and it would not be possible to use these capabilities in several different scenarios (e.g., both filming and disaster). Therefore, the goal of this task is the development of a middleware that supports transparent communication in a heterogeneous network with dynamic topology changes. Based on the specification document the BBCS communication system is adapted and the middleware is designed and implemented in this task.

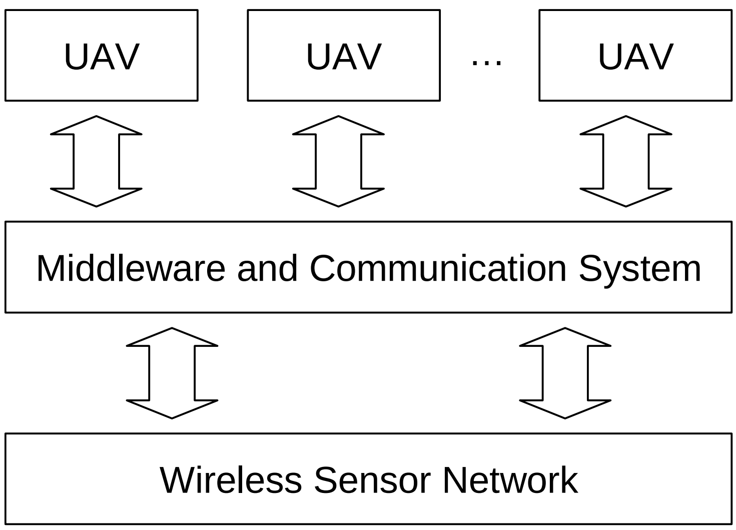


Figure 7.1.1: Middleware for the integrated UAV-WSN system

The last task of this WP is ***Integration and verification of the software platform***. In this task the different subsystems of the project, i.e., the subsystems related to UAVs and WSNs, are integrated into a coherent software platform. This integration is necessary to make sure that the subsystems, which are – to some extent – developed independently, cooperate seamlessly. Using simulation tools for both the UAVs and wireless sensor network the functioning of the combined software is then tested. So even before the general experiments potential problems can be detected.

Workpackage WP3 is devoted to the ***Ground wireless sensor networks.*** This WP is led by UT, and has inputs from USTUTT, which leads task 3.3 providing expertise in ground sensor network with mobile nodes, and AICIA that will provide inputs on the cooperation with these mobile nodes. This project requires hybrid wireless sensor networks, in which both static (placed in fixed locations on the terrain) and dynamic (carried by people, cars, etc.) sensor nodes are used. The network could be fully deployed from the beginning or can be extended if/when needed. Therefore, sensor nodes should be able to establish self-assembling networks that are incrementally extensible and dynamically adaptable to mobility of sensor nodes, changes in task and network requirements, device failure and degradation of sensor nodes. The objective of this Workpackage is to design the architecture of a network of hybrid sensor nodes. To be able to do so, the sensor network architecture, the sensor node system software, and networking mechanisms for such a hybrid sensors network are developed.

The first task is the definition of the ***Network architecture and protocols***. This tasks aims at (i) defining the requirements for sensor nodes to support heterogeneity, cooperation and mobility of sensor nodes, and (ii) improving the functional lifetime of the sensor network using energy-efficient network protocols, routing techniques, and dynamic power management techniques. The specification of the node platform will be included in Deliverable D4 at t0+6, and the designed protocols supporting dynamic heterogeneous networking will be presented at t0+18 in the Deliverable D13.

The second task is devoted to the ***Dynamic self-organization and repair***. The capabilities of self-organizing sensor nodes are self-awareness, self-configurability and autonomy. These capabilities fit well the network that we have in mind, i.e., extensible, dynamically adaptable, robust against faults and failure, consisting of hybrid nodes. Nodes are aware of their own capabilities and those of other nodes around them, which may provide the networking and system services or resources that they need. Within this task we will first study the feasibility of current technologies and protocols. Then we will define and implement the interface and algorithms that enable sensor nodes to function as reconfigurable smart sensor nodes.

The third task addresses the ***Cooperation between sensor nodes.*** In order to reach energy efficiency, scalability, fault tolerance and reliability, and high accuracy, cooperation among sensor nodes is a must. Although nodes are autonomous, they may cooperate with one another to disseminate information, reach consensus, or assist each other in adapting to changes in the environment and available resources. Despite the dynamic changes in the configuration of the sensor network, the network should remain functional. This can be achieved only through cooperation of sensor nodes. This task aims at defining and implementing the cooperation concept in wireless sensor networks through identification of requirements and specification of networking functionalities.

The last task is the ***Implementation and evaluation.*** In this final phase of the Workpackage we will evaluate the overall architecture against our initial goals and objectives. The differences between the behaviour of nodes in reality and results obtained from lab will be studied.

Workpackage WP4 is devoted to the self deployment, self configuration and self repairing of the sensor network by means of the cooperation of multiple helicopters, as well as for using helicopters equipped with sensors as intelligent sensor nodes. WP4 is led by TUB, with contributions from AICIA, which leads task 4.4 providing expertise in control and cooperation of autonomous helicopters for environment sensing, and UT which will provide inputs and requirements of the ground sensor network to be deployed configured and repaired.

In the first part of the WP4 the transport of autonomous sensor nodes to the required locations with autonomous helicopters will be considered. This will allow to deploy the sensor network in the environment as well as to reconfigure or to repair the network by means of replacing sensor nodes at other locations or to exchange the failed sensor nodes by new ones. This is especially important for non mobile sensor nodes and for environments where the required locations of the mobile sensor nodes are difficult to reach. Here the transport of one sensor node with one autonomous helicopter as well as the transport of one sensor node with multiple coupled autonomous helicopters will be considered depending on the load of the equipment.
In the second part of this WP the control and coordination of the positioning and movement of several autonomous helicopters equipped with sensors will be addressed. For environment perception with multiple heterogeneous sensors the proper positioning of the sensors is crucial for the perception results. The movement of the sensors to desired positions or along desired trajectories can significantly improve the perception results or even make the perception task possible. An autonomous helicopter will be considered as universal platform for carrying sensors. Depending on the sensor, it will be connected to the autonomous helicopter either rigid or with the aid of special passive or active mount devices with additional degrees of freedom. The algorithms for determining the best suitable sensors which allow fulfilling specified perception task as well as the algorithms for determining suitable positions or trajectories for chosen sensors will be provided in WP5. In this part of the WP4 the algorithms for movement control and coordination of multiple autonomous helicopters where each helicopter is equipped with one or more sensors will be provided.
In both described parts of the WP4 the embedded software for different levels (from hardware level of one particular helicopter up to sensor planning provided in WP5) for control and cooperation of autonomous helicopters will be developed, implemented and tested. The embedded software for the helicopter control and cooperation will be coupled with the middleware from WP2 in order to integrate the functionalities of autonomous helicopters described in this WP into the whole system.
For the development of the embedded software for control and coordination the simulation environment and the tools for automatic transferring of the simulated embedded system to the real hardware will be realized. In the first stage the embedded software for control and coordination of autonomous helicopters will be designed, implemented and tested in this simulation environment. After that the embedded system for control and coordination will be automatically transferred to the real hardware on the helicopters. This will ensure the equivalence of the simulated and real embedded systems as well as allow the usage of different hardware for the helicopters.

Both systems for load transportation as well as for environment sensing will be developed in parallel. The development of the algorithms for both systems and their testing in simulation environment are addressed in WP4.2 and WP4.4. The results of these two WP's are collected in D15. The implementation and transferring of the developed algorithms to the real helicopters (for both systems) are addressed in WP4.3 and WP4.5. These two WP's include also testing and tuning of the both systems as well as their integration in the whole system using results from WP2, WP5, as described above. The results of WP4.3 and WP4.5 are collected in D23.

Workpackage WP5 is devoted to the development of functionalities for the operation of the full system including the UAVs and the ground sensor network. WP5 is coordinated by AICIA and has inputs from FC, which leads task 5.1, and TUB. This Workpackage will start at t0+3 when the guidelines for the specification are produced in WP2. The task 5.1 is devoted to the required ***updating and adaptation*** of the existing UAVs to be integrated. New hardware and software components will be integrated for reliable communication and cooperation over the wireless network. Extensive experimentation at the partner sites is envisaged. These experiments will prepare the UAVs for the general experiments to be conducted every project year as will be described in WP6. The prototypes will be tuned every year to prepare for the general experiments. This task will start at t0+3 and will produce updated prototypes every project year. The final updating and integration is a Deliverable of the project.

Task 5.2 is concerned with the design of new ***functionalities for surveillance and tracking*** to be used in the filming and Disaster Management/Civil Security applications. The baseline will be the results previously obtained in the COMETS project as well as the reported research activities from the literature. The **main differences with the previous research and development will be**: 1) the cooperation between the UAVs and the ground wireless sensor network with static and mobile nodes, 2) the adoption of a distributed network-centric approach for cooperation, and 3) the joint use of the cameras on-board UAVs and the cameras on-ground (fixed and mounted on ground vehicles) for tracking, integrated with the information of the sensors carried out by the objects being tracked (see applications in filming). The task will start at t0+3 and will produce a design deliverable at the end of the first project year.

Task 5.3 is devoted to the implementation of the tools. The functionalities to be developed are: cooperative area/perimeter surveillance, including optimal UAV patrolling, detection and localisation and cooperative tracking. These completely new functionalities will exploit the possibilities of the AWARE architecture and middleware. The task will begins at t0+12, just after the end of the previous one. The final Deliverable jointly with task 5.4 at t0+30 will provide a description of the developed functionalities. The final implementation will be not possible until the third year of the project. However, partial implementations will be available in t0+24 and a preliminary document will be prepared to be presented at the review meeting.

Task 5.4 will be devoted to the development of tools to increase the ***reliability*** of the system. The redundancies in vehicles and sensors will be exploited to achieve reliable cooperation. Then, it will be possible to consider the main sources of failures such as the loss of communications with the UAVs and the GPS positioning degradation. Then, techniques to optimal cooperation using redundancies in communications and positioning techniques will be developed. Preliminary non implemented research results obtained in COMETS will be extended to consider the information from the ground sensor network and implemented. The task will start at t0+12. The experiments of the first year will provide significant inputs for the design that will be completed at t+18 with an internal document that will be presented at the review meeting (t0+24) to show preliminary results. The joint Deliverable with task 5.3 will be at t0+30 providing inputs to be tested in the final experiments.

Both the general experiments required to integrate the system and the validation from the obtained results are included in the **Workpackage 6**. All the partners participate in this WP, which is led by FC, a company expert in one of the validations. The first task (6.1) in this Workpackage is devoted to define a ***common experimentation scenario*** and to perform ***integrated experiments*** in this scenario. This task will start in the Kick-off meeting and is led by the company ITU which will provide the facilities and equipment required for the experiments. AICIA will also provide the expertise in the organization of these experiments. The experimentation scenario will satisfy two requirements: 1) being representative of the problems that can be encountered in the two applications considered in the project: Disaster Management/Civil Security and Filming, and 2) being affordable with the existing UAVs, and wireless sensor nodes. The experiment of the first year could be used to familiarise with the experimental site, test equipments and communications and obtain feedback for the design of the integrated AWARE platform. The experiments of the second year will provide valuable information to test the functionalities and some integration. The experiments of the third year will involve the integrated platform and main functionalities developed in the project.

A summary report will be prepared after the general experiments of the first and the second year. These documents, that will be ready at t0+12 and t0+24, will be used to prepare the final Deliverable at t0+36.

Task 6.2, led by FC, will be devoted to the ***validation of the platform for the filming applications***. In this task several activities relevant for the Media industries will be considered including cinematography, documentary production, and broadcasting of live events for TV networks by means of the cooperation of the cameras on the UAVs, the cameras on the ground and the sensors carried by persons and vehicles.

On the other hand, the task 6.3 addresses the ***validation for the Disaster Management/Civil Security***, and will be led by SELEX. Here the activities related to self-deploying, surveillance, detection, and monitoring the scenario by cooperation of the UAVs and the ground sensor network will play an important role. Furthermore, network repairing due to the damages of the nodes will be also particularly addressed.

The validation activities will be addressed in the third year of the project after the developments and experiments performed in year 2. Particularly, these activities will be intensified in the last sixth months of the projects, after the completion of WP3, WP4 and WP5

WP7 will be devoted to ***Exploitation***. This WP is coordinated by SELEX, and has inputs from all the partners. It has two tasks devoted to the ***Exploitation for filming*** (7.1, led by FC) and the ***Exploitation for Disaster Management and Civil Security applications*** (7.2, led by ITU). Figures 7.1.2 and 7.1.3 illustrate these exploitation scenarios.

Then, it can be noticed that the three companies involved in the project have a leading role in both WP6 and WP7. AICIA as project coordinator, also will devote significant efforts in these WPs

Figure 7.1.2: The filming application.

This Workpackage will start at t0+6. Exploitation plans will be based on assessment of market prospects being updated at regular intervals. Then, exploitation plans will be produced at t0+18 and 10+36, generating two corresponding Deliverables: D14 and D33 for the exploitation of the different applications. Exploitation will be also based on the Dissemination activities performed in WP8, including the material to promote the project results: video presentations and brochures.

Special attention to activities promoting the exploitation of the results will be paid in the second half of the project involving feasibility studies for the technologies developed in the project. These studies will include short term prospect for the well established technologies and also longer term plans for the promising but no full established technologies and techniques. Lessons learned in the project experiment and validation will be used for the assessment of the above technologies. Best practices for the early use and exploitation of the technologies developed in the project will be developed.

This WP also includes the definition of the User Group with members of targeted users of the AWARE results: Agencies and Government offices in charge of Disaster Management and Civil Security, IT industries, including developers and vendors SMEs, and members of the Academia. The User Group will have members of at least all the countries of the partners.

The activities with the User Group conducted in WP8 will generate feedback for the Exploitation Plans.

Figure 7.1.3 Applications in Disaster Management/Civil Security applications

The Intellectual Property Rights for the exploitation activities will be managed following the Consortium Agreement in accordance with the guidelines in Section 6.

The Workpackage will also consider the Academic exploitation of the project results including the use in regular courses, summer schools, and the generation of case studies to be considered in Diploma Theses and PhD Theses.

WP8 is devoted to the ***Dissemination***. This WP, led by AICIA, will also start at the beginning of the project. A project web site will provide information to three types of users: 1) end-users of the system and technologies of the project, such as civil security organisations, fire brigades and Media-related end-users; 2) Information Technologies companies potentially interested in the technologies developed; 3) Research community. Furthermore, the Web site will also provide updated information to the Commission and evaluators of the project. Conference presentations and journal publications will support dissemination activities. The first draft of the Web site will be ready one month after the beginning of the project. An updated version at the end of the first three months will be the first Deliverable (D1). The site will be continuously updated during the full project. A status of the web site at t0+30 will constitute Deliverable D26.

The dissemination activities will include the production of Project Brochures, promotional videos (one per project year) and Dissemination in the Media including Newspapers and TV magazines. A plan for general press publicity of the project will be developed during the first period of the project.

Presentations in Scientific Journals and Conferences will disseminate the project in the Scientific Community. Special Issues in Journals, Invited Sessions and Workshops in Conferences will be organized. The project will be also presented in Exhibitions such as the IST events.

This WP also includes the management of the activities of the User Group constituted according to WP7. These activities will be meetings and presentations of the project. The feedback obtained in these activities will be useful for the final design and implementation of the AWARE platform and also for the Exploitation Plans in WP7. Furthermore representatives of the User Group will be also invited to the final General Experiments of the project in order to provide inputs to the final Exploitation Plan.

The Dissemination Workpackage also includes activities related to the definition of links with on-going research in Europe in the framework of the European Research Area. Thus, other national and international initiatives related to AWARE will be specifically addressed following the Dissemination Plan defined in Deliverable D6. The international cooperation will be also addressed taking into account the state of the technology (see Section 5) and following existing contacts. Thus, the interaction with Institutions in USA, Asia and Australia has been planned.

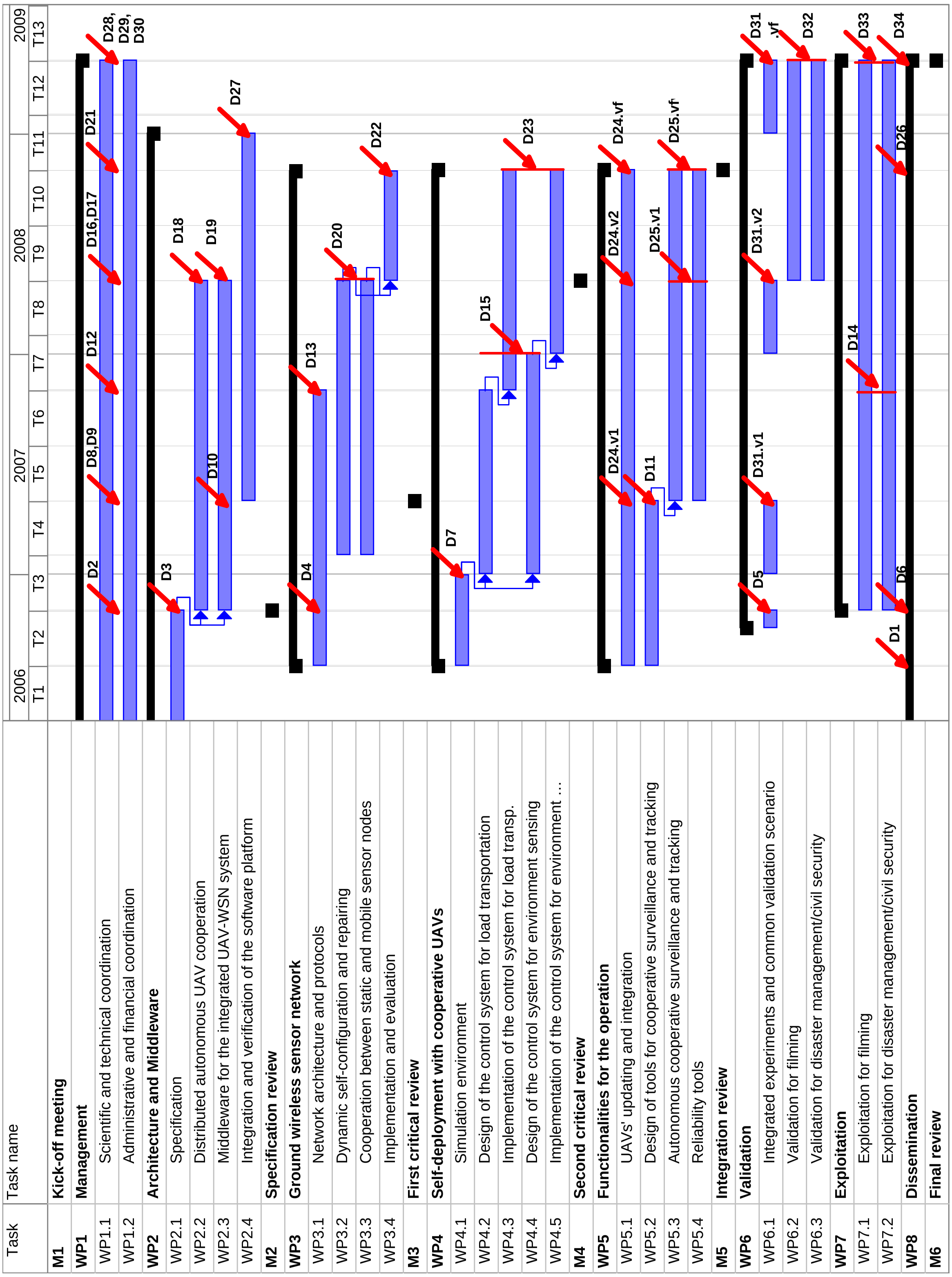
The first Dissemination Plan will be produced by the end of the first semester being the subject of Deliverable D6. The final Dissemination report will be the Deliverable D34.

Finally, it should be noted that the general yearly experiments will provide important inputs and will be associated to Milestones of the project. Then, after the first and second general experiments, the project will have critical reviews that define the Milestones M3 and M4. Furthermore, at t0+32 the project will have the integration Milestone M5. The final Milestone M6 is at the end of the project.

In addition of these general Milestones of the project, the WPs will have their own internal **Workpackage Milestones** to control the WPs. These Milestones will be presented in section 7.6, the WP description.

7.2 Workplanning and timetable

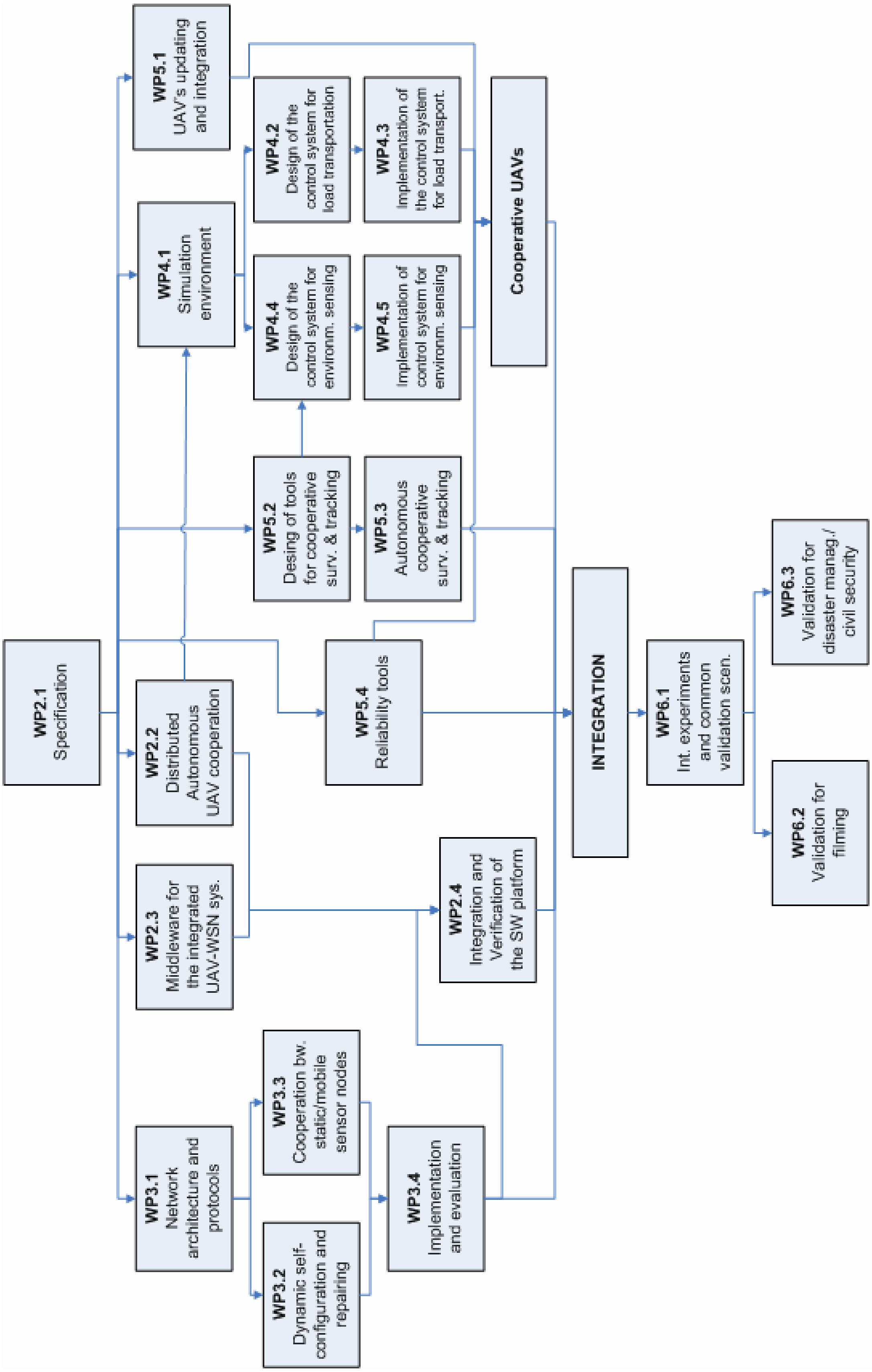
Gantt chart of the project.



(*) Only the project general milestones are shown in the Gantt chart.

7.3 Graphical presentation of work packages

The relationships of WP1, WP7 and WP8 are omitted for the sake of clarity.



7.4 Work package list /overview

Work package list (full duration of project)

Workpackage No[1]	Workpackage title	Lead contractor No[2]	Person-months[3]	Start month[4]	End month[5]	Deliv-erable No[6]
1	Management	1	29	0	36	D2, D8, D9, D12, D16, D17, D21, D28, D29, D30.
2	Architecture and Middleware	5	85	0	32	D3, D10, D18, D19, D27.
3	Ground wireless sensor network	4	68	3	30	D4, D13, D20, D22.
4	Self-deployment with co-operative UAVs	2	68	3	30	D7, D15, D23.
5	Functionalities for the operation	1	74	3	30	D24, D11, D25.
6	Validation	3	85	5	36	D5, D31, D32.
7	Exploitation	6	22	6	36	D14, D33
8	Dissemination	1	20	0	36	D1, D6, D26, D34.
	TOTAL		451			

There are no significant non-paid effort (person-months).

[1] Workpackage number: WP 1 – WP n.
[2] Number of the contractor leading the work in this workpackage.
[3] The total number of person-months allocated to each workpackage.
[4] Relative start date for the work in the specific workpackages, month 0 marking the start of the project, and all other start dates being relative to this start date.
[5] Relative end date, month 0 marking the start of the project, and all ends dates being relative to this start date.
[6] Deliverable number: Number for the deliverable(s)/result(s) mentioned in the workpackage: D1 - Dn.

7.5 Deliverables list

Deliverables list

Deliverable No[7]	**Deliverable name**	**WP no.**	**Lead participant**	**Estimated person-months**	**Nature**[8]	**Dissemination level**[9]	**Delivery date**[10] (project month**)**
D1	First project Web site and project presentation	WP8	AICIA	4	P	PU	3
D2	Intermediate Activity Report #1	WP1	AICIA	3	R	PP	6
D3	Specification Document	WP2	SE	14	R	PU	6
D4	Specification of the node platform	WP3	UT	10	R	PU	6
D5	Specification of the experimentation scenario	WP6	FC	10	R	PU	6
D6	Dissemination plan Update Update	WP8	USTUTT	3	R	PU	6 12 24
D7	Simulation environment for distributed embedded control systems	WP4	TUB	12	P	PU	8
D8	Year 1 Activity Report	WP1	AICIA	3	R	PP	12
D9	Year 1 Management Report	WP1	AICIA	3	R	PP	12
D10	Middleware and communications design document	WP2	USTUTT	16	R	PU	12

[7] Deliverable numbers in order of delivery dates: D1 – Dn

[8] Please indicate the nature of the deliverable using one of the following codes:
- **R** = Report
- **P** = Prototype
- **D** = Demonstrator
- **O** = Other

[9] Please indicate the dissemination level using one of the following codes:
- **PU** = Public
- **PP** = Restricted to other programme participants (including the Commission Services).
- **RE** = Restricted to a group specified by the consortium (including the Commission Services).
- **CO** = Confidential, only for members of the consortium (including the Commission Services).

[10] Month in which the deliverables will be available. Month 1 marking the start of the project, and all delivery dates being relative to this start date.

D11	Design of autonomous co-operative surveillance and tracking tools	WP5	AICIA	24	R,D	PU	12
D12	Intermediate Activity Report #2	WP1	AICIA	3	R	PP	18
D13	Design of protocols supporting dynamic heterogeneous networking	WP3	UT	12	R	PU	18
D14	First exploitation plan	WP7	SE	11	R	RE	18
D15	Embedded systems in simulation environment	WP4	TUB	28	P	PU	20
D16	Year 2 Activity Report	WP1	AICIA	3	R	PP	24
D17	Year 2 Management Report	WP1	AICIA	3	R	PP	24
D18	Distributed autonomous UAV cooperation document	WP2	AICIA	14	R	PU	24
D19	Middleware and communications implementation	WP2	USTUTT	21	P	PU	24
D20	Energy efficient MAC protocol supporting heterogeneous network	WP3	UT	23	R	PU	24
D21	Intermediate Activity report #3	WP1	AICIA	3	R	PP	30
D22	Assessment and evaluation of the ground WSN	WP3	UT	23	P	RE	30
D23	System composed of multiple autonomous helicopters for self deploying, self organisation, self repairing of sensor networks, and filming.	WP4	TUB	28	P	PU	30
D24	UAV updating and integration First version Second version Final version	WP5	FC	25	P	RE	 12 24 30

D25	Autonomous cooperative functionalities and reliability tools. First version Final version	WP5	AICIA	25	R	PU	 24 30
D26	Final version of the Web site	WP8	AICIA	8	P	PU	30
D27	Integration and verification document	WP2	USTUTT	20	R	PU	32
D28	Year 3 Activity Report	WP1	AICIA	3	R	PP	36
D29	Year 3 Management Report	WP1	AICIA	3	R	PP	36
D30	Final Report	WP1	AICIA	2	R	PP	36
D31	Report of the General Experiments First version Second version Final version	WP6	FC	45	R	PU	 12 24 36
D32	Validation report	WP6	FC	30	R	RE	36
D33	Final exploitation plan	WP7	SE	11	R	RE	36
D34	Final Plan for using and disseminating knowledge.	WP8	AICIA	5	R	PU	36
			TOTAL	451			

7.6 Work package descriptions

WP1: Management

Workpackage number	1	**Start date or starting event:**				T0		
Participant id	**AICIA**	TUB	FC	UT	USTUTT	SE	ITU	
Person-months per participant:	24	1	1	1	1	1		

Objectives

The objectives of this Workpackage are to assure the fulfilment of the project goals by means of an appropriated coordination of all the activities of the project, and the management of the interfaces with the Commission.

Description of work

1.1 Scientific and Technical Coordination.

This task is devoted to set clear achievable scientific and technological objectives and to ensure the coherency of the different contributions, solving conflicts and technical discrepancies. The coordination of the WPs (schedules and planning) and the monitoring of the production of the Deliverables will be performed in the framework of the Project Technical Board (see section 6). The task also includes the collection and synthesis of technical information from all partners to be used in the reports.

1.2 Administrative and Financial Coordination.

This task includes the activities of the Project Office (see section 6) with the development and implementation of the Quality Assurance Plan for monitoring project development, review internal and external Deliverables and conducts audits processes. This task also involves the monitoring of the project costs, the generation of the Reports for the Commission, the organization and generation of minutes of the project meetings, the interfaces with the Commission and the management of the Project Committee (see section 6). The task also includes the implementation of the project management services in the project Web site.

Deliverables

D2 (t0+6): Intermediate Activity Reports 1
D8(t0+12) : Year 1 Activity Report
D9 (t0+12): Year 1 Management Report
D12 (t0+18): Intermediate Activity Report 2
D16(t0+24) : Year 2 Activity Report
D17 (t0+24): Year 2 Management Report.
D21 (t0+30) : Intermediate Activity Report 3
D28(t0+36) : Year 3 Activity Report
D29(t0+36) : Year 3 Management Report
D30 (t0+36): Final Report.

Milestones[11] and expected result

M1 (t0)**:** Kick-off Meeting.

M2 (t0+ 6)**:** Specification Review.

M3 (t0+12): First Critical Review.

M4 (t0+24): Second Critical Review.

M5 (t0+30): Integration Review.

M6 (t0+36): Final Review.

[11] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

WP2: Architecture and Middleware

Workpackage number	2	**Start date or starting event:**			T0		
Participant id	AICIA	TUB	FC	UT	**USTUTT**	SE	ITU
Person-months per participant:	14	3	3	6	49	5	5

Objectives

The objective is to develop the architecture and middleware required for the cooperation of the heterogeneous objects. The middleware will make the communication among these heterogeneous nodes transparent, even in the case of topology changes. Such a middleware adds a level of abstraction in order to simplify application development. The architecture will be designed to enable the cooperation between aerial vehicles, static sensor-actuator nodes, and mobile nodes carried by ground vehicles and persons.

Description of work

2.1 Specification.

In this task we first define the structure of the specification document and outline the general guidelines about the content. Then each subsystem specifies the functionality of its part and identifies dependencies to other subsystem. The specification documents for each subsystem are integrated into a specification of the overall system. Finally, the complete specification document has to be evaluated against the project goals. This step makes sure that the specification document as a whole is complete and can be used as a basis for the following workpackages that rely on the interfaces defined here.

2.2 Distributed autonomous UAV cooperation.

This task is devoted to the design and implementation of schemes to enable autonomous interaction capabilities between the UAVs. This architecture has to provide mechanisms to achieve cooperative activities ranging from simple coordination through signals to distributed task allocation. Furthermore, the design has to cope with heterogeneity in the decisional capabilities of the UAVs.

2.3 Middleware for the Integrated UAV-WSN system.

The objective of this task is to design and implement a middleware for transparent communication in a heterogeneous network with dynamic topology changes. The middleware has to consider the specific properties and resource constraints of the nodes. Since the sensor nodes do not use the same communication interface as the UAVs, some nodes have to be equipped with both interfaces and act as bridges. To ensure connectivity these nodes have to route the traffic between the different network technologies. The middleware integrates the functionality offered by the Black-Board Communication System (BBCS) developed in the COMETS project. This system will be adapted to the new properties of AWARE (e.g., presence of a wireless sensor network) and an implementation will be provided that can deal with this new setting. For the middleware algorithms to consider the heterogeneity of nodes and mobility will be developed. A design document describing the internal architecture of the middleware serving as a basis for the implementation will be produced. This document will also include the changes necessary to BBCS. The implementation of the middleware including the modifications of BBCS and the newly developed algorithms is the next step. As the middleware has to deal with heterogeneity it has to be executed on all platforms used in the project. The last step is the test and evaluation of the middleware and algorithms using simulation and – where possible – real hardware devices. This step ensures that the implementation of the middleware meets the requirements needed by the project.

2.4 Integration and verification of the software platform.

In this task the software of the subsystems for UAVs and wireless sensor nodes are integrated to form a consistent software platform. In addition, the correct functioning of this platform is verified using simulators of the UAVs and the WSN nodes. The results of this task are described in an integration and verification document.

Deliverables

D3 (t0+6): Specification document.

D10 (t0+12): Middleware and communications design document.

D18 (t0+24): Distributed autonomous UAV cooperation document.

D19 (t0+24): Middleware and communications implementation.

D27 (t0+32): Integration and verification document.

Milestones[12] and expected result

M2.1 (t0+6) Specification of the AWARE platform.

M2.2 (t0+24) Communication, Middleware and Cooperation techniques.

M2.3 (t0+32) Integration and experimentation of the platform.

Results: Specifications, Middleware, Communications, Architecture for cooperation.

[12] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

WP3: Ground wireless sensor network

Workpackage number	3	**Start date or starting event:**				T0+3	
Participant id	AICIA	TUB	FC	**UT**	USTUTT	SE	ITU
Person-months per participant:	5			51	12		

Objectives

The objectives are: 1) to design and develop an architecture for a network of heterogeneous sensor nodes, including appropriate protocol definitions that are dynamically re-configurable, energy-efficient, robust against fault and failure and collaborative; 2) to implement prototypes of the sensor networks and designed protocols.

Description of work

3.1 Network architecture and protocols.

Capturing the basic requirements, and defining the functionality and interfaces of the services of the cross layered architecture.

3.2 Dynamic self-organization and repair.

Designing protocols supporting adaptability of sensor nodes to environmental changes as well as available resources and services.

3.3 Cooperation between static & mobile sensor node .

Developing protocols supporting cooperation between heterogeneous sensor nodes.

3.4 *Implementation and evaluation.*

Nodes using the proposed architecture will be deployed and the difference between the behaviour of nodes in the reality and results obtained from lab will be studied.

Deliverables

D4 (t0+6) Specification of node platform. A report describing the overall architecture and definition of functional entities.

D13 (t0+18) Design of protocols supporting dynamic heterogeneous networking.

D20 (t0+24) Energy efficient protocols supporting heterogeneous network. This deliverable will describe some innovative ideas developed within this WP by considering MAC, error control and routing in isolation.

D22 (t0+30) Assessment and evaluation of the ground wireless sensor network. This report will evaluate the results of the prototype, and the generality and applicability of the chosen approaches.

Milestones[13] and expected results

M3.1 (t0+12) Evaluation of existing algorithms

M3.2 (t0+20) Design and extension of algorithms.

M3.3 (t0+24) Simulation results of the developed protocols

M3.4 (t0+28) Implementation of protocols

M3.5 (t0+30) Test & evaluation

[13] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

WP4: Self-deployment with co-operative UAVs

Workpackage number	4	**Start date or starting event:**			T0+3		
Participant id	AICIA	**TUB**	FC	UT	USTUTT	SE	ITU
Person-months per participant:	16	48		4			

Objectives

The objective is to develop the embedded system for the control and coordination of several autonomous helicopters for self deploying, self configuration and self repairing of the sensor network as well as for using autonomous helicopters equipped with sensors as intelligent sensor nodes. Further, this software should be connected to the middleware from WP2 in order to integrate the functionalities of the autonomous helicopters into the whole system. For the development of the embedded software for control and coordination, a simulation environment and tools for automatic transferring of simulated embedded system to the real hardware will be created.

Description of work

4.1 Simulation environment for distributed embedded control system for multiple autonomous helicopters.

The simulation environment for design, implementation and testing of the control and coordination system for multiple autonomous helicopters will be developed. This development will be based on adaptation and modification of the available software tools. This environment should allow testing and verification as well as an automatic transferring of the simulated embedded system to the real hardware on helicopters. The last feature of the simulation environment will ensure the equivalence of the simulated and real control system and will simplify the usage of different hardware on helicopters.

4.2 Design of the embedded control system for load transportation with multiple autonomous helicopters for self deploying, self configuration and self repairing of the sensor networks.

The embedded control system will be specified, developed and tested in the simulation environment provided in 4.1. This distributed embedded control system should have general character but will be focused on the application scenario considered in the proposed project: civil security disaster scenario. The transport of one sensor node with one autonomous helicopter as well as the transport of one sensor node with multiple coupled autonomous helicopters will be considered. By transportation of a sensor node with multiple helicopters, the required amount of helicopters, connected to this sensor node, will depend on the weight of the sensor node. The embedded control system should allow a flexible reconfiguration for different amount of involved helicopters. The distributed embedded control system developed in this task will be composed of two different layers: control level for each helicopters and logical layer with low level intelligence. The second layer will allow the connection to the middleware from WP2.

4.3 Implementation and integration of the embedded control system for load transportation with multiple helicopters.

The embedded system from 4.2 will be transferred to real helicopters. The transferring will be performed with tools developed in 4.1. The embedded system will be tested as stand alone (without middleware and the rest of the system). Then, the embedded system will be integrated into the middleware from WP2 and tested with the whole system. Testing of the self deploying, self organization and self repairing with the whole system for the civil disaster scenario will be performed.

4.4 Design, development and testing, using the simulation environment from 4.1, of the embedded control system for environment sensing with multiple autonomous helicopters.

The embedded control system for the movement control and coordination of multiple autonomous helicopters will be specified, developed and tested in the simulation environment provided in 4.1. This distributed embedded system should have general character but will be focused on filming scenario. Here the information gathering with multiple sensors mounted on multiple helicopters (helicopters equipped with sensors will be considered as intelligent sensor nodes) will be considered. The distributed embedded control system developed in this task will be composed of two different layers: control level for each helicopters and logical layer with low level intelligence. The second layer will allow the connection to the middleware from WP2. The results from COMETS project will be taken as starting point for this task and extended with capabilities of tight movement cooperation of multiple helicopters for object tracking.

4.5. Implementation and integration of the embedded control system for environment sensing with multiple helicopters.

The embedded system from 4.4 will be transferred to real helicopters. The transferring will be performed with tools developed in 4.1. The embedded system will be tested as stand alone (without middleware and the rest of the system). After that, the embedded system will be integrated into the middleware from WP2 and tested with the whole system. Testing of the environment sensing and object tracking in filming scenario will be performed.

Deliverables

D7 (t0+8): Simulation environment for distributed embedded control systems.

D15 (t0+20): Embedded systems in simulation environment.

D23 (t0+30): System composed of multiple autonomous helicopters for self deploying, self organisation, self repairing of sensor networks, and filming.

Milestones[14] and expected result

M4.1 (t0+18): Experiments with embedded control system for environment sensing in simulation environment.

M4.2 (t0+20): Experiments with embedded system for load transportation in simulation environment.

M4.3 (t0+24): Field experiments with stand alone system for load transportation composed of multiple cooperating autonomous helicopters.

M4.4 (t0+24): Field experiments with stand alone system for environment sensing composed of multiple cooperating autonomous helicopters.

M4.5 (t0+30): Field experiments with the system for self deploying, self organisation, self repairing of sensor network in civil security disaster scenario.

M4.6 (t0+30): Field experiments with the system for environment sensing in filming scenario.

[14] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

WP5: Functionalities for the operation

Workpackage number	5	**Start date or starting event:**				T0+3		
Participant id	**AICIA**	TUB	FC	UT	USTUTT	SE	ITU	
Person-months per participant:	**43**	10	21					

Objectives

The objective of this WP is the development of network-centric functionalities for the system operation. Then, it will deal with the development of perception techniques required for the self deployment and operation of the network, including surveillance, localisation and tracking. Furthermore, reliable co-operation strategies based on the explicit consideration of the main sources of failures in the operation of the network will be considered.

Description of work

5.1 UAV updating and integration.

The existing UAVs will be updated and integrated in AWARE. New hardware and software components will be integrated for reliable communication and cooperation over the wireless network. The task includes extensive experimentation to prepare the UAVs for their integration. Internal reports will be generated for each year general experiments describing the UAVs status and update up to that time.

5.2 Design of tools for cooperative surveillance and tracking.

Design of new functionalities for surveillance by means of the cooperation between the UAVs and the ground wireless sensor network with static and mobile nodes. A distributed network-centric approach will be adopted. Also, new functionalities for cooperative object tracking based on the joint use of the cameras on-board UAVs and the cameras on-ground (fixed and mounted on ground vehicles) will be designed. Furthermore, the images will be integrated with the information of the sensors carried out by the objects being tracked. Preliminary experiments will be conducted in order to gain insight for the design.

5.3 Autonomous cooperative surveillance and tracking tool.

Development of the previously designed tools for cooperative surveillance and tracking. The functionalities to be developed are: cooperative area/perimeter surveillance, including optimal UAV patrolling, detection and localisation and cooperative tracking.

5.4 Reliability tools.

Development of tools to increase the reliability of the system. Techniques for optimal cooperation using redundancies in communications and positioning techniques, including perception based techniques and the information obtained from other nodes of the network will be developed.

Deliverables

D11 (t0+12): Design of autonomous co-operative surveillance and tracking tools.

D24: UAV updating and integration. First version D24.v1 (t0+12), second version D24.v2 (t0+24), final version D24.vf (t0+30).

D25: Autonomous cooperative functionalities and reliability tools. First version D25.v1 (t0+24), final version D25.vf(t0+30).

Milestones[15] and expected result
M5.1 (t0+12) Design of tools for surveillance and tracking. **M5.2** (t0+12) First evaluation of the updated UAVs. **M5.3** (t0+24) Second evaluation of the updated UAVs. **M5.4** (t0+30) Implementation of tools for surveillance, tracking and improve the reliability. **M5.5** (t0+36) Final evaluation of UAVs.

[15] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

WP6: Validation

Workpackage number	6	**Start date or starting event:**				T0+5		
Participant id	AICIA	TUB	**FC**	UT	USTUTT	SE	ITU	
Person-months per participant:	12	6	31	6	6	5	19	

Objectives

The objective of this Workpackage is twofold: 1) conduct general experiments in a suitable experimentation scenario, and 2) validate the technologies developed in the project for the two envisaged applications: Filming and Disaster Management/Civil Security applications. The results of the experiments will play an important role for the validation activities.

Description of work

6.1 Integrated experiments and common validation scenario.

The first activity will be the detailed specification of the Scenario in which the project objectives will be validated. Then, general experiments will be organized and conducted every project year in this scenario. This task includes all the activities required for these experiments including the permissions, the conditioning of the site and all the logistic aspects. Internal reports will be generated after the first and second year general experiments.

6.2 Validation for Filming.

The system developed in the project and the different involved technologies will be validated for applications relevant in the Media industries: cinematography, documentary production, and broadcasting of live events for TV networks.

6.3 Validation for Disaster Management/ Civil Security.

In this task the architecture and middleware of the system as well as the developed functionalities will be validated for Disaster Management and Civil Security applications. Self-deploying, network repairing and particular functionalities such as the surveillance will be also validated.

Deliverables

D5 (t0+6): Specification of the experimentation scenario.

D31: Report of the general experiments. First version D31.v1 (to+12), second version D31.v2 (t0+24), final version D31.vf (t0+36).

D32 (t0+36): Validation report.

Milestones[16] and expected result

M6.1 (t0+12)**:** Evaluation of the first year general experiments.

M6.2 (t0+24): Evaluation of the second year general experiments.

M6.3 (t0+36): Validation of AWARE for filming and Disaster Management/Civil Security.

M6.4 (t0+36): Evaluation of the last general experiments.

[16] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

WP7: Exploitation

Workpackage number	7	**Start date or starting event:**			T0+6		
Participant id	AICIA	TUB	FC	UT	USTUTT	**SE**	ITU
Person-months per participant:	4	1	5	1	1	5	5

Objectives

The objective of this Workpackage is to study the exploitation of the project results. The two validation fields considered in the project, i.e. Applications for the Media industries and Disaster Management/Civil Security, will be particularly addressed.

Description of work

7.1 Exploitation for Filming.

This task will include activities devoted to promote the commercial exploitation of the results in the Media related industries and end-users. Thus, both the companies developing services for cinematography, documentary filming and TV broadcasting as well as the end-users of these technologies will be targeted in the exploitation plans.

7.2 Exploitation for Disaster Management and Civil Security Applications.

This task is devoted to promote the commercial application of the project results among the National, Regional and Local Agencies in charge of the Disaster Management and Civil Security.

The exploitation plans will include sections particularly devoted to present the results of each of the above tasks.

Feasibility studies of the technologies developed in the project will be performed. These studies will include short term prospect for the well established technologies and also longer term plans for the promising but no full established technologies and techniques. Lessons learned in the project experiment and validation will be used for the assessment of the above technologies. Best practices for the early use and exploitation of the technologies developed in the project will be developed.

The work in this WP also includes the definition of the User Group, the coordination of actions targeting future exploitation of SMEs, the Management of IPR (see section 6) and the coordination of Academic exploitation efforts.

Deliverables

D14 (t0+18): First exploitation plan.

D33 (t0+36): Final exploitation plan.

Milestones[17] and expected results

M7.1 (t0+18)**:** First Exploitation Plans.

M7.2 (t0+36): Final Exploitation Plans.

[17] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

WP8: Dissemination

Workpackage number	8	**Start date or starting event:**			T0			
Participant id	**AICIA**	TUB	FC	UT	USTUTT	SE	ITU	
Person-months per participant:	8	3	2	3	3		1	

Objectives

The objective of this Workpackage is the Dissemination of the results of the Project in three communities: End-Users, IT industries and Academia.

Description of work

A dissemination plan will be defined by the beginning of the project. This plan will be constantly updated during the project life.

The dissemination activities will include the production of Project Brochures, promotional videos (one per project year) and Dissemination in the Media including Newspapers and TV magazines. Furthermore, a plan for general press publicity of the project will be developed during the first period of the project.

Presentations in Scientific Journals and Conferences will disseminate the project in the Scientific Community. Special Issues in Journals, Invited Sessions and Workshops in Conferences will be organized.

The first version of the project Web site will be designed in the Kick-off meeting and implemented in the first month of the project. The Web site will be updated by loading information of the experiments, validations and public deliverables.

The WP also includes the management of the relations with the User Group including Agencies with responsibilities in Disaster Management/Civil Security applications, Media Industries and IT companies. Meetings and presentations of the project will be organized. Members of the User Group will be also invited to the experiments.

The WP also involves coordination actions in the European Research Area and the participation in activities toward the International Cooperation.

Deliverables

D1 (t0+3): First project Web site and project presentation.

D6 (t0+6): General Dissemination Plan. Update (t0+12), Update (t0+24).

D26 (t0+30): Final version of the Web site.

D34 (t0+36): Final Plan for using and disseminating knowledge.

Milestones[18] and expected results

M8.1 (t0+3**):** Web site working.

M8.2 (t0+ 6)**:** First dissemination plan.

M8.3 (t0+36): Final updating of Web site and final dissemination plan.

[18] Milestones are control points at which decisions are needed; for example concerning which of several technologies will be adopted as the basis for the next phase of the project.

8. Project resources and budget overview

8.1 Efforts for the project (STREP/STIP Efforts Form in Appendix 1)

STREP/STIP Effort Form - Full duration of project
(insert person-months for activities in which partners are involved)
Project number acronym: **AWARE**

STREP/STIP Activity type								
	AICIA	TUB	FC	UT	USTUTT	SELEX	ITU	TOTAL ACTIVITIES
RTD/Innovation activities								
WP1 Management	11	1	1	1	1	1		16
WP2 Architecture and Middleware	14	3	3	6	49	5	5	85
WP3 Ground Wireless Sensor Network	5			51	12			68
WP4 Self-Deployment with coop. UAVs	16	48		4				68
WP5 Functionalities for the system operation.	43	10	21					74
WP6 Validation	8	6	31	6	6	5	19	81
WP7 Exploitation	1	1	5	1	1	5	5	19
WP8 Dissemination	5	3	2	3	3		1	17
Total research	**103**	**72**	**63**	**72**	**72**	**16**	**30**	**428**
Consortium management activities								
WP1 Management	13							**13**
WP6 Validation	4							**4**
WP7 Exploitation	3							**3**
WP8 Dissemination.	3							**3**
Total consortium management	23							**23**
TOTAL per Participant	**126**	**72**	**63**	**72**	**72**	**16**	**30**	
Overall TOTAL EFFORTS								**451**

There are no significant non-paid effort (person-months)

8.2 Overall budget for the project (Forms A3.1 & A3.2 from CPFs)

Contract Preparation Forms

EUROPEAN COMMISSION
6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number	033579	Proposal Acronym	AWARE

Financial information - whole duration of the project

Participant n°	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities: RTD or innovation related activities (1)	Demonstration activities (2)	Consortium Management activities (3)	Total (4)=(1)+(2)+(3)	Total receipts
1	AICIA	FC	Eligible costs	*Direct Costs (a)*	384.155,60	,00	78.772,00	462.927,60	,00
				of which subcontracting	,00	,00	6.000,00	6.000,00	
				Indirect costs (b)	293.302,80	,00	65.494,80	358.797,60	
				Total eligible costs (a)+(b)	677.458,40	,00	144.266,80	821.725,20	
			Requested EC contribution		338.729,20	,00	144.266,80	482.996,00	
7	GRUPO ITURRI	FC	Eligible costs	*Direct Costs (a)*	216.394,00	,00	2.000,00	218.394,00	,00
				of which subcontracting	,00	,00	2.000,00	2.000,00	
				Indirect costs (b)	14.000,00	,00	,00	14.000,00	
				Total eligible costs (a)+(b)	230.394,00	,00	2.000,00	232.394,00	
			Requested EC contribution		115.197,00	,00	2.000,00	117.197,00	
5	USTUTT	AC	Eligible costs	*Direct Costs (a)*	366.275,00	,00	3.000,00	369.275,00	,00
				of which subcontracting	,00	,00	3.000,00	3.000,00	
				Indirect costs (b)	73.255,00	,00	,00	73.255,00	
				Total eligible costs (a)+(b)	439.530,00	,00	3.000,00	442.530,00	
			Requested EC contribution		439.530,00	,00	3.000,00	442.530,00	
2	TUB	AC	Eligible costs	*Direct Costs (a)*	449.797,00	,00	3.000,00	452.797,00	,00
				of which subcontracting	,00	,00	3.000,00	3.000,00	
				Indirect costs (b)	89.959,00	,00	,00	89.959,00	
				Total eligible costs (a)+(b)	539.756,00	,00	3.000,00	542.756,00	
			Requested EC contribution		539.756,00	,00	3.000,00	542.756,00	
6	SELEX	FC	Eligible costs	*Direct Costs (a)*	126.628,00	,00	2.000,00	128.628,00	,00
				of which subcontracting	,00	,00	2.000,00	2.000,00	
				Indirect costs (b)	171.010,00	,00	,00	171.010,00	
				Total eligible costs (a)+(b)	297.638,00	,00	2.000,00	299.638,00	
			Requested EC contribution		148.819,00	,00	2.000,00	150.819,00	

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.1

Please use as many copies of form A3.1 as necessary for the number of partners

Proposal Number	033579	Proposal Acronym	AWARE

Financial information - whole duration of the project

Participant nº	Organisation short name	Cost model used	Estimated eligible costs and requested EC contribution (whole duration of the project)		Costs and EC contribution per type of activities: RTD or innovation related activities (1)	Demonstration activities (2)	Consortium Management activities (3)	Total (4)=(1)+(2)+(3)	Total receipts
4	UT	FC	Eligible costs	*Direct Costs (a)*	293.750,50	,00	3.000,00	296.750,50	,00
				of which subcontracting	,00	,00	3.000,00	3.000,00	
				Indirect costs (b)	293.750,50	,00	,00	293.750,50	
				Total eligible costs (a)+(b)	587.501,00	,00	3.000,00	590.501,00	
			Requested EC contribution		293.750,00	,00	3.000,00	296.750,00	
3	FC	FC	Eligible costs	*Direct Costs (a)*	474.228,00	,00	3.000,00	477.228,00	,00
				of which subcontracting	,00	,00	3.000,00	3.000,00	
				Indirect costs (b)	53.675,00	,00	,00	53.675,00	
				Total eligible costs (a)+(b)	527.903,00	,00	3.000,00	530.903,00	
			Requested EC contribution		263.952,00	,00	3.000,00	266.952,00	
TOTAL			Eligible costs		**3.300.180,40**	**,00**	**160.266,80**	**3.460.447,20**	**,00**
			Requested EC contribution		**2.139.733,20**	**,00**	**160.266,80**	**2.300.000,00**	

A3.2

Contract Preparation Forms

EUROPEAN COMMISSION

6th Framework Programme on Research, Technological Development and Demonstration

Specific Targeted Research or Innovation Project

A3.2

Proposal Number	033579	Proposal Acronym	AWARE

Estimated breakdown of the EC contribution per reporting period

Reporting Periods	Start month	End month	Estimated Grant to the Budget	
			Total	In which first six months
Reporting Period 1	1	12	805.000,00	,00
Reporting Period 2	13	24	805.000,00	402.500,00
Reporting Period 3	24	36	690.000,00	345.000,00
Reporting Period 4			,00	,00
Reporting Period 5			,00	,00
Reporting Period 6			,00	,00
Reporting Period 7			,00	,00

8.3 Management level description of resources and budget.

8.3.1 Human and material resources.

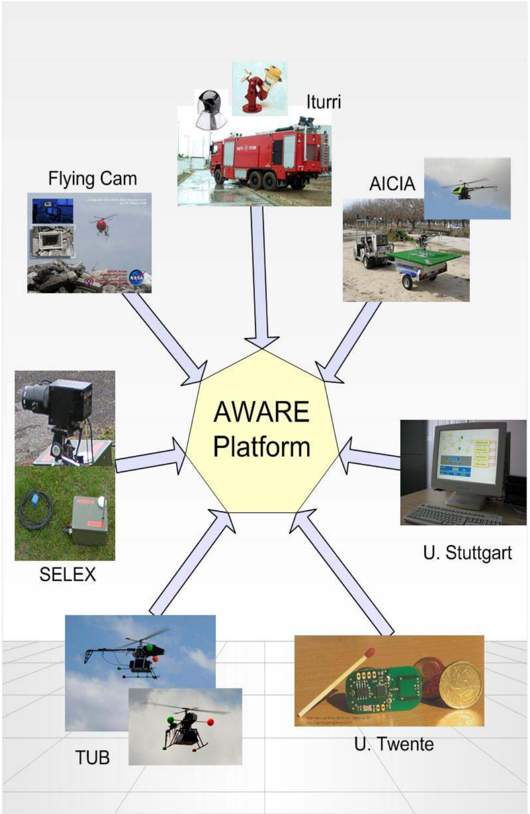


Figure 8.1: Resources provided.

The project will mobilise important human and material resources that will be deployed for its implementation. The partners have personnel with important expertise in every task to be developed in the Work Programme, and could provide the required equipment, including the aerial and ground systems that have been developed in National projects in Spain, Germany, Belgium, The Netherlands, and United Kingdom (see Fig. 8.1). Particularly, the results of the following European projects and National projects will be used:
- COMETS. IST 2001-30304 on the real time coordination and control of multiple heterogeneous unmanned aerial vehicles. AICIA has been the Scientific and Technical Coordinator and TUB has been a partner.
- German DFG project HO 1257/26-1 on lifting and transporting loads by the cooperation of several autonomous helicopters., led by Prof. Hommel, TUB.
- CROMAT, Spain on the coordination of aerial and ground autonomous vehicles, led by the AICIA group.
- Flying-Cam III Diamond Project, including the SARAH Concept: Special Aerial Response Autonomous Helicopter.
- Eyes IST-2001-34734.Energy efficient sensor networks. Project co-ordinated by UT.
- Smart Surroundings, The Netherlands. Project coordinated by UT.
- CONSENSUS, The Netherlands. Project coordinated by UT.

AWARE will enable the integration of the results of previous successful IST projects and other projects funded by National Agencies and private funds.
It should be also noted that AICIA, UT, USTUTT and TUB are collaborating in the framework of the Embedded Wisents Coordination Action on Wireless Sensor Networks and Cooperating Objects in which the state of the technology has been analysed and the European Road Map will be formulated. In this Coordination Action the cooperation between partners has been established. Furthermore, ITU has the possibility of conducting the experiments in a suitable scenario and will provide forest fire trucks and equipment. Thus, the requested funding in equipment has been minimized.

The consortium includes universities as well as companies and associations with important resources. It should be noted that the development of the project requires important scientific development and industrial capabilities of the partners. Then, it is difficult to find partners that fulfil these requirements in Europe at national level. Finally, the development of the platform proposed in the project requires a scenario suitable for experimentation in realistic conditions similar to the one encountered in the applications. This is no easy task due to the legal aspects, safety requirements and required coordination.
Thus, this project offers a valuable opportunity to meet all the requirements mobilising all the resources in a joint effort.

8.3.2 General Budget justification.

1) Personnel.
The project effort form in section 8.1 shows the effort devoted by each partner in each Workpackage. It can be seen that the main efforts are devoted to the "WP2: Architecture and Middleware" and the "WP6: Validation", almost 19% each. Notice that WP2 includes the Specification of the platform, the Middleware, communications, distributed autonomous cooperation and the integration and verification of the AWARE platform. Then, the participation of all the partners is required. The validation WP6 includes the experimentation (one General experiment every year), and the particular validation in two domains: "Filming", and "Disaster Management/Civil Security Scenarios". Then the contribution of all the partners is also required. Taking into account the expertise in preliminary projects, it has been considered that 85PM effort for WP2 and 85PM total effort (81 R&D +4

Management) for WP6 is strictly required for these WPs. It should be noticed that previous projects pointed out that the integration and general (integrated) experimentation activities are important for the success of the project but very demanding in terms of resources.

Furthermore, between 68 and 74 PM are required for each of WP3, WP4 and WP5. Taking into account the complexity of these WPs (i.e. joint self-transportation using multiple autonomous helicopters, UAV cooperation, wireless ground sensor network with mobile nodes) that is pointed out in section 7, and the expertise in previous projects, it is also clear that these resources are strictly required. Moreover, these WPs also involve important experimentation activities, which are also very resources demanding.

Finally, 71 PMs are required in total for the activities related to Management (29 PMs), Exploitation (22 PMs) and Dissemination (20PMs).

In the STREP Project effort form of section 8.1, the Management efforts in the **Research and Innovation Table** will be devoted to the Scientific and Technical Coordination with the activities mentioned in section 6 and section 7, including the Management of the Project Technical Board (PTB). All the WP leaders are members of the PTB and have resources in this Table. On the other hand, the **Consortium Management Activities Table** in section 8.1 includes the following efforts: WP1, Administrative and Financial Coordination, including the activities of the Project Office (see section 6) and other management activities described in section 6 and section 7; WP6, Management of the Validation and particularly the General Experiments involving the logistic for a large number of people (project teams, fire fighters, User Group, Media), equipment and facilities; WP7, Definition of the User Group, coordination of exploitation plans for different applications and communities steered by the feedback obtained from the User Group, coordination of actions targeting future SME exploitation, management of IPR (see section 6) and coordination of Academic exploitation; WP8, Management of the User Group, European and international cooperation, coordination of dissemination material, and management of the Scientific Dissemination (see section 7 for details).

2) Durable equipment.

The partners contribute to the project with very important equipment resources obtained in National Projects and with their own funds and production. However, some additional equipment will be required. WP4 involves experimentation with three autonomous helicopters devoted to load transportation for self deploying, self-configuration and self-repairing of the sensor networks, to allow for sufficient operational safety. An experimental setup with indoors electrical helicopters has been developed by TUB. However, a new outdoor prototype with enough payload is required for the joint self-deployment with 3 helicopters. TUB will contribute with two autonomous helicopters fully equipped with sensors, controller electronics and communications. A third outdoor helicopter is needed for the experiments. The helicopter includes:

- A large payload radio-controlled commercial helicopter.
- A 2cm-kinematic DGPS receiver.
- An inertial measurement unit.
- Magnetic compass and ultrasonic sensors.
- Onboard PC and microcontroller.
- Remote control unit.
- Other material (batteries, mechanical parts, electronic parts, …)

Furthermore, the three helicopters will need to be adapted for operation and cooperation in the experiments:

- A mount device for sensor node transportation will be installed in each helicopter.
- For coupled operation, the helicopters will need an additional sensor system for determining relative position of helicopters to each other. This system will be based on onboard small size stereo vision system, which includes: small firewire cameras (two for each helicopter), actuated mount devices for cameras and on board vision data processing computer.
- For joint load transportation, the three helicopters will need ropes equipped with force sensors for control feedback.

Additionally, fast notebooks equipped with large RAM amounts will be needed to be able to use the simulation environment described in WP4.1 for automatic controller code generation in field experiments.

FC will also contribute with important equipment resources, including helicopters and filming equipment, for the participation in WP5 and the validation experiments in WP6. However, an additional real-time wireless video transmission system and a helicopter-mounted professional video camera will also be needed.

3) Consumables and small equipment.
Consumables and small equipment are required to perform all the experimentation planned in the project. In fact, it is well known that the experimentation with UAVs and mobile equipment always requires significant consumables. Furthermore, it should be noticed that the General Experiments will involve the simulation of Disasters with real fires involving significant consumables and the deployment of fire brigades.
The list of small equipment required includes the following:

- Helicopter spare parts. According to the experience gathered in previous projects, the operation of the prototype helicopters in the experiments will require the purchase of replacement and spare parts, including rotor blades, engine, gears, servos and radio control equipment.
- Electronics material will also be required for repairing and replacing parts of the helicopter control electronics, wireless sensor nodes, base stations and communications equipment.
- Aerial photos and digital cartography of the areas where experiments are planned, for site selection and for test planning and analysis.
- Pyrotechnic material to produce instantaneous fire ignition at pre-designated points in the test sites.
- Mechanical hardware parts to mount and repair the structures that will support the civil disaster scenario.
- Helicopter fuel for the operation of the helicopters during the experiments.

4) Travelling and transportation.
The execution of the Work Programme requires significant travelling to attend the experiments (large member teams) and general meetings. Furthermore, partners will also have meetings to integrate functionalities using simulations (see Section 6). Besides, the project experiments, and particularly the General experiments, will involve significant transportation costs. In addition of the regular project meeting, the Work Programme requires:

- General experiments. There will be one each year. These experiments involve the travelling and accommodation of large member teams for several days. Some of the partners will need to transport equipment (autonomous helicopters and other hardware). For that, van rentals will be needed, and in some cases several days road travelling will also be required.
- Integration meetings. Several additional integration meetings will also be required. Some of the partners will attend to test and integrate functionalities of the system.
- Field experiments at local sites. Some of the partners will need to perform additional experiments in local sites that will require short-distance displacements and short-time van rentals.

8.3.3 Partners Cost Justification

The budget breakdown is given in Table 8.1.

Table 8.1 Partners breakdown Table.

Partner	**Personnel**	**Travel**	**Equipment**	**Consumables and others**	**Management +Audit**	**Total cost**	**Requested**
AICIA	619.194,80	34.263,60		24.000,00	144.266,80	821.725,20	482.996
TUB	432.000,00	39.300,00	56.500,00	11.956,00	3.000,00	542.756,00	542.756
FC	469.796,00	35.157,00	18.000,00	4.950,00	3.000,00	530.903,00	266.952
UT	557.501,00	20.000,00		10.000,00	3.000,00	590.501,00	296.750
USTUTT	409.530,00	30.000,00			3.000,00	442.530,00	442.530
SELEX	272.928,00	18.000,00		6710,00	2.000,00	299.638,00	150.819
ITU	194.394,00	14.000,00		22.000,00	2.000,00	232.394,00	117.197
TOTAL	2.955.343,80	190.720,60	74.500,00	79.616,00	160.266,80	3.460.447,20	2.300.000

Cost justifications for AICIA (Partner 1).

Travel and Subsistence

The AICIA travel and subsistence costs will be devoted to the following activities:

- Participation in project meetings including general meetings (9 meetings, 3 persons), review meetings (3 meetings, 3 persons) and project integration meetings (4 meetings, 3 persons).
- Preparation and participation in the general experiments (3 experiments, 10 persons) and partner experiments (12 experiments, 5 persons) that require the rental of vans and other vehicles for the transportation of people and equipment to the experimental sites.
- Meetings for activities of the IST programme and embedded system unit, and dissemination of the project in conferences and events (9 travels, 1 person).

The total estimated cost for travel and subsistence is 34,252 EUR.

Consumables

It is well known from other projects that the field experimentation involved in AWARE require significant consumable costs for electrical and electronic components and spare mechanical parts, which can be damaged in the experiments.

The estimated cost is 10,000 EUR.

Other significant project costs

These costs include 10,000 EUR for the following activities:

- Production of dissemination material including brochures and videos.
- Invitation of local experts and representatives of National (Spain) and Regional (Andalusia) institutions in the User Group activities including meetings, project experiments (year 1 and year 2), final experiments (year 3) and Workshop.
- Organization of workshops and meetings with the experts, representatives of institutions and media.
- Registration in meetings, conferences and other events to disseminate the project

Furthermore, an estimation of 6000 EUR for Audits costs has been included.

Cost justifications for TUB (Partner 2).

Durable Equipment

The system composed of multiple autonomous helicopters requires a ground station consisting of three notebooks. This ground station is needed both for local testing and for the field experiments and will be under heavy use and subject to frequent transportation. To be able to use the simulation environment (see WP4.1) for automatic controller code generation in field experiments (in order to debug and to change the controller code), notebooks with 2MHz and 2GB RAM are needed. Three autonomous helicopters will be involved in field experiments, see description to WP4.2, therefore three middle-class notebooks for 2.500 EUR each are needed for the ground station.
Two helicopters are provided from COMETS project and therefore only one additional helicopter is needed for WP4. The costs of the helicopter, equipped with navigation sensors required for performing experiments, are 25.000 EUR.
For each helicopter a mount device for sensor node transportation is needed. Each device costs 1.000 EUR.

The coupled helicopters will be equipped with an additional sensor system for determining relative posture of helicopters to each other (DGPS is not reliable enough to control the coupled helicopters). For each helicopter this system will be composed of following components: two fire wire cameras for 1.000 EUR each; actuated camera mount device for 2.000 EUR and additional onboard computer for vision data processing for 2.000 EUR. The ropes of coupled helicopters will be equipped with force sensors (three sensors are required), 1.000 EUR for each.

Travel and Subsistence

The operation of the prototype autonomous helicopter requires the presence of a human safety pilot for testing and emergency reasons. Therefore the flight experiments require the presence of both research persons and of two additional assistants. These four persons are required to maintain the system and to manual control the landing of multiple helicopters in case of system failure to prevent the loss of helicopters.
For the field experiments at the local site approximately 30 testing days are needed. In the city of Berlin, the operation of model aircrafts is forbidden. This requires the testing to take place on a certified model-helicopter “airport” in the countryside, which is 50 km away from the TUB location. The cheapest way of convenient transportation is a rental van (e.g. DC Sprinter), which can be rented not far from TUB for 100 EUR per 24 hours (http://www.allround-autovermietung.com/lkw.php?car=5). In addition 30 EUR for gas and 100 EUR for catering of four persons required for experiments are calculated.
To fulfill the project working plan and to succeed in final experiments, each year one field experiment in Spain with other partners is needed. In each general experiment 4 persons for 14 days should participate (6 days travel time, 7-8 days field work). For equipment transportation two vans will be rented. One van can be rented for 1.500 EUR for two weeks. Gas costs for one van should be calculated with 700 EUR. For board and lodgings for 4 persons and 14 days 6.400 EUR are needed (calculated with 100 EUR for person per day). In total for three field experiments in Spain 32.400 EUR are calculated. In total for local field experiments 6.900 EUR are calculated.

Then the total costs of travel and subsistence is 39300.

Consumables

WP4.3 and WP4.5 include up to 200 hours of flight-time for testing. According to the experience gathered with the MARVIN and COMETS projects, the operation of the prototype helicopter system will require the purchase of replacement and spare parts, including rotor blades, engine, gears, servos, radio control equipment, micro-controller boards including power-supply and interfacing boards as well as orientation sensors. In order to minimize the risk of the total loss of the helicopter, replacements will be done on a regular basis without waiting for symptoms of malfunctioning. Therefore 11.956 EUR have been planned for upgrading of three helicopters for three years.

Other significant project costs

An estimation of 3000 EUR for Audits costs has been included.

Cost justifications for FC (Partner 3).

Durable equipment

Digital Cofdem system for video transmission and one camera: 18000 EUR

Travel and Subsistence.

The expenses will include Travel for participation in the experiments and attendance of project meetings.

The costs for the participation of 6 persons in the experiments include car expenses, equipment transportation, travel and subsistence.

The total for travel and subsistence is 35,157 EUR

Consumables

The consumables costs will include exchange pieces, gas, methanol, oil, tapes, dust air and other consumables required for the experiments. The total estimated cost is 4,950 EUR.

Other significant costs.

Audit: 3000 EUR

Cost justifications for UT (Partner 4).

Travel and Subsistence

The travel costs requested by UT are needed for its personals to be able to participate regular project meetings as well as relevant conferences and workshops.

The estimated cost is 20000 EUR

Consumables

UT is heavily involved in ground sensor networks (WP3), in which one of the objectives is to implement prototypes of large scale sensor networks and the interaction with UAVs will be part of it. This requires significant consumable costs.

The estimated cost is 10000 EUR.

Other significant project costs

An estimation of 3000 EUR for Audits costs has been included.

Cost justifications for USTUTT (Partner 5).

Travel and Subsistence

Since USTUTT will have at least two persons full-time involved in the project, the travel costs requested by USTUTT are needed to participate in the annual general experiments as well as regular project meetings.

The estimated cost is 30000 EUR

Other significant project costs

An estimation of 3000 EUR for Audits costs has been included.

Cost justifications for SELEX (Partner 6).

Travel and Subsistence

The following assumptions have been made on travel:

There will be two trips for two people of a week each to support each of the three general experiments therefore costs for these meetings will be: Flights 300 EUR, Hotel / Subsistence 700 EUR (5 days at 140 Euros each) this implies a total amount of 1000 EUR. Allowance for these trips = 2 x 2 x 3 x 1000 = 12000 EUR

Assume we will be attending 12 other meetings of one to two days duration for the co-ordination of the programme activities and the activities associated with workpackages 2, 6 and 7. This will be: Flights 300 EUR, Hotel / Subsistence 200 EUR (2 days at 100 Euros each), then Total of 400 EUR. Allowance for these trips = 12 x 500 = 6000 EUR.

Therefore, the total allowance for travel = 18000 EUR

Other Costs

The other costs (6710 EUR) is a contingency for the following:

- Shipping of equipment to support experimentation
- Procurement of incidentals (Batteries, small electrical and mechanical parts)

Furthermore, an estimation of 2000 EUR for Audits costs has been included.

Cost justifications for ITU (Partner 7).

Travel and Subsistence

The expenses will include Travel for participation in the experiments and attendance of project meetings.
The estimated cost is 14000.

Consumables and other costs

Required for the organization of the experiments. These costs include mechanical hardware parts to mount and repair the structures that will support the civil disaster scenario, pyrotechnic material to produce instantaneous fire ignition at pre-designated points in the test sites, aerial photos and digital cartography of the areas where experiments are planned, for site selection and for test planning and analysis.
The estimated costs is 22000 EUR

Furthermore, an estimation of 2000 EUR for Audits costs has been included.

9. Ethical Issues

There are no specific ethical or gender issues associated with the subject of AWARE.

The sensitive ethical questions Table follows:

Does your proposed research raise sensitive ethical questions related to:	YES	NO
Human beings		X
Human biological samples		X
Personal data (whether identified by name or not)		X
Genetic information		X
Animals		X

Furthermore, the proposal does not involve research activities mentioned in the ethical issues form. Then the filled Table is the following:

	YES	NO
Confirmation : the proposed research involves none of the issues listed in previous sections	X	

10. Other Issues

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Appendix A - Consortium description

A.1 Participants and consortium

The consortium has been carefully designed to meet all the capabilities required for the project: 1) Expertise in the cooperation of autonomous mobile systems; 2) Expertise in wireless sensor networks; 3) Expertise in middleware and architectures for co-operating objects; 4) Already operating equipment and hardware including UAVs; 5) System for the lifting and transporting loads by the cooperation of autonomous helicopters; 6) Industrial expertise and ability to conduct experiments in the filming scenario and the disaster management scenario; and 7) Exploitation capabilities in Civil Security, Disaster Management and Filming.

Furthermore, the combination of the **scientific competence and industrial capability** has been pursued. It should also be stressed that AWARE is a challenging project. Its objectives can only be reached because of the substantial preliminary achievements of the partners. Taking into account these above requirements, the consortium includes the following partners:

- **Partner 1, Asociación de Investigación y Cooperación Industrial de Andalucía** (**AICIA**) has important expertise in the **cooperation of autonomous mobile systems for natural environments**, including disaster scenarios. AICIA led the COMETS project on the coordination of multiple heterogeneous UAVs, and several other National projects on autonomous systems, involving experiments in natural scenarios. It has participated in several EU projects dealing with these technologies and applications, including the Embedded Wisents Action on Cooperating Objects and Wireless Sensor Networks. Then, it is a very good partner to deal with the **cooperation of autonomous mobile systems** including cooperative perception functions as well as to perform **experiments** in the proposed scenarios. AICIA has **strong links with many** SMEs potential user of results
- **Partner 2, Technische Universität Berlin** (**TUB**) (Real-Time Systems & Robotics group), has developed innovative communication architectures with provable real-time and fault-tolerance capabilities that have been applied in the COMETS system, as well as different UAVs including the MARVIN II autonomous helicopters(see Fig. 8.3.1), which has been integrated in COMETS. Furthermore it has a national DFG project on **lifting and transporting loads with helicopters.** TUB is the ideal partner for the development of the **self-deploying system.**
- **Partner 3, Flying-cam (FC)** is a **SME world-leader** on **remotely piloted helicopters for cinematography.** FC develops helicopters for the Media industry conducts a project on autonomous helicopters and has R&D personnel with expertise in autonomous helicopters. FC also worked on Disaster Management projects with NASA and other partners. It is the ideal partner for the **experimentation and validation for the Media industry and assures the exploitation for this application**.
- **Partner 4, University of Twente (UT)** is an European leader on wireless sensor networks, coordinating several projects in this field including Smart Surroundings and Eyes. Furthermore it has participated in several EU projects dealing with these technologies and applications, including the CoBIs on Collaborative Bussiness Items and the Embedded Wisents Coordination Action on Cooperating Objects and Wireless Sensor Networks. It is the partner that will lead the design and development of the **wireless ground sensor network** providing expertise on scalable and self-organizing platforms for the management of these networks. UT is linked to several companies including SMEs and then will also contribute to the exploitation of the results.
- **Partner 5, University of Stuttgart (USTUTT)** provides excellence and strong expertise on **Middleware for cooperating objects and wireless sensor networks [28][29].** USTUTT has participated in many European projects in distributed systems, including wireless sensor networks with mobile nodes and is also a partner of the Embedded Wisents Coordination Action on Cooperating Objects and WSNs. The group involved in AWARE is leading the German Excellence Centre on Spatial World Models for Mobile Context-Aware Applications and several research projects and collaboration with companies dealing with Middleware for distributed systems. Thus, USTUTT is the ideal partner to coordinate the activities in middleware development for the project, assuring that the result of AWARE could be also used in other co-operating mobile object applications.
- **Partner 6**, **SELEX sensors and airborne systems (SELEX)** is a strong industrial partner providing hardware/software platforms to be used in the project. SELEX will also contribute with its expertise on the specification and validation of the system for security scenarios. SELEX have also developed a suite of Unattended Ground sensor nodes with video, acoustic and seismic sensor and wireless networking capabilities

which have been extensively trialled with the UK MoD and security forces and so bring directly relevant expertise to the programme. Its participation assures industrial **exploitation of the project results**.

- **Partner 7, ITURRI (ITU)** is a provider of equipment and systems for operational agencies dealing with disaster management, including fire protection and fighting equipment. Thus, the company Protec-Fire, belonging to the ITURRI industrial group, is the leader in the Spanish fire-fighting vehicles and equipment, and also has significant presence in international markets. This company has important expertise in demonstration of these equipment and systems and strong relationships with these agencies. Thus, it is the ideal partner for the preparation and running of the **experiments**. It also assures the **validation and exploitation of the project results for disaster management**.

These partners have demonstrated capability for each responsibility of the Work Programme. Table A.1 illustrates the main functions in the project (dark grey boxes) and complementarities. It also shows the main cooperation between partners (light grey boxes). It can be seen how UT and USTUTT will collaborate in the aspects related to the Ground Sensor Network and the Middleware, also receiving inputs from TUB (UAV communications) as well as from the companies SELEX and ITU (hardware and software). On the other hand, AICIA, TUB and FC will collaborate in autonomous system cooperation and UAVs. Furthermore, FC will assist to ITU in the experiment preparation providing inputs related to filming, and AICIA will be involved in the experiments coordination. It should be noted that all the partners will participate in the experiments.

	AICIA	TUB	FC	UT	USTUTT	SELEX	ITU
CAMS							
SD							
UAVMI							
WSN							
MID							
SE							
EXP							

Table A.1: Complementarities and Specialization for the project. CAMS (Cooperation of Autonomous Systems), SD (lifting and transporting loads for Self-Deployment), UAVMI (Unmanned Aerial Vehicles for the Media Industry), WSN (Wireless Sensor Networks), MID (Middleware), SE (Sensors, Equipment), EXP (Experiments Organization).

General description of partners

Asociación para la Investigación y Cooperación Industrial de Andalucía (AICIA). Web http://www.aicia.es

AICIA is a public interest non-profit Association linked to the University of Seville with 43 industrial companies as associates. Its objectives are to boost, guide and promote industrial research, and the technology transfer. The activities of AICIA are set out in a long list of research and development projects, engineering works, tests, evaluations, reports, analysis and consultations. AICIA had 29 international projects in 2003. The Robotics, Vision and Control group will participate in the project. The group has emphasised applications in outdoor natural environments including autonomous ground and aerial vehicles, perception systems and forest fire applications. The group participated in 23 projects in the last years including 4 projects of the IV and Framework Program (DEDICS, INFLAME, FAMIMO, ROSPIR), three projects of the V Framework Programme (SPREAD, EURFIRELAB and COMETS) and the Embedded Wisents Coordination Action of the VI Framework Programme. In the last years the group specialized in distributed networked systems and co-operating object approaches. AICIA has been the Scientific and Technical Coordinator of the Consortium in the COMETS project "Real-time coordination and control of multiple heterogeneous unmanned aerial vehicles". The AICIA group also coordinated the CROMAT Spanish project on the coordination of aerial and ground autonomous vehicles.

Aníbal Ollero. Electrical Engineering (1976), Dr Engineer (1980) with honors (doctorate award), Univ. Seville. Professor at the Universities of Vigo, Málaga and Sevilla, "Stagiaire" at LAAS-CNRS, Toulouse, France (1979) and visiting scientist (1990-1991) at the Robotics Institute, Carnegie Mellon University, Pittsburgh PA, USA. He has 29 years of RTD activities in autonomous systems including robotics, computer vision and control systems. He participated in or led 56 research and development projects, including 10 projects funded by the European Commission. He has been the Scientific and Technical Coordinator of the COMETS IST Project, and the Coordinator of the CROMAT Spanish Project and has been involved in many industrial cooperation projects and technology transfer activities. He is the author or co-author of 3 books,

and more than 250 papers. He is currently the Vice-Chairman of the Technical Board of the "International Federation of Automatic Control".
Other members of the team will be **Prof. P. Moreu** , Associate **Prof. B. Arrue** (intelligent systems, computer vision), Associate **Prof. J. Ferruz**, (computer vision, embedded systems, mobile robotics), Associate **Prof. G. Heredia** (robotics, control engineering), Assistant **Prof. R. Martinez de Dios** (computer vision, IR systems), and Assistant **Prof**. **Ivan Maza** (cooperation of autonomous systems).

Technische Universität Berlin (**TUB**). **Web http://pdv.cs.tu-berlin.de/**
The Real-Time Systems and Robotics group of the TUB, led by Prof. Dr.-Ing. Dr. h.c. Günter Hommel. One research area of the group is Robotics, with the focus on autonomous intelligent systems. Since 1993, the group has been developing and constructing unmanned autonomous vehicles. In 1997, the group started the development of the flying robot MARVIN (Multipurpose Aerial Robot Vehicle with Intelligent Navigation), which is based on an outdoor model helicopter. MARVIN participated in the International Aerial Robotics Competitions (IARC) in USA of 1999 and 2000, organised by the Association for Unmanned Vehicle Systems International, and showed the best performance in each competition. A second research area of the group is the modelling of complex real-time, communication, and production systems in order to derive reliability and performance measures, mostly using stochastic Petri nets. The tool TimeNET, which has been developed in the group and permanently updated, is a state-of-the-art tool for stochastic Petri net modelling and has been deployed to more than 300 institutions and companies around the world.
Prof. Dr.-Ing. Dr. h.c. Günter Hommel received his diploma degree in Electrical Engineering in 1970 and his Ph.D. in Computer Science in 1975, both from TUB. In 1978 he joined the Nuclear Research Center in Karlsruhe working in the field of real-time systems. From 1980 he was the head a research group in Software Engineering at the German National Research Center for Information Technology (GMD, today FhG) in Bonn. In 1982 he was appointed professor at the Institute for Computer Science of TU Munich, where he worked in the fields of real-time programming and robotics. Since 1984 he has been professor at the Institute for Computer Engineering of TU Berlin heading the Real-Time Systems and Robotics Group. In 2002 he received an honorary doctorate (Dr. h.c.) from the Moscow State Academy of Instrument Engineering and Computer Science. In 2004 he was appointed Advisory Professor at Shanghai Jiao Tong University. In 2005 he was nominated Director of "TU Berlin - Shanghai Jiao Tong University Research Labs for Information and Communication Technology" in Shanghai.
He has published more than 150 papers and 10 books. He is and has been an organizer of, chairman of, and reviewer for numerous (international) conferences and journals. He is a reviewer for the German National Science Foundation (DFG) and has evaluated computer science faculties of universities in the former GDR after the unification of Germany. Since 1990 he continuously receives funding for Ph.D. programs financed by DFG. He is a founder member of the International Postgraduate School of Engineering and Advanced Technologies at TU Berlin. He runs a research group with 15 scientists and receives annual grants of approximately € 600 000.
Dr.-Ing. Konstantin Kondak, research assistant in the group since 1999. The main research areas are motion planning, navigation for autonomous robots, optimization, nonlinear and optimal control, flight control.
Dr.-Ing. Marek Musial, research assistant in the group since 1994. His research areas are focused on flight control, design and assessment of real time communication systems, artificial intelligence.
Dipl.-Ing. Volker Remuss, research assistant in the group since 2003 with main interests in robotics, microelectronics, computer architecture, and communication systems.
Dipl.-Ing. Carsten Deeg, research assistant in the group since 2003. His main research areas are modeling and simulation of helicopters including control and sensor processing.

Flying-cam (FC). http://flying-cam.com
is a **SME world-leader** on the application **of remotely piloted helicopters for cinematography** having obtained a Technical Achievement Award from the Academy of Motion Pictures Arts and Science in 1995 for the pioneering concept and for the development of mounting a motion picture camera on a remotely-controlled miniature helicopter**.** Furthermore, FC develops helicopters for the Media industry conducts a project on autonomous helicopters and has R&D personnel with expertise in autonomous helicopters. FC is currently working on the Flying-Cam III Diamond Project which include the SARAH Concept: Special Aerial Response Autonomous Helicopter, and also participated in the NASA DART (Disaster Assistance and Rescue Team) event in San Francisco for a Site Assessment exercise after a simulated bombing. It is the ideal partner for the experimentation and validation for the Media industry and assures the exploitation for this application.
Marco La Civita, Master in Mechanical Engineering at the University of Roma, Italy, 1987. PhD. in Mechanical Engineering at Carnegie Mellon University, 2003. Visiting Researcher at NASA/Ames Rotorcraft Division in the summer 2000. He is working at Flying-Cam as Responsible of Technology Innovation since 2003.
Jan Sperling, Master in Mechanical Engineering at the University of Braunschweig, Germany, 1989. He worked in the R&D department of Schaltbau, Munich, in development of micro-switches from 1989 to 2000.

He participated in the F3C World and European Championships with remote helicopters in 1995-1996. He is working at Flying-Cam as Technical Director since 2000.

University of Twente / CTIT. Web www.utwente.nl / www.ctit.utwente.nl
The CTIT is a multidisciplinary research institute of the University of Twente (UT), Enschede, The Netherlands, within the area of telematics and information technology. The Embedded Systems group performs research on distributed systems and computer architecture of (real-time) embedded and communication systems and has a significant research background on various aspects of ubiquitous computing. These are complex, heterogeneous, networked systems that operate in often hostile environments, and under severe resource constraints. CTIT is primarily focused on system architectures covering the entire systems design trajectory from digital devices, efficient wireless network protocols, distributed systems, and security.
For experiments the group has extensive prototyping facilities, development boards, computer infrastructure including development software in their laboratories. They have a long experience in building complex distributed systems (software as well as hardware). The group has developed and deployed a very large wireless sensor network (750 nodes, perhaps the largest in the world), which is being used for testing protocols and developing applications.
Dr. Paul J.M. Havinga is associate professor in the Computer Science department at the University of Twente in the Netherlands. He received his PhD on the thesis entitled "Mobile Multimedia Systems" in 2000, and was awarded with the 'DOW Dissertation Energy Award' for this work. His research interests are in the area of large scale, heterogeneous wireless systems, sensor networks, energy-efficient architectures and protocols, ubiquitous computing, personal communication systems, and wireless communication networks. This research has resulted in over 160 scientific publications in journals and conferences. He is project manager of the Bsik project Smart Surroundings, on ambient intelligence, the European project EYES, on energy efficient sensor networks, the Dutch projects Featherlight on distributed system software, and CONSENSUS, on application support for collaborative sensor networks. He is workpackage leader in the EU IST projects CoBis on collaborative business items, in the EU project e-SENSE on ubiquitous sensor networks, and in Embedded WiSeNts on sensor networks and applications. He is editor of several journals and magazines. He is involved as program committee chair, member, and reviewer for many conferences and workshops. He has been a visiting researcher at the University of Pisa in 1998, and the Communications Research Laboratory in Yokosuka Japan in 2000. He regularly serves as independent expert for reviewing and evaluation of international research projects for the EU, the US, and international government.

Universität Stuttgart - Institute of Parallel and Distributed Systems. Web http://www.ipvs.uni-stuttgart.de
The Institute of Parallel and Distributed Systems (IPVS, formerly known as IPVR) at the University of Stuttgart (USTUTT) in Germany was founded in 1989. Scientists at the IPVS work on research and development projects for government agencies, associations and industry (Daimler-Chrysler, Bosch, IBM, Hewlett-Packard, Microsoft...).
The SCOOP project (IST-2000-25200), an example for a European project at the IPVS, developed a production planning and control system for highly dynamic distributed e-business and e-works environments in the printing and textile industry. Recently, the distributed systems research group of the IPVS participated in the CarTALK project (IST2000-28185). While the overall objective of CarTALK is the development of driver assistance systems using ad hoc communication between vehicles, the distributed systems research groups contributed routing protocols for ad hoc networks. Currently, IPVS is participating in the Embedded WiSeNts project (FP6-004400). Additionally, a large research program - the nexus project - which is set up for twelve years investigates the structure, management and possibilities of an augmented world model for context-aware applications. The nexus project is funded by the German DFG and currently incorporates nine project partners in 14 research projects at the University of Stuttgart. One of the main current focuses of the distributed systems research group is the area of ubiquitous information systems. In the 3PC project, architectures and protocols are being developed to create system software that supports adaptive applications in Peer-to-Peer-based spontaneous networks.
Prof. Dr. Dr. h.c. Kurt Rothermel received his doctoral degree in Computer Science from the University of Stuttgart in 1985. From 1986 to 1987 he spent a sabbatical at the IBM Almaden Research Center, working on distributed database management systems. In 1988 he joined IBM's European Networking Center, where he was responsible for several projects in the area of distributed application systems. He left IBM in 1990 to become a Professor for Computer Science back at the University of Stuttgart, where he now leads the Distributed Systems Research Group. Currently, he has published over 110 scientific papers at international conferences and journals. His current research interests are context-aware and mobile computing, middleware for pervasive computing environments and sensor networks.
Dr. Pedro José Marrón received his bachelor and master's degree in computer engineering from the University of Michigan in Ann Arbor in 1996 and 1998 respectively. At the end of 1999, he moved to the

University of Freiburg in Germany to work on his Ph.D., which he received with honours in 2001. Since 2003, he works at the University of Stuttgart as a senior researcher, where he leads the mobile data management and sensor network group. His current research interests are distributed systems, mobile data management, location aware computing and sensor networks.

SELEX sensors and airborne systems (SELEX). http://www.selex-sas.com/selex-uk
SELEX Sensors and Airborne Systems Ltd is the UK's foremost supplier of electronic systems for civil and military platforms in the air, at sea and on land. SELEX involvement within this programme will be through its Electro-optics Sector business unit based in Basildon UK. SELEX specialises in developing world class integrated sensor solutions for land sea and air domains. It is a leader in radars and electro-optical surveillance, tracking and targeting and imaging systems. SELEX are also a leader in the field of security and homeland defence supplying a range of surveillance products that are actively in use world-wide helping to maintain the security of the borders and other key facilities. The SELEX experience in complex surveillance system design will be employed within this programme ensuring the requirements capture and system design phases of this programme are addressed in a systematic manner.
The SELEX product range is diverse and ranges from ISTAR infrastructure, platforms, mission systems, HMI products and Sensors and this extensive coverage provides a unique in site into the issues of whole system integration. Products of particular applicability to the AWARE programme include: Mobile Surveillance and Control Unit, EO sensors, Unattended ground sensors, Passive Littoral surveillance systems and UAV payload systems.
Mr Alan Varco – graduated in 1980 with a BSc (Hons) from Loughborough University of Technology. He has 20 years of experience in Systems engineering and programme management, on national and international programmes. He was the programme manager for a major multi-million Euro mission computer development programme for an aerospace application. He also has experience in the management of internal research and development programmes, and is currently responsible for the product development strategies and investment programmes for a portfolio of products including integrated and networked surveillance products, wireless systems and Homeland security systems.

ITURRI. http//www.iturri.com
ITURRI is a Spanish group of companies with 65 years of activities centred on industrial safety equipment and systems including their own developments and the integration and marketing from other manufacturers. The company Protec-Fire of the Iturri group, is the leader in the Spanish fire-fighting vehicles and equipment, and also has significant presence in international markets. Iturri develops the engineering and implementation of fire systems for large industries and oil refineries, including all the prevention and extinguishing equipment. Furthermore, ITURRI has important expertise in demonstration of these equipment and systems and has strong relationships with these agencies. Thus, it is the ideal partner for the preparation and running of the experiments providing the required equipment and facilities. It also assures the validation and exploitation of the project results for disaster management.
Manuel Arregui, Mechanical Industrial Engineering and Director of Research, Development and Innovation of the Iturri Group. **Juan Luis Gonzalez**, head of Fire Equipments and Systems. He is strongly related with Fire Management Offices in different countries and also manage the relations with companies, Universities and Research centres related to Fire Systems.

A.2 Subcontracting

Only subcontracting for audits have been foreseen.

A.3 Third parties.

It has not been planned the use of resources of third parties to carry out part of the work.