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Name of the scientific representative of the project’s co-ordinator¹, Title and Organisation:
Mr. Pedro Sinogas
Tel: +351 213 304 300
Fax: +351 213 304 301
E-mail: pedro.sinogas@tekever.com

Project website² address: http://www.monet-ict.eu

¹ Usually the contact person of the coordinator as specified in Art. 8.1. of the grant agreement
² The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm ; logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.
4.1 Final publishable summary report

This section must be of suitable quality to enable direct publication by the Commission and should preferably not exceed 40 pages. This report should address a wide audience, including the general public.

The publishable summary has to include 5 distinct parts described below:

- An executive summary (not exceeding 1 page).
- A summary description of project context and objectives (not exceeding 4 pages).
- A description of the main S&T results/foregrounds (not exceeding 25 pages),
- The potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results (not exceeding 10 pages).
- The address of the project public website, if applicable as well as relevant contact details.

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

Executive Summary

The potential of Mobile wireless Ad hoc Networks (MANET) is significantly high. However, MANET applications often happen in infrastructure-less or remote regions where remote connectivity to the outside world has to be provided by some other means. Satellite is one of the solutions to provide this and sometimes the only solution. Current expectations dictate that satellite will be seen not only as a component of an alternative routing path but also as part of a unique (really integrated) system.

![Figure 1 - Hybrid MANET-Satellite network and MONET concept.](image)

Figure 1 - Hybrid MANET-Satellite network and MONET concept.
The concept of a hybrid MANET-Satellite network is therefore a natural evolution of considering the problem of providing local and remote connectivity in a highly mobile, dynamic and often remote environment. These composite networks raise significant challenges such as: optimising network resources and link availability; providing Quality of Service (QoS) and Quality of Experience (QoE); minimizing costs and energy.

The EC FP7 project MONET performed research on a number of areas related to the improvement of resource management in particular segments of the hybrid network concept (i.e. the satellite and MANET segment) as well as for the system as a whole. The algorithms proposed (in the areas of load balancing, QoS, satellite bandwidth allocation, routing and gateway selection among others) have shown promising results in terms of potential increases in network lifetime, reduction in delay, increased throughput and improved connectivity. A subset of these studies has been chosen for implementation and has been successfully implemented and ported into HW platforms which were created MONET nodes. After a very challenging integration of the implemented algorithms on the nodes (in particular ensuring that MONET functionalities are compatible and can be used simultaneously when relevant), the consortium has carried out an integration activity in a laboratory environment, performed tests using satellite and radio environment emulators.

In parallel, a field test was prepared. The consortium defined an operationally driven trial that was successfully held in Madrid on September 2012. Feedback from users and industry has been positive and several advantages to MONET have been identified:

- IP network with little or no configuration effort required from users;
- No base stations;
- Ad-hoc multiple hop communications;
- Support of useful applications such as voice traffic and video and file transfer.

Nonetheless, in order to succeed in a real operational environment some challenges remain to be solved and these include:

- Improvements to coverage and range;
- Reduction of the difference of flows in the deployment of the MANET and satellite segments;
- Reduction of delays in voice communications;
- Improvement of the average sound quality;
- Improvement of the robustness of the entire system.

**Project context and Objectives**

The potential of Mobile wireless Ad-hoc Networks (MANET) is significantly high. The application of MANET to areas such as emergency rescue, environmental observation, scientific investigations, commercial environments, home and enterprise networking, educational applications, entertainment, military operations and location-aware services holds great promises. They have been proposed as a solution to answer temporary communication needs within groups of hosts that perform a collective task, usually in rough areas where networking infrastructure is not present.

As is well understood some of the intrinsic capabilities of satellite telecommunication technology make them more interesting than their terrestrial counterparts, namely the very large coverage areas, speed of implementation and inherent multicasting and broadcasting capabilities. Therefore, satellite is one of the solutions to provide this remote connectivity and sometimes the only solution for the MANET to communicate with other parts of the world. Current expectations dictate that satellite will be seen not only as a component of an
alternative routing path but also as part of a unique (really integrated) system. Convergence of satellite and terrestrial networks is becoming a key factor in forming the foundation for efficient global information infrastructures.

So on one hand, ad-hoc networks are characterised by dynamic topologies, limited bandwidth, energy consumption constraints, limited physical security and no centralised management. Some of the many problems they’re subject to include:

- Routing information technique choice;
- Configuration;
- Management;
- Limited bandwidth which means the network management slice must be minimized to enable maximum “payload” data exchanges;
- Changeable links which means that link quality information is mandatory to properly operate radio communications;
- Hidden nodes which can lead to simultaneous broadcast by two unbeknownst nodes and thus collision;
- Energy meaning that battery autonomy is limited;
- Mobility and dynamic topology;

On the other hand, broadband communications via satellite are useful in many different scenarios, especially:

- When a suitable terrestrial communication infrastructure is not available;
- Where the broadcast nature of the satellite system can be exploited (e.g. TV broadcast);
- Or where the satellite networks are complementing or backhauling other, e.g. terrestrial networks.

Examples of the benefits of satellite include IP via satellite in regions with no access to terrestrial DSL, new architectures for near-video on demand, satellite networks integrated with WiFi, WiMAX, LTE or TETRA, or satellite networks backhauling collectively mobile networks in ships, trains, or airplanes.

The concept of a hybrid MANET-Satellite network is therefore a natural evolution of considering the problem of providing local and remote connectivity in a highly mobile, dynamic and often remote environment. The vision for a hybrid satellite-MANET communications network based on MONET is essentially to have one or more MANET clusters (each with one or more nodes with satellite access) which can communicate between themselves through satellite, can access the internet or private networks through satellite and can choose the best link to do this (either terrestrial or the most appropriate satellite link from a choice of different available services). All this should be done semi-automatically with little user intervention (unless desired) and in the most transparent of ways. In this vision, the hybrid network will make use of any type of satellite service (FSS, MSS at GEO or LEO) and the user terminals will be fully integrated (single terminal integrating satcom and ad-hoc radios in a single device and managing the links in fully automatic and transparent manner to the user). According to this vision, the terminals should easily become a world-class reference in the market of mobile wireless ad-hoc terminals with an integrated satellite connection solution, able to provide full seamless broadband connectivity to everyone, everywhere and at anytime. Furthermore this should be achieved in a form factor close to a near-handheld device: laptop-size.
Figure 2: MONET vision

The implementation of the MONET concept for a hybrid network will therefore result in the following advantages:

- Providing remote access and broadband to rural or remote areas
  - Helping to bridge the digital divide;
  - Collaborative work and e-business;
  - Everyday operations of large field teams (e.g. forest monitoring services, environmental service teams, community services);
  - Health services and telemedicine;
- Providing on demand connectivity to mobile users (such as in airports and aircraft for example);
- Providing communication services to Public Safety users (e.g. providing emergency communications during/after disasters, support to fighting forest fires, floods and earthquakes and coastal monitoring);
- Multiple services support (routing according to service);
- Policy vs. application based QoS;
- Use of satellite as access point
  - Connect new links to increase through-put;
  - Change links to provide connectivity due to MANET reconfiguration;
- Use of satellite as relay between ad-hoc clusters (e.g. 2 MANETs);
- Integration with MSS and/or with FSS;

The MONET consortium has established some high level objectives required to achieve the vision described above:
To develop a complete understanding of the problems and complexity underlying the highly dynamic and heterogeneous environment of a hybrid MANET-Satellite network;

To optimize the use of satellite access links in a MANET through mechanisms that propose and implement changes in topology and resources used;

To provide seamless broadband services to everyone at any time in a hybrid MANET-satellite network thanks to optimized algorithms and network mechanisms;

To overcome performance bottlenecks and roadblocks in hybrid MANET-Satellite networks to enable a more pervasive and optimized network structure;

These can be further detailed into the following technical objectives:

- Identify and define a set of application scenarios to serve as the backdrop and canvas for the research work;
- Derive requirements from such hybrid networks based on the application scenarios;
- Propose an overall system and node architecture;
- To study and propose mechanisms, algorithms and modifications to existing protocol suites that optimize the use of network resources in the MONET concept;
- To implement a subset of these mechanisms in real HW platforms capable of functioning as MONET nodes;
- To assess the MONET mechanisms functionalities and performance in a controlled lab environment and to demonstrate the complete hybrid network in a real-time environment representative of a promising application.

### Scientific and Technological Results

The MONET project followed a simple approach in its plan: it began by defining a set of applications and application scenarios where a concept like MONET could be advantageous. Based on these, it became possible to identify and establish a set of requirements for a hybrid MANET-Satellite network. The MONET requirements were developed in partnership with potential end-users and were traced from the beginning up to the end of the project, always establishing a correspondence between requirements, mechanisms investigated, algorithms implemented and functionalities demonstrated and assessed. Based on this set of requirements, the consortium carried out extensive research, first establishing a system architecture for the network and defining a MONET node architecture as well as working on a multitude of mechanisms that seemed promising at system, satellite and MANET level. Theoretical investigation was complemented by simulations which allowed the consortium to judge the most promising algorithms among those considered. These were chosen to be implemented in an existing HW radio platform that could carry out the role of MONET node. After the successful implementation of algorithms, the consortium initiated a challenging exercise of integration of the algorithms, first within the nodes themselves, and of afterwards of the nodes with a laboratory test bed for testing purposes. Final validation of the system was performed through a live demonstration where a real-life event was simulated. End-users were requested at this point to provide their inputs and feedback once more and share with the consortium their thoughts about the advantages and shortcomings of MONET.
In order to limit the MONET “playing grounds”, a suitable working canvas was created. In that sense, application scenarios were designed which would serve as the basis and set the context and scope of the project. Examples of scenarios considered include:

- Forest Fire, with fire brigades, police and medical service involved;
- Mountain Rescue, where mountain rescuers will carry positioning equipment, body sensors, video cameras, connected to a wearable MONET node with wireless wideband communication;
- Coastal Monitoring, where the Fixed Command Post and the Back Office are connected by a satellite link, and terrestrial, aerial and maritime mobile units carry portable MONET nodes;
- Ground Traffic Management in Airport, where ground handling vehicles are nodes which form a MANET, and a satellite link is used as a relay between two MANETs.

These were ranked according to a set of Parameters chosen for scenario comparison and one scenario was chosen, through a scoring exercise carried out by the partners, to represent the most demanding application for MONET and the one that would later be demonstrated. The results of the ranking exercise which are represented in the next table and the chosen scenario is represented in Figure 4.

### scenario scoring

<table>
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<tr>
<th>parameters</th>
<th>scenario A</th>
<th>scenario B</th>
<th>scenario C</th>
<th>scenario D</th>
<th>scenario E</th>
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<tr>
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<td>Airport</td>
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<td>- Video</td>
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<td>- Voice calls</td>
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<th>scenario B</th>
<th>scenario C</th>
<th>scenario D</th>
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Table 1 – Scenario scoring (taken from MONET D2.4).
In order to define the requirements of the MONET system, end-users opinion and feedback were taken into account. These needs not only covered the features provided by communication systems currently used by public safety actors, but also contained several requests that may be fulfilled by MONET and that would definitely improve the communication efficiency in the selected scenarios. Starting from an operational perspective and hence mission requirements seven categories of requirements were defined: environmental, mechanic and electric, performance, radio interface, service, security and economical requirements.
A MONET system architecture was proposed taking into account the requirements. Three different roles or functionalities for nodes were defined:

- **General**, 
- **Interconnection**, 
- **Performance/Interoperability**

**Figure 5 – Requirements overview.**

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• Cooperative
• and Gateway nodes
The MONET network can be composed by all these types of MONET nodes that are linked via MANET or satellite links as indicated in Figure 6. All nodes perform functions depending on the device types. Each node has a radio system by which it is able to communicate with other nodes according to the scenarios and operator needs. So each MONET node can play a different role and has a different importance in the MONET system.

![Figure 6. MONET System Building Block](image)

A layered protocol stack was also defined for the MONET nodes. This stack combines regular functions ensured by existing protocols and complements them with MONET specific additions. By following a similar structure to the IP stack, the consortium wanted to achieve an IP based MONET radio.

![Figure 7. MONET Node Architecture Diagram](image)

Layer 1 defines MONET node’s physical layer. It provides a number of interfaces to the peripheral devices, such as sensor nodes, WIFI nodes, and/or an interface to satellite terminal, and other interfaces such as GPS, PSU, satcom modem.
Layer 2 hosts MAC protocols, interference management, channel state monitoring, and multichannel assignment algorithms, and QoS scheduling. We can specify the functionalities as below:

- **MAC algorithms**: wireless ad hoc networks rely on transmission power to maintain the connectivity. Relay nodes can help the message forwarding. This kind of cooperative communication paradigm represents a new way to reduce energy consumption and coverage extension.
- **Interference management**: this function manages node interference by setting or controlling RF power. Although MIMO can provide the diversity of transmission, considerable cost is required to deploy it. Cooperative communications can increase link diversity without additional hardware cost. An optimization algorithm needs interference aware relay node selection.
- **Channel state monitoring**: this function can be set on different level. The coarse monitoring states are “good”, “median”, “bad”. The more accuracy level of channel state can be measured by SINR (signal-interference noise ratio). The high level protocol design can use this information to perform cross-layer optimization.
- **Channel assignment Algorithms**: Each MONET node has 2 radios at 2.4GHz and 5GHz frequency band. Each frequency band can have up to 13 channels. Optimization algorithms can use this information in their design. Optimization algorithm should take advantages of using this information to increase link diversity.
- **QoS scheduling**: Particularly, scheduling algorithms will be used for QoS guarantee parameters in MANET. It remains a challenge to use scheduling on heterogeneous networks especially when satellite is considered. This function block takes multiple factors (e.g. Throughput, delay, jitter, and loss rate) into consideration, and adjusts the system behaviors according to the given policy. The adjustment can be made on PHY layer, MAC layer, and network layer, by means of cross-layer design.

Layer 3 offers features for routing, load balancing (resource management), network coding (network communication optimization) and satellite optimization.

- **Routing mechanisms**: Routing mechanisms calculate multi-path routes on ad hoc nodes that can frequently move. In the MONET system, OLSR is assumed to be used as routing protocol for the segment of MANET part. OLSR v2 provides better experimental mechanism for MANET. Currently, it is under IETF MANET WG standard track. Other routing mechanisms such as energy-aware routing, geo-routing will be studied as well, in complementary to OLSR in the MANET segment.
- **Load balancing**: Load balancing is a mechanism using multiple links in order to balance load repartition and resource consumption over the network.
- **Network coding building block**: network coding is a new approach to reduce transmission overhead and increasing reliability in lossy wireless network.
- **Satellite optimisation**: this optimisation will be studied at satellite segment only.

Layer 4 provides services for MANET applications. An auto-configuration daemon called MONET daemon is introduced to pass the requests of application APIs to the proper function box, for example, auto-configuration of new MONET nodes. Or some configuration parameters can be passed through these interfaces to control mobility policy, bandwidth allocation module, routing policy or algorithm selection, and scheduling policy. In order to have auto configuration mechanism, it can have a daemon process to enable a unified control platform which can avoid the potential conflict between individual optimization measures.
Based on the MONET architecture, consortium expertise and competence, and crossing these with the MONET requirements, the team selected some mechanisms to investigate which were relevant towards the support of MONET requirements and which are represented in Figure 8.

![Figure 8 - Map of WP4 optimisation studies](image)

At system level the consortium proposed, among other studies to assess how the extension of routing at system level could impact positively on the performance of MONET. It was shown that by extending routing to system level it’s possible to reduce packet loss substantially during handover procedure for both concentrated and distributed traffic.

Load balancing algorithm based on both static and dynamic parameters was shown to improve network performance but its performance is highly dependent on the scenario. This algorithm is especially important when satellite links are not well distributed.

An optimized QoS scheduling based on diffserv was studied and proposed. It has been shown to improve latency for Push To Talk high priority traffic, position reports and network critical data, however in order to prevent user starving (although guarantee depends highly on hops) strict enforcement by all users is required.

Finally, at system level Real Time services were addressed. Two main aspects were considered in the studies:
• Service topology
• Video encoding - Network adaptive encoding

Concerning service topology the use of satellite as a backbone was discussed (mainly for scalability purposes). SIP protocol was proposed for P2P communications and it was suggested to create multicast groups for multi-session (where aspects like security versus flexibility were discussed and lack of control shown to be improved by cross-layering combined with multicast.

Network adaptive encoding was analysed and proposed for video encoding. This can be achieved through Intra application approaches (e.g. using application specific codec like the SILK audio codec of Skype) or through Extra application approaches (e.g. scripts to apps like VLC or media player).

At the level of the satellite segment studies, the positive potential impacts of Satellite Mesh architecture and also of regenerative and OBP (On Board Processing) payloads on a hybrid network like MONET were shown. Mesh architectures can reduce delays and improve multicast traffic. OBP payloads can improve link budget, adapt to link conditions (FMT, ACM), reduce delays and improves connectivity.

The most advanced studies focused on developing bandwidth efficiency solutions and following were analysed and studied:
• Adaptive BoD based on congestion pricing and game theory dynamically adapts queue length reducing total transmission delay (aggressive when abundant and soft when congested)
• Resource management with ACM (Adaptive coding and modulation) – focused on uplink frame structure. Dynamic framing enhances link capacity in clean sky and increases link availability under severe attenuation
• CAC (Call Admission Control) with Reinforced Learning with dropping control to solve MDP (Markov Decision Processes) – ability to solve CAC online and to control blocking and dropping probabilities
• Crosslayer mechanisms – a back pressure algorithm between MAC and IP queues provided best performance for real-time traffic (e.g. video)

Multicast handover procedures were also analysed and it was shown that the usage of anycast to adapt network to satellite access point unavailability, failure or multicast source change handover interruptions can be reduced significantly (to 0-8 sec)

Concerning the study of mechanisms for turning on/off satellite terminal and triggers several were identified but not implemented totally as this would require access to satellite terminal programming:
• Due to power, cost, link-loss and QoS / bandwidth reasons
  – Passed directly to nodes instead of users
  – Commands or dedicated command interfaces
  – Hybrid terminals
• Explicit and implicit triggers for network re-organization
  – Implementation through routing metrics and hello messages
With respect to the optimization studies carried out for the MANET segment of MONET the following results were achieved.

The development of Multi Interface Multi Channel (MIMC) routing by extending AODV and AOMDV (Disjoint Multipath routing AODV) was shown to improve path bandwidth stability and load balancing of the MANET segment by introducing interference and path load estimations in route discovery.

The proposal of adding geo-based, energy aware and satlink routing metrics to standard OLSR routing protocol has been shown to result in:

- Reduced re-transmissions and timeout waits through the use of Geo-based routing;
- An increase of minimum lifetime of each node and of the network through the use of energy aware routing (at the expense of an increase in end-to-end delay);
- Capability to reduce communication costs by including satlink info in routing decisions.
- Better network reaction times to battery loss and node mobility due to predictive character of the metrics (still this requires careful balance between processing capability and network overhead).

The consortium also showed that fault tolerance and mobility management can be achieved by extending Q-routing protocol with an energy metric and pro-activeness in another MANET segment study.

Cooperative K-anypath routing was studied with the purpose of reducing switching time for sparsely distributed nodes. This was shown as was the fact that any candidate within the selected path is still a shortest path.

Finally, the application of network coding to the MANET segment enhances performance and delivery ratio with respect to regular OLSR but at the expense of a slight increase in end-to-end delay.

After the investigation of algorithms it was necessary to carry out an analysis of HW platforms which might be suitable to take the role of MONET nodes. 11 terrestrial radio platforms (ranging from TETRA terminals to military radios to partner prototypes) and 16 satellite terminals (from phones to satmodems from Iridium to Inmarsat to Globalstar and Thuraya) were analysed. The consortium decided to use the coordinator’s prototype MANET radios: WAC (Wireless Adaptive Communications nodes). The main criterion applied in the selection was the capability to have a platform that could be manipulated and accessed at will while providing a development environment as stable as possible. Having chosen a suitable HW platform it became necessary to choose also which algorithms would be implemented. Based on the application of a set of selection criteria the following algorithms (from the set described above) were chosen for implementation:

- Geo-based routing metric;
- Energy aware routing metric;
- Satellite link based routing metric with BGAN command support;
• Load Balancing algorithm;
• QoS scheduling;
• Context aware metrics;
• Anycast extension to OLSR;
• Network coding;

A number of additional components that enabled the control and management of the algorithms, a basic set of functionalities and a set of applications were deemed necessary:

• Push To Talk application to enable voice communications between first responders;
• Network routing basic protocols (Static, OLSR) to provide a baseline for comparison;
• A Daemon like component, MONET-D;
• A MONET Manager comprising a routing switch and a node configuration manager.

The development process of MONET was successfully carried out using open tools to favour partner exchanges and minimize costs and SW licenses. The integration of the implemented functions in the MONET nodes and the subsequent integration of these with the lab test bed at Astrium followed a fairly straightforward approach which is represented in Figure 9.

Figure 9 – MONET integration activity flowchart.

After the code was ported to the HW platforms integration with the BlueLab as Astrium was necessary. Three such integration sessions over the course of the reporting period were carried out in Toulouse. A first step in the calibration of the matrix attenuation consisted in a comprehensive analysis of the attenuation tool, in order to facilitate the integration with the test bed and the nodes, and to anticipate any problem that could occur. This phase was conducted in two steps. In the first step the matrix was tested with a spectrum analyser and signal generator. During the second step, WAC nodes were used in order to gather the data required to estimate the parameters that have been used for the lab tests. The calibration experiments were important to better understand some behaviours of the matrix, in particular the recombination phenomenon which hinders the predictability of the degradation of the signal along with the attenuation. After the successful integration of the MONET nodes the test bed (represented in Figure 10) became operational and ready for use in lab testing. A number of mobility scenarios were defined to support the tests (basically to define the displacement of the different communication terminals and their
translation into attenuation values in the matrix channels which simulated the radio environment). The consortium considered:

- 3 fixed scenarios
- 10 mobile scenarios with two walk speed each
- 1 mobile scenario with three motion ranges and two walk speed.

for a total of 29 mobility scenarios that can be played. The MONET test plan was divided in several phases.

- The first phase contains the **integration tests** which must be run when the final test bed is assembled before running the actual tests. It contains test 0.
- The second phase contains the **unit tests** that will be performed on specific parts or features of the system.
- The third phase consists in validating the compatibility of MONET with the **BGAN system**.
- The last phase consist in **overall performances tests**, assessing several combination of features in different situations to test their interworking.

All tests are applied and the integration and testing phase was successfully concluded. The tests reinforced and corroborated the results already obtained during simulations in WP4.

![Figure 10: MONET Nodes installation](image)

The last stages of the project were dedicated to the preparation and execution of a field demonstration which was held in INTA facilities in Madrid on the 4th of September of 2012. The trial attendance included EC representatives, end users from civil protection, medical emergency, police, and red cross. The test trial focused on the demonstrating the MONET functionalities that could support first responder operations (in a simulated forest fire operation as represented in Figure 11) and not so much on the technical aspects.
The trial included the demonstration of voice communications between fixed points (a command post) and mobile units all in the same MANET and over different MANETS. Isolated MANETS were also demonstrated and the leaving and joining of nodes was shown to have minor impacts on overall connectivity (although very dynamic networks can result in significant delays in voice exchanges). Video streaming from simulated fire areas was also demonstrated. Finally, due to a satellite service provider failure (on the provision of public IPs for the BGAN terminals) the use of satellite as relay between two MANET clusters was not demonstrated.

After the conclusion of the trial simulating the operation of forest fire fighting, some Q&A was held and an additional test was performed in order to test the reconfiguration capabilities of the network and assess qualitatively the importance and impact of compound delay on the PTT communications. For this test all nodes were positioned in a row, with the
middle nodes acting as relay for the end-nodes. The objective was for the last node to communicate with the Command Post.

Figure 13 - FR in a row

Figure 14 – Actual execution of test configuration of Figure 13.

Figure 15 – Q&A at the command post.
An assessment strategy to judge the results of the field trials based on a questionnaire to be filled by end-users attending the demo was defined. The overall feedback from end users was good, considering MONET a good concept which would improve the communication amongst the Command Post and the First responders deployed in the area of operations, since MONET offers the possibility to establish such communication without the need of any previous infrastructure. However, when comparing the results of the trial with the current day to day use of established technologies such as TETRA or VHF, different reactions were captured as not all users believe that the MONET ad-hoc node capabilities are better than their legacy terminals. Overall, MONET was considered a good concept that still needs to be improved in order to become a credible alternative to or even replace users’ current terminals and state of play technologies. Bearing in mind the results out of the questionnaires, showed in the different figures, and advantages provide by the system, (improvement of communication among FRs, easy to deploy, no need of previous infrastructure, support their current application (PTT) and future required applications (file and video exchanges), compatible with their way of work, etc.) the majority of users thinks that MONET comes out as a candidate for future communication system for Public Safety agencies.

The following figures provide support for the conclusions and feedback drawn in the previous paragraph.

Figure 16 – Feedback about general usefulness of MONET concept and nodes.
Figure 17 – Feedback about user friendliness and data rates provided by MONET.

Figure 18 – Feedback about deployment of the MONET network
To complete the assessment and evaluation of MONET a set of challenges which MONET still needs to consider and address in order to become a fully viable solution competitive with existing technologies were identified:

- Improvement of the network reliability and robustness;
- The quality of the provision of services and the way these are used;
- Terminals and their characteristics, in particular how they compare to existing terminals of other technologies.

Each of the above mentioned challenges is closely linked to the requirements of MONET. The following table establishes correspondences between each of the challenges and the subset of associated and relevant MONET requirements. This information was fed back to WP3 and to WP8 for the roadmap and adoption timeline definition activities.

<table>
<thead>
<tr>
<th>MONET Challenge</th>
<th>Relevant set /subset of MONET requirements</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network reliability and robustness</td>
<td>Operational requirements Global capacity requirements Interoperability requirements Connectivity requirements</td>
<td>In particular deployment, resilience, capacity and coverage requirements within the subsets identified</td>
</tr>
<tr>
<td>Service quality and way to use</td>
<td>Connectivity requirements Data rate requirements Traffic requirements QoS requirements</td>
<td>In particular related to delay and bit rates as well as QoE (e.g. perceived quality of sound)</td>
</tr>
<tr>
<td>Terminals</td>
<td>Interfaces and compatibility requirements</td>
<td>Especially those related to interfacing with other equipment,</td>
</tr>
</tbody>
</table>
Based on the feedback provided by WP5, WP6 and WP7 and the experience gathered in said work packages, the MONET architecture has been revised. Modifications to the system architecture and to the node protocol stack have been proposed taking into consideration the challenges and benefits stemming from the implementation work carried out in WP5.

Project results will provide support for a wider variety of edge networks, in particular MANET, and the combination of ad-hoc management capabilities with satellite. Users have, in fact, expressed their interest in the MONET concept stating they believe MONET to be very useful in enhancing the communications in their operational duties. Users also believe MONET adhoc networking capabilities can improve upon current communications technologies like TETRA and VHF or UHF radios and have praised the quick, “no fuss” deployment characteristics of the network (for further details refer to D7.3). However, users have identified aspects to improve in future research and development, namely robustness and application resilience (e.g. delay in voice communications).

The consortium believes MONET research has been successful in demonstrating the worth of the hybrid network and may lead to new views on the "best effort" paradigm driving the original design of the internet. By developing solutions to the issue of resource usage in composite networks with broad applications the consortium and other European players through partnerships and through access to MONET research results made available by the foreseen dissemination mechanisms and advisory board will reinforce their position and thus Europe’s on the international scene.
Potential Impact

Based on the feedback from the end-users and industry attending the field trial and on the foreground generated by the project, the consortium is confident that MONET can have some impact on the target user community.

The MONET concept and system was considered very interesting as a new way to transfer voice and data between terrestrial network clusters. Voice is and will continue to be the mission critical service. Some users worry that video and the new possibilities introduced by new technologies might lead to information overflow and prevent efficient operations. Although most end-users continue to consider voice as the most relevant aspect, industry believes that once the capabilities of video are demonstrated and assimilated into the everyday operational procedures, imagery and video services will become mandatory. For example, in Inmarsat’s opinion, video is an incredibly important service which will grow in the future so it’s relevant that it is considered within MONET.

Generally, the users and industry attending the demo believe that MONET can be improved by adding more robustness to the last mile nodes and by investigating and implementing better control over which traffic goes in and out of the MONET network. The simultaneous transmission of voice and video over the same link was considered impressive. Field testing is the most important aspect of RTD projects for the end-users. In order to ensure good participation of end-users at trials and demos, it is important to show the added valued of attending and to tailor invitations to the entities and persons targeted (either technical or operational persons). Even if the operation validation is important for end-users, they pinpoint on the importance of getting involved on all aspects of the testing. This is extremely important to ensure a good impact for project results.

Interactions between the consortium and end-user groups have resulted in some insightful inputs towards ensuring a greater impact of project results. The success of the type of applied research carried out in MONET and consequently the impact its results might have is highly dependent on the perceived value by the target end-user communities. In order to guarantee a good and honest feedback it is necessary to enable users to judge by themselves the value of proposed solutions. This will open the first doors towards early testing in operational environments and possibly early adoption. A possible way of facilitating comparison of technical solutions to the state of play and ensuring relevance of the trial for end-users is to replay real incidents. In most cases, these have real data already available (from the time they first took place) as well as KPIs (Key Performance Indicators) in some cases. Furthermore, timelines and baseline performances are already established. The user committee stressed the importance of testing real-life, credible scenarios.

Although most users (i.e. public safety authorities and emergency response bodies) don’t foresee exactly the introduction of new terminals and technologies in the short term (due to voluminous investments in emergency communications infrastructure), most believe there is room to complement existing systems and technologies with new ones. Another area where new systems like MONET could have a direct impact is in incident areas where no
infrastructure exists or where the existing infrastructure is incompatible. Bringing new infrastructure or in the case of MONET infrastructure-less systems to incident areas and supporting usage by existing terminals will be seen in a very positive light by user community.

Users believe availability and redundancy to be two of the most important aspects of public safety communications. The interoperability of systems is also very important for them. (It will be very useful if Finland police forces for instance can come to Italy and operate their TETRA system on the Italian infrastructure). In this sense, MONET is very well positioned to have a significant impact. The combination of the MANET and satellite technologies improves availability as the consortium believes was shown during the trials. The fact that MONET is based on IP networks is in line with current trends towards all-IP networks and will in that case reduce the amount of effort and investment required to ensure interoperability.

Another aspect where MONET can have a positive impact is the fact that according to the users, probably the best HMI is something along the lines of GSM phones or smart phones/tablets. This is precisely the type of HMI that MONET proposed to use.

Most end-users with whom the consortium has interacted believe MONET could be implemented in real life under the scope of initiatives like MESA and that its best chance of making it into the market would be to support multiple services over the same physical bearer. Still, the implementation and adoption of MONET as a full system by potential customers, is still some years away. The results of the project have shown that in order to have a fully functional and convincing system, further work at the terminal and satellite segment level is required.

While it may be feasible to expect the introduction of fully integrated hybrid terrestrial-satellite terminals capable of using existing satellite commercial services on the market in the next 3-5 years, it rather more difficult to consider the introduction of the satellite segment optimizations in the same timeframe. The introduction of some MONET satellite segment optimizations on the ground segment of satellite networks (e.g. Network Control Centres) might be possible in the short term, especially if satellite operators are involved and willing to modify their ground segments (following, of course appropriate plans to ensure the safety of satellite operations). Introduction of MONET optimizations in the space segment (actual satellite payloads) if relevant is more difficult. New satellite platform development can easily take 10 years and generally requires a set of interested customers to justify the investment. A possible alternative to reduce the time required for space segment development might be the application of MONET algorithms in micro and nano-satellite platforms for demonstration purposes. A space flight validating Satellite segment MONET optimizations will, in our opinion, jump start interest from the major satellite operators which in turn will generate new developments from satellite manufacturers.
The MONET adoption timeline is deeply connected to further research being carried out on terminals, the MANET optimizations, the satellite optimizations and the applications. All of this must come together simultaneously to ensure the success of the MONET concept. The introduction of a MONET like system without all elements on the market comprises an important risk: that potential customers lose confidence in the system (e.g. because applications are not adequate – such as deficient sound quality in PTT) and decide that MONET is not the solution. It is extremely important that once introduced in the market MONET causes a good first impression. Second chances are hard to come by if the first impression is that the technology or the system is not mature enough.

The following timeline of adoption was developed in WP8 and is shown here because the consortium believes that MONET impact is deeply connected to this timeline.

<table>
<thead>
<tr>
<th>Time from present day</th>
<th>Steps</th>
<th>Assumptions made</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>Fielding of the first MONET system</td>
<td>MONET complies with all regulatory aspects. Financial situation of public accounts allows for investment of at least one country in this technology.</td>
<td></td>
</tr>
<tr>
<td>2020</td>
<td>All commercial relations in place</td>
<td>Partners have the necessary contact networks in place and satellite operators demonstrate interest in MONET</td>
<td>Necessary to enable commercial exploitation of MONET and provide necessary support to customers</td>
</tr>
<tr>
<td>2018-2020</td>
<td>Successful extended pilot of MONET</td>
<td>Availability of an end-user to use MONET in addition to existing system in real operations</td>
<td>Required to raise confidence of users</td>
</tr>
<tr>
<td>2016-2018</td>
<td>All satellite segment implementations achieved</td>
<td>Satellite services operator is willing to implement these in their space and ground segments</td>
<td>Alternatives may include the use of micro and nano satellites of lower cost (e.g. CubeSats)</td>
</tr>
<tr>
<td>2014-2017</td>
<td>Fully integrated hybrid terrestrial satellite terminals</td>
<td>Improvements at antenna level, pointing mechanisms and SDR required</td>
<td>Partnerships with satellite terminal manufacturers may be required</td>
</tr>
<tr>
<td>Year</td>
<td>Description</td>
<td>Research Continuation</td>
<td>Expected Outcome</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>2014-2015</td>
<td>MONET enabled applications developed</td>
<td>Suitable applications are feasible</td>
<td>Voice PTT as a minimum. Video and mapping (blue force tracking) applications also interesting</td>
</tr>
<tr>
<td>2014-2015</td>
<td>Further optimizations at system level</td>
<td>Continued research in this domain – i.e. continued interest from researchers and availability of funds (internal and national / European)</td>
<td></td>
</tr>
<tr>
<td>2014-2015</td>
<td>Development of a full MONET protocol suite</td>
<td>Continued research in this domain – i.e. continued interest from researchers and availability of funds (internal and national / European)</td>
<td>Covering complete set of layers</td>
</tr>
<tr>
<td>2014-2015</td>
<td>Tailoring of satellite segment optimizations to new standards and specific satellite architectures</td>
<td>Continued research in this domain – i.e. continued interest from researchers and availability of funds (internal and national / European)</td>
<td>E.g. DVB-RCS2</td>
</tr>
<tr>
<td>2014-2015</td>
<td>Development of self-adaptive routing protocols and background service protocols in MANET segment</td>
<td>Continued research in this domain – i.e. continued interest from researchers and availability of funds (internal and national / European)</td>
<td></td>
</tr>
</tbody>
</table>

Table 3 – MONET adoption timeline.

So currently, the consortium believes that the impact of MONET is mostly limited to the algorithms and to showing the feasibility of the hybrid network concept which requires little or no user intervention in setting up, deploying and operating. Although this may seem minute, we believe this is a great impact as it opens the horizons of user communities to the possibilities of these types of networks and raises their interest in participating in future initiatives in this domain. Once users get on board and gain enthusiasm, the satellite service provider and manufacturers will be the next ones to board the train. This step is extremely important as MONET cannot work without implementation taking place also at the ground and space segment of satellite networks (which can be significantly harder due to the long lead times connected to the introduction of new satellites and the high investments necessary to fly and operate satellite).

Perhaps the greatest impact has been the demonstration of the use of PTT application and simultaneous transmission of voice and video over the MANET segment – these results are quite promising and if the consortium addresses the challenges identified during the project and focuses on raising the robustness of the network and providing better control over the
type of traffic coming and going, we believe we will have a very competitive system and set
of technologies at hand capable of changing paradigms concerning the way public safety
communications work today.

**Project contacts and further information**

More information on the MONET project and the results of the work performed (including
deliverables) can be found at its website at [http://www.monet-ict.eu](http://www.monet-ict.eu).

Partner contacts are also provided:

**TEKEVER (coordinator):**
Mr. Pedro Sinogas
E-mail: [Pedro.sinogas@tekever.com](mailto:Pedro.sinogas@tekever.com)
T: +351 213 304 300

**CRAT:**
Dr. Antonio Pietrabissa
E-mail: [Pietrabissa@dis.uniroma1.it](mailto:Pietrabissa@dis.uniroma1.it)
T: +39 06 7727 4037

**UNIS:**
Prof. Zhili Sun
E-mail: [z.sun@surrey.ac.uk](mailto:z.sun@surrey.ac.uk)
T: +44 (0) 1483 68 9493

**ISDEFE:**
Mr. Diego Gimenez
E-mail: [dgimenez@isdefe.es](mailto:dgimenez@isdefe.es)
T: +34 91 411 50 11

**ASTRIUM:**
Ms. Melânie Monier
E-mail: [Melanie.monier@astrium.eads.net](mailto:Melanie.monier@astrium.eads.net)
T: +33 5 62 19 65 79

**URSZR:**
Ms. Katja Juros
E-mail: [Katja.banovec.juros@urszr.si](mailto:Katja.banovec.juros@urszr.si)
T: +386 (0) 1 471 32 55

### 4.2 Use and dissemination of foreground

A plan for use and dissemination of foreground (including socio-economic impact and target
groups for the results of the research) shall be established at the end of the project. It
should, where appropriate, be an update of the initial plan in Annex I for use and
dissemination of foreground and be consistent with the report on societal implications on
the use and dissemination of foreground (section 4.3 – H).

The plan should consist of:
Section A

This section should describe the dissemination measures, including any scientific publications relating to foreground. **Its content will be made available in the public domain** thus demonstrating the added-value and positive impact of the project on the European Union.

Section B

This section should specify the exploitable foreground and provide the plans for exploitation. All these data can be public or confidential; the report must clearly mark non-publishable (confidential) parts that will be treated as such by the Commission. Information under Section B that is not marked as confidential **will be made available in the public domain** thus demonstrating the added-value and positive impact of the project on the European Union.
Section A (public)

This section includes two templates

- Template A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.

These tables are cumulative, which means that they should always show all publications and activities from the beginning until after the end of the project. Updates are possible at any time.

<table>
<thead>
<tr>
<th>NO</th>
<th>Title</th>
<th>Main author</th>
<th>Title of the periodical or the series</th>
<th>Number, date or frequency</th>
<th>Publisher</th>
<th>Place of publication</th>
<th>Year of publication</th>
<th>Relevant pages</th>
<th>Permanent identifiers (if available)</th>
<th>Is/Will open access provided to this publication?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Internetworking of satellite and wireless ad hoc networks for emergency and disaster relieve services</td>
<td>A Oliveira</td>
<td>International Journal of Satellite Communications Policy and Management (IJSCPM)</td>
<td>Int. J. Satellite Communications Policy and Management, Vol. 1, No. 1, 2011</td>
<td>Inderscience</td>
<td>2011</td>
<td></td>
<td></td>
<td></td>
<td>No</td>
</tr>
</tbody>
</table>

3 A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).

4 Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.
| 4 | Dynamic uplink frame optimization with ACM in DVB-RCS2 satellite networks | A Pietrabissa | International Journal of Satellite Communications and Networking | 2012 | No |
| 5 | MQ-Routing: Mobility-, GPS- and Energy-Aware Routing Protocol in MANETs for Disaster Relief Scenarios | D Macone | Ad-hoc networks | Elsevier | 2012 | No |

**TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES**

<table>
<thead>
<tr>
<th>Type of activities</th>
<th>Main leader</th>
<th>Title</th>
<th>Date/Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU FP7 projects</td>
<td>UNIS CRAT</td>
<td>Future Network &amp; Mobile Summit 2010</td>
<td>16th-18th June 2010</td>
</tr>
<tr>
<td>Community</td>
<td>URSZR</td>
<td>19th International Electrotechnical and Computer Science</td>
<td>20-22 September</td>
</tr>
<tr>
<td>Conference</td>
<td>Date</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>---------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentation of MONET project to the Assembly + Dissemination to ISI members, EC representatives</td>
<td>November 2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper Presentation and networking with ad hoc network research community. Chair Ad-Hoc Routing session (UNIS)</td>
<td>6th-10th December 2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presentation of MONET Concept and idea to BSM community</td>
<td>February 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>to be in line in MONET and to keep in mind users requirements and key issues for Public Safety community</td>
<td>June 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>being representative of MONET, which is one of the few on-going satellite-related projects</td>
<td>May 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dedicated event</td>
<td>November 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synergies</td>
<td>December 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conference/Event</td>
<td>Implications</td>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>---------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Conference (ICSSC)</td>
<td>Special focus on optimization, implementation and on testing. Useful comments and discussions for the MONET implementation, lab and field test final phase.</td>
<td>July 2012</td>
<td></td>
</tr>
<tr>
<td>Astrium FUNEMS (Future Network Summit 2012)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissemination to the audience of an optimization carried out in WP4</td>
<td>CRAT 20th Mediterranean Conference on Control and Automation (MED 2012)</td>
<td>July 2102</td>
<td></td>
</tr>
<tr>
<td>CRAT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEK Farnborough Airshow</td>
<td></td>
<td>July 2012</td>
<td></td>
</tr>
<tr>
<td>TEK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissemination of MONET project along with the distribution of dedicated brochure.</td>
<td>Astrium Space EU conference</td>
<td>February 2012</td>
<td></td>
</tr>
<tr>
<td>Astrium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissemination of MONET and contributions to discussions related to standardisation of Satellite architectures and protocols for emergency communication.</td>
<td>Astrium SATEC</td>
<td>May 2012</td>
<td></td>
</tr>
<tr>
<td>Astrium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very useful to discuss and gather feedbacks from stakeholders.</td>
<td>TEK, CRAT, UNIS, Astrium PSCE forum</td>
<td>May 2012</td>
<td></td>
</tr>
<tr>
<td>TEK, CRAT, UNIS, Astrium</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section B (Confidential or public: confidential information to be marked clearly)

Part B1

No applications for patents, trademarks, registered designs, have been made as of the final month of the MONET project.
<table>
<thead>
<tr>
<th>Type of Exploitable Foreground</th>
<th>Description of exploitable foreground</th>
<th>Confidenti al Click on YES/NO</th>
<th>Foresee n embargo date dd/mm/yyyy</th>
<th>Exploitable product(s) or measure(s)</th>
<th>Sector(s) of application</th>
<th>Timetable, commercial or any other use</th>
<th>Patents or other IPR exploitation (licences)</th>
<th>Owner &amp; Other Beneficiary(s) involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>General advancement of knowledge</td>
<td>Load balancing algorithm described in section 3.2 of D4.1</td>
<td>YES</td>
<td>Knowledge can be used to advance internal and collaborative research</td>
<td>Satellite communication s Terrestrial infrastructure-less communication s</td>
<td>2015</td>
<td>N/A</td>
<td>Beneficiary 5 - Astrium</td>
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<tr>
<td>General advancement of knowledge</td>
<td>Optimized QoS management described in section 4 of D4.1</td>
<td>YES</td>
<td>Knowledge can be used to advance internal and collaborative research</td>
<td>Satellite communication s Terrestrial infrastructure-less communication s</td>
<td>2015</td>
<td>N/A</td>
<td>Beneficiary 5 – Astrium</td>
<td></td>
</tr>
<tr>
<td>General advancement of knowledge</td>
<td>Real-time service optimization presented in section 5 of D4.1</td>
<td>YES</td>
<td>Knowledge can be used to advance internal and collaborative research</td>
<td>Satellite communication s Terrestrial infrastructure-less communication s</td>
<td>2015</td>
<td>N/A</td>
<td>Beneficiary 5 – Astrium</td>
<td></td>
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<tr>
<td>General advancement of knowledge</td>
<td>Frame composition optimization</td>
<td>YES</td>
<td>Knowledge can be used to advance internal and collaborative research</td>
<td>Satellite communication s</td>
<td>2015</td>
<td>N/A</td>
<td>Beneficiary 2 – CRAT</td>
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<td>Type of Exploitable Foreground&lt;sup&gt;8&lt;/sup&gt;</td>
<td>Description of exploitable foreground</td>
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<td>Foresee n embargo date dd/mm/yyyy</td>
<td>Exploitable product(s) or measure(s)</td>
<td>Sector(s) of application&lt;sup&gt;9&lt;/sup&gt;</td>
<td>Timetable, commercial or any other use</td>
<td>Patents or other IPR exploitation (licences)</td>
<td>Owner &amp; Other Beneficiary(s) involved</td>
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<tr>
<td>----------------------------------------</td>
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<tr>
<td>General advancement of knowledge</td>
<td>n algorithm described in section 4 of D4.2</td>
<td></td>
<td>collaborative research</td>
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<td></td>
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<tr>
<td>Call Admission Control optimization algorithm described in section 4 of D4.2</td>
<td>YES</td>
<td>Knowledge can be used to advance internal and collaborative research</td>
<td>Satellite communications</td>
<td>2105</td>
<td>N/A</td>
<td></td>
<td></td>
<td>Beneficiary 2 – CRAT</td>
</tr>
<tr>
<td>General advancement of knowledge</td>
<td>Bandwidth on Demand optimization algorithm based on congestion pricing and game theory described in section 5 of D4.2</td>
<td>YES</td>
<td>Knowledge can be used to advance internal and collaborative research</td>
<td>Satellite communications</td>
<td>2015</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General advancement of knowledge</td>
<td>Fault tolerant and energy aware routing protocol described in section 8 of D4.3</td>
<td>YES</td>
<td>Knowledge can be used to advance internal and collaborative research</td>
<td>Terrestrial infrastructure-less communications</td>
<td>2014</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General advancement of knowledge</td>
<td>Multi-Interface Multi-</td>
<td>YES</td>
<td>Knowledge can be used to advance Terrestrial infrastructure-</td>
<td>2014</td>
<td>N/A</td>
<td></td>
<td></td>
<td>Beneficiary 3 – UNIS</td>
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<tr>
<td>Type of Exploitable Foreground</td>
<td>Description of exploitable foreground</td>
<td>Confidential Click on YES/NO</td>
<td>Foreseen embargo date dd/mm/yyyy</td>
<td>Exploitable product(s) or measure(s)</td>
<td>Sector(s) of application</td>
<td>Timetable, commercial or any other use</td>
<td>Patents or other IPR exploitation (licences)</td>
<td>Owner &amp; Other Beneficiary(s) involved</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------------------------------</td>
<td>-----------------------------</td>
<td>---------------------------------</td>
<td>-----------------------------------</td>
<td>------------------------</td>
<td>--------------------------------------</td>
<td>---------------------------------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>General advancement of knowledge</td>
<td>Channel routing based on cost aware MIMC-AOMDV described in section 5 of D4.3</td>
<td>YES</td>
<td></td>
<td>internal and collaborative research</td>
<td>less communications</td>
<td></td>
<td></td>
<td>Beneficiary 3 – UNIS</td>
</tr>
<tr>
<td>General advancement of knowledge</td>
<td>Cooperative K-Anypath routing described in section 9 of D4.3</td>
<td>YES</td>
<td></td>
<td>Knowledge can be used to advance internal and collaborative research</td>
<td>Terrestrial infrastructure-less communications</td>
<td></td>
<td></td>
<td>Beneficiary 3 - UNIS</td>
</tr>
<tr>
<td>Commercial exploitation of R&amp;D results</td>
<td>Geo-based and energy aware routing metrics presented in section 6 of D4.3</td>
<td>YES</td>
<td></td>
<td>Future internal and collaborative research Integration in TEK WAC product line</td>
<td>Terrestrial infrastructure-less communications</td>
<td></td>
<td></td>
<td>Beneficiary 1 - TEK</td>
</tr>
<tr>
<td>Commercial exploitation of R&amp;D results</td>
<td>MONET HW nodes</td>
<td>YES</td>
<td></td>
<td>Integration in TEK WAC product line</td>
<td>Public safety telecommunications market terrestrial infrastructure-</td>
<td></td>
<td></td>
<td>Beneficiary 1 - TEK</td>
</tr>
</tbody>
</table>
Most of the foreground generated by MONET corresponds to the algorithms and metrics that were proposed and developed by the partners in WP4 (except for the final point – the MONET HW nodes).

The purpose of all these algorithms is to improve the performance and management of resources of a hybrid network comprising a terrestrial infrastructure-less sub-network (one or more MANET) and a satellite sub-network. Hence, they may be exploited in several ways:

1. By building more sophisticated and advanced algorithms based on the results of the work performed in MONET thus advancing even more the scientific knowledge in this domain;
2. By introducing them into existing commercial products based on IP communications which might benefit from their functionalities. Examples of such products include mobile ad-hoc terrestrial radios and satellite platforms for satellite communications provision.

While the first bullet can be exploited almost immediately through incorporation of R&D results into internal research or into new collaborative projects, the second bullet may require (in the cases of the academic partners) the establishment of partnerships with industrial players and definitely needs the identification and existence of products which must be willing and able to incorporate the results produced. In any case, the foreground will be exploited by the beneficiaries who have generated it.

Currently, no additional protection measures for the algorithms foreground are foreseen. Further research could in fact improve the developed algorithms and may lead to an increase in the potential commercial value of the foreground by improving performance of the algorithms.

The impact of these algorithms is expected mostly in the medium term (especially for the satellite networks) and will consist essentially of reduced delays in communications, improved and seamless connectivity and reduction in network deployment times. In the case of MONET it is sometimes hard to quantify the impact of these algorithms as some result in the provision of a capability that was previously unavailable.

Regarding the remaining item of foreground, the MONET HW nodes, its purpose is quite clear: to become an alternative terminal to personal radios currently in use by public safety and emergency response entities, especially one that does not require any
infrastructure to work (being therefore interesting for catastrophe response when the communications infrastructure can become damaged or in remote regions where the cost of deploying infrastructure is prohibitive).

The coordinator believes that the MONET HW nodes can be exploited in two ways:

- Commercial exploitation of the nodes as solely terrestrial MANET radios alternative to UHF and VHF or even TETRA radios (which will require further research and improvements at the levels of transmission power, range and robustness);

- Commercial exploitation of the nodes as hybrid terrestrial-satcom (MANET) terminals with added connectivity capacity for long range. This strategy is more long term as this requires research at the level of physical integration of terrestrial radio and satellite modem into a single equipment which is portable and has enough power autonomy.

In both cases the algorithms developed by the other partners could be included in the radios and exploited by TEK. If this becomes the case, then TEK will enter into suitable agreements with the other beneficiaries towards using their foreground on TEK products. For both node exploitation cases the end customer will be composed of entities from the emergency response and public safety sectors as well as NGOs or industries working in very remote locations (e.g. oil or gas drilling). The coordinator, being the owner of the foreground is intent on exploiting it as soon as possible. In that sense, a request for registration of design of the MONET nodes is foreseen to take place during the year of 2012-2013 as well as the registration of a trademark in preparation for a commercial launch.

As was already hinted, the coordinator believes that research on terminal integration and on tools to ensure simultaneous use of multiple radio interfaces, while ensuring adequate transmission power commensurate with required ranges and improving reception of transmissions and flexibility to upgrade terminals and use different waveforms will be necessary. Hence, integration of MONET research with research work at the level of antennas (e.g. MIMO technology), software defined radio (e.g. to reduce the footprint of terminals enabling smaller terminals comprising both satellite modems and terrestrial radios and providing higher flexibility) and waveform design is deemed interesting.

Preliminary interest from some national entities in the MONET node prototypes has already been signalled and one can estimate that if a successful commercial launch is done during 2014, a national market share of around 5% of terminals used by public safety users could be reasonable to expect.
### 4.3 Report on societal implications

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

| A General Information **(completed automatically when Grant Agreement number is entered.)** |
|---------------------------------|-----------------------------------------------|
| Grant Agreement Number:         | 247176                                       |
| Title of Project:               | Mechanisms for Optimization of hybrid ad-hoc networks and satellite NETWorks |
| Name and Title of Coordinator:  | Mr. Pedro Sinogas                            |

<table>
<thead>
<tr>
<th>B Ethics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Did your project undergo an Ethics Review (and/or Screening)?</td>
</tr>
<tr>
<td>- If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports?</td>
</tr>
<tr>
<td><strong>NO</strong></td>
</tr>
</tbody>
</table>

Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 'Work Progress and Achievements'

<table>
<thead>
<tr>
<th>2. Please indicate whether your project involved any of the following issues (tick box):</th>
<th>YES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RESEARCH ON HUMANS</strong></td>
<td></td>
</tr>
<tr>
<td>- Did the project involve children?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve patients?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve persons not able to give consent?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve adult healthy volunteers?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve Human genetic material?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve Human biological samples?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve Human data collection?</td>
<td></td>
</tr>
<tr>
<td><strong>RESEARCH ON HUMAN EMBRYO/FOETUS</strong></td>
<td></td>
</tr>
<tr>
<td>- Did the project involve Human Embryos?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve Human Foetal Tissue / Cells?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve Human Embryonic Stem Cells (hESCs)?</td>
<td></td>
</tr>
<tr>
<td>- Did the project on human Embryonic Stem Cells involve cells in culture?</td>
<td></td>
</tr>
<tr>
<td>- Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?</td>
<td></td>
</tr>
<tr>
<td><strong>PRIVACY</strong></td>
<td></td>
</tr>
<tr>
<td>- Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?</td>
<td></td>
</tr>
<tr>
<td>- Did the project involve tracking the location or observation of people?</td>
<td></td>
</tr>
<tr>
<td><strong>RESEARCH ON ANIMALS</strong></td>
<td></td>
</tr>
</tbody>
</table>
- Did the project involve research on animals?
- Were those animals transgenic small laboratory animals?
- Were those animals transgenic farm animals?
- Were those animals cloned farm animals?
- Were those animals non-human primates?

**Research Involving Developing Countries**
- Did the project involve the use of local resources (genetic, animal, plant etc)?
- Was the project of benefit to local community (capacity building, access to healthcare, education etc)?

**Dual Use**
- Research having direct military use
- Research having the potential for terrorist abuse

### C Workforce Statistics

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

<table>
<thead>
<tr>
<th>Type of Position</th>
<th>Number of Women</th>
<th>Number of Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Coordinator</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Work package leaders</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Experienced researchers (i.e. PhD holders)</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>PhD Students</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
<td>14</td>
</tr>
</tbody>
</table>

4. How many additional researchers (in companies and universities) were recruited specifically for this project? 4

Of which, indicate the number of men: 4
### D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project? 
- [ ] Yes
- [ ] No

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

<table>
<thead>
<tr>
<th>Action</th>
<th>Not at all effective</th>
<th>Very effective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and implement an equal opportunity policy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set targets to achieve a gender balance in the workforce</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organise conferences and workshops on gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Actions to improve work-life balance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?
- [ ] Yes - please specify
- [ ] No

### E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?
- [ ] Yes - please specify
- [ ] No

PhD courses and seminars were held based on project results.

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?
- [ ] Yes - please specify
- [ ] No

### F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?
- [ ] Main discipline\(^\text{10}: 2.2\)
- [ ] Associated discipline\(^\text{10}: 1.1\)
- [ ] Associated discipline\(^\text{10}: \) 

### G Engaging with Civil society and policy makers

11a. Did your project engage with societal actors beyond the research community? (if 'No', go to Question 14)
- [ ] Yes
- [ ] No

11b. If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?
- [ ] No
- [ ] Yes - in determining what research should be performed
- [ ] Yes - in implementing the research
- [ ] Yes, in communicating /disseminating / using the results of the project
11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

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

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

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

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

<table>
<thead>
<tr>
<th>Agriculture</th>
<th>Energy</th>
<th>Human rights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audiovisual and Media</td>
<td>Enlargement</td>
<td>Information Society</td>
</tr>
<tr>
<td>Budget</td>
<td>Enterprise</td>
<td>Institutional affairs</td>
</tr>
<tr>
<td>Competition</td>
<td>Environment</td>
<td>Internal Market</td>
</tr>
<tr>
<td>Consumers</td>
<td>External Relations</td>
<td>Justice, freedom and security</td>
</tr>
<tr>
<td>Culture</td>
<td>External Trade</td>
<td>Public Health</td>
</tr>
<tr>
<td>Customs</td>
<td>Fisheries and Maritime Affairs</td>
<td>Regional Policy</td>
</tr>
<tr>
<td>Development Economic and Monetary Affairs</td>
<td>Food Safety</td>
<td>Research and Innovation</td>
</tr>
<tr>
<td>Education, Training, Youth</td>
<td>Foreign and Security Policy</td>
<td>Space</td>
</tr>
<tr>
<td>Employment and Social Affairs</td>
<td>Fraud</td>
<td>Taxation</td>
</tr>
<tr>
<td></td>
<td>Humanitarian aid</td>
<td>Transport</td>
</tr>
</tbody>
</table>
13c  If Yes, at which level?
- Local / regional levels
- National level
- European level
- International level

H  Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals? 4

To how many of these is open access\textsuperscript{11} provided? 0

How many of these are published in open access journals? 0

How many of these are published in open repositories? 0

To how many of these is open access not provided? 4

Please check all applicable reasons for not providing open access:

- publisher's licensing agreement would not permit publishing in a repository
- no suitable repository available
- no suitable open access journal available
- no funds available to publish in an open access journal
- lack of time and resources
- lack of information on open access
- other\textsuperscript{12}: ...............  

15. How many new patent applications (‘priority filings’) have been made? (‘Technologically unique’: multiple applications for the same invention in different jurisdictions should be counted as just one application of grant). 0

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).

<table>
<thead>
<tr>
<th>Intellectual Property Rights</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trademark</td>
<td>0</td>
</tr>
<tr>
<td>Registered design</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
</tr>
</tbody>
</table>

17. How many spin-off companies were created / are planned as a direct result of the project?

Indicate the approximate number of additional jobs in these companies: 0

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

<table>
<thead>
<tr>
<th>Impact on Employment</th>
<th>In small &amp; medium-sized enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in employment, or</td>
<td>In large companies</td>
</tr>
<tr>
<td>Safeguard employment, or</td>
<td>None of the above / not relevant to the project</td>
</tr>
<tr>
<td>Decrease in employment,</td>
<td></td>
</tr>
<tr>
<td>Difficult to estimate / not possible to quantify</td>
<td></td>
</tr>
</tbody>
</table>

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (\textit{FTE = one person working fulltime for a year}) jobs: 10
**I Media and Communication to the general public**

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

| ☐ Yes | ☐ No |

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

| ☐ Yes | ☐ No |

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

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

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

| ☐ Language of the coordinator | ☑ English |

**Question F-10:** Classification of Scientific Disciplines according to the Frascati Manual 2002


**FIELDS OF SCIENCE AND TECHNOLOGY**

1. **NATURAL SCIENCES**
   1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]
   1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)
   1.3 Chemical sciences (chemistry, other allied subjects)
   1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)
   1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2. **ENGINEERING AND TECHNOLOGY**
   2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)
   2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]
2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES
3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)
3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)
3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES
4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)
4.2 Veterinary medicine

5. SOCIAL SCIENCES
5.1 Psychology
5.2 Economics
5.3 Educational sciences (education and training and other allied subjects)
5.4 Other social sciences [anthropology (social and cultural) and ethology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary, methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES
6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)
6.2 Languages and literature (ancient and modern)
6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic “research” of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]
2. FINAL REPORT ON THE DISTRIBUTION OF THE EUROPEAN UNION FINANCIAL CONTRIBUTION

This report shall be submitted to the Commission within 30 days after receipt of the final payment of the European Union financial contribution.

Report on the distribution of the European Union financial contribution between beneficiaries

_This information is currently being compiled._

<table>
<thead>
<tr>
<th>Name of beneficiary</th>
<th>Final amount of EU contribution per beneficiary in Euros</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
</tr>
<tr>
<td>n</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>