GNSS User Requirements in Emergency Management

Charles S. Dixon & Reinhard Haas; EADS Astrium

Abstract

This paper addresses GNSS support to operations that are necessary for the management of various types of emergency. The results from a thorough analysis and consolidation of current and future user requirements of users for GNSS applications, as accomplished within project MAGES (Mature Applications of Galileo for Emergency Scenarios), are presented in the paper. Some of these applications exist today in some form for some emergency users. Other applications are presently only used by subset user groups but are considered to have high potential benefits in the future across a wide spectrum of emergency domain users. This document shows the definition of emergency user groups and requirements for a selection of emergency management applications which evolving technologies should aim to satisfy in the future. It includes a highlight of unique differentiators emanating from the introduction of Galileo and EGNOS with respect to existing systems, and on their importance for actors in emergency management.
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1. Introduction

This paper presents User Requirements for GNSS in the Emergency Management domain. The work reported was derived from direct interviews with end users in the domain as well as collecting together information from previous studies. The supporting programme is project MAGES [1], which is a pan-European project involving approximately 20 organisations and companies with interests in this domain and is led from the Portsmouth UK offices of EADS Astrium.

This paper presents an overview of the recently completed first phase of the MAGES programme, which focused on the capture of Emergency Management User Requirements. In this paper, consolidation of requirements according to defined User Groups is explained. Then specific Emergency Navigation Applications are outlined that were found to be common across this heterogeneous domain. Specific examples of requirements are presented, focusing on Fire Fighters. Following this section, certain specific delta requirements for other Emergency User Groups are highlighted. The paper explains benefits that will be derived in the domain from the introduction of Galileo and EGNOS, and finally presents conclusions from this major phase of project activities.

2. General Overview of MAGES User Requirement Capture

Project MAGES aims to contribute to the introduction of GNSS, and in particular Galileo and EGNOS, for emergency management applications. The project includes investigation into technical and non technical benefits and advantages of Galileo in comparison to existing solutions. It also provides a platform to involve the user community in the optimisation of EGNOS and Galileo. And finally, it provides a number of specific Emergency Demonstrations. The work reported in this paper was derived from the first Phase of project MAGES, which focused on the collection and consolidation of Emergency Management user requirements. The supporting efforts involved a number of partner companies, namely Astrium Ltd., EADS Astrium Services, Helios Technology, Logica CMG, GMV Aerospace & Defence, GMV Sistemas, and 425 Company. A wider set of partners are involved in project MAGES; the interested reader is referred to [2] for a fuller project description and for a complete list of participants.

The potential contribution of satellite systems and services has been relatively widely examined in this field. The MAGES project examined various sources of information that were already available and built on this through a series of expert interviews, finally producing a consolidated understanding of user requirements. This process is illustrated in Figure 1.

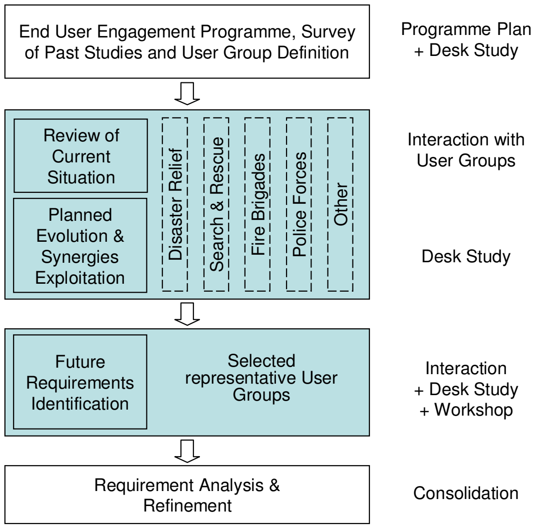

Figure 1: Process of User Requirements Capture

The aim of this work was to produce user requirements, grouped according to common needs, across the very heterogeneous domain of emergency management. This domain encompasses police forces, ambulance services, fire brigades, civil protection forces, emergency humanitarian aid groups, and others. In addition, different states have different organisational and operational needs. Nevertheless, within this complexity certain common User Groups could be identified (see §3 below), as well as common Applications (see §4 below); these categorisations greatly assisted the consolidation process and the overall understanding of domain needs.

3. User Groups Outline

The Emergency Management (EM) domain is characterised by mainly public institutions and authorities (Health Ministry, Ministry of Interior, Ministry of Defence, Search and Rescue) who represent the dominant players in the segment. These are also involved in the regulation, definition, purchasing and the use of positioning systems and navigation equipment. Also present are a large number of private disaster relief organisations and service providers.

Overall within the EM domain there are several levels of organisation with distinct roles within the Emergency Management Cycle: Policy level organisations, Risk assessment level organisations and Operational level organisations.

The last of these groups, the Operational Level, is the primary focus of project MAGES, as it is directly applicable to GNSS applications and the respective User Requirements.

The main operational fields or User Groups are described in detail below.

Fire Brigades

The fire brigades user group consists of a number of resources including fire trucks, fire personnel, fixed wing aircraft and helicopters. Additionally, command and control facilities (typically fixed location) provide the ongoing management of fire resources and carry out the planning and preparation for emergencies. Such a command and control facility will manage dispatch, manage and monitor resources by whatever means are available, while acting as a central point for information from emergency scenes and providing information needed by specific resources.

Fire brigades typically provide a number of types of emergency services, to address fires, road accidents, etc. They must therefore operate across diverse operational environments, including deep indoor, urban and rural scenarios.

The organisation of fire services in Europe varies between different states, and has variable degrees of centralisation, integration and cooperation. However, there are overall trends in Europe towards promoting greater cooperation between regions and towards centralising overall policy and procurement. Twin priorities of fire services are fast response to emergency situations, and safety of fire personnel in the hazardous environments in which they operate.

Health Services

The health services user group consists of a number of resources including ambulances (car, truck and motorcycle), paramedics, air ambulances and command and control facilities. Health services are often very fragmented, due to the fact that services are largely de-centralized in most states.

In general, the time to arrive can be considered one of the most significant factors driving navigational requirements in the user group. Typically there are two possible ways to reduce the intervention time delay: a) decentralize the service, b) modernize the service, increasing the intervention efficiency through the application of fleet management concepts.

Another issue concerns the medical assistance on board the ambulances (both air and land). Medical assistance can be better provided if the medics on board the ambulances can effectively communicate with and benefit from specialized assistance from the interested hospitals or health care centres.

Police Forces

The police user group consists of a number of resources including land vehicles (car, truck, and motorcycle), police officers and police helicopters. As with other emergency services, the police forces in each nation are largely fragmented into regions; this leads to great variations of the uptake of technology across the EU and even across individual countries.

The driving factors in navigation technology adoption concern the improved operational efficiency and effectiveness in deploying resources. Of equal concern is the safety of staff and ensuring the security of information and communications related to the safety of staff and the integrity of police operations. Of all the user groups studied, the police have the most stringent requirements for security, including requirements for protection from hostile attack on information or personnel.

Helicopter Search and Rescue

There are two main types of user within the Search and Rescue user group:

• Airborne and maritime search and rescue services: In Europe these are coast guard agencies, in some cases within the Military. They primarily conduct both off and on-shore operations involved in locating and removing people from hazardous situations.

• Mountain search and rescue and similar services: In Europe, these consist of mountain rescue organisations and other land-based services supporting search and rescue.

The main drivers from users are to be able to safety conduct operations in more challenging metrological conditions and environments (such as near cliffs or off-shore)

Disaster Relief

Disaster relief operations are the most complex because of the need to co-ordinate many different emergency services and agencies for a wide variety of incidents. In major disaster relief operations it is likely that the police, health services, fire and search and rescue services will be involved. These users are addressed in the other high level user groups, and the main additional priority in Disaster Relief operations is to promote close cooperation between the various involved services and agencies.

This user group incorporates complex interrelationships between international, regional or national institutions and Non-Governmental Organisations (NGOs). Typical operations include the provision of food, water and other resources, and carrying out rescue services for potentially large numbers of people and over potentially large geographic areas.

4. Emergency Navigation Applications

Within project MAGES, requirements of GNSS users were identified on the basis of specified GNSS applications. The defined applications are described within this chapter.

Route Guidance and Optimisation

Route Guidance and Optimisation concerns the presentation on personnel and vehicle platforms of navigation guidance. The navigation guidance is based on an optimised route to a defined location. Its primary benefit is to increase the time to respond to emergencies.

This application is applicable to all user groups for use in vehicle platforms, with highly comparable requirements across all user groups. The application is also applicable to personnel platforms, where guidance is provided to hand-held units.

One of the driving factors behind today's implementations and for the setting of navigation requirements is the need to respond quickly to critical emergencies – in some cases this is set down as a government mandate. For example, within the UK the national response time standards (2007/2008) stated that conditions which may be immediately life threatening should receive an emergency response within 8 minutes irrespective of location in 75% of cases.

Current limitations of today's implementations include incomplete or inaccurate mapping information available on the GIS (Geographic Information System) of the guidance systems. Locating remote locations where post codes are not sufficiently accurate can be a problem, as can locating useful features such as fire hydrants, forest tracks or large bodies of water for pick up by airborne resources. It is also important to users that the route optimisation facility should present routes that include on-road legal manoeuvres which emergency vehicles are permitted to use (e.g. one way street driving).

Users stress current limitations for manual entry of the target location as a problem in some cases. This can be time consuming and challenging in time-critical and fast-moving environments.

Specific GNSS aspects identified by users as in need of improvement include the Time to First Fix (TTFT) for guidance systems from a warm start. Additionally, for some activities the accuracy is insufficient (e.g. indentifying the correct side of the road of the target location).

Fencing Areas at Risk

Fencing Areas at Risk concerns the establishment of specific geographic areas within which users should not go; an alert is provided upon approaching or entering the area. The special case where alert is only provided to "central command" is covered within Resource Management below.

The virtually cordoned areas can be updated in real time or set up in advance of operations. Areas would be cordoned in situations such as fire, chemical risks, hostile attack, floods or to protect crime scenes. Once a platform enters the fenced area an alarm is provided to ensure the safety of the platform.

There is no evidence that Fencing Areas at Risk is employed by the EM user community today. However it is seen as a useful progression from current applications based on ongoing trends in technology.

Some interest in the application was expressed by users as it is seen as a natural progression from alarm call functions of existing equipment. The introduction of the application is also eased by the lack of any requirements for a complex MMI on the platform. The ability to communicate the geo-fenced areas presents the main progression from today's systems.

Situational Awareness

Situational Awareness concerns providing awareness to individual resources of the surrounding resources, features and hazards. This application essentially presents to individual platforms information typically only available today at central command facilities.

The application has widespread applicability across platforms and user groups. The greatest operational and safety benefits are formed in scenarios involving multiple resources and agencies. Land vehicles and personnel platforms present the most obvious benefit for the application - although helicopter and aircraft implementation could be foreseen; however this presents greater complexity and challenges in communication, integration and certification.

The application has very low maturity in the EM community today.

Resource Management

Resource Management concerns the coordination and management of resources either in preparation for or during EM scenarios. The application includes a central command facilities to perform the management functions of resources under its remit.

Resource Management is the most diverse of the application studied in project MAGES in terms of the functions that can be performed. The various functions include the tracking of resources, managing dispatches, logging arrivals at destination points, auditing performance, monitoring resource status, optimising resource usage and geofencing. Within the Resource Management application, additional functionality may be included for certain User Groups and for certain emergencies. For example, Disaster Relief of large scale emergencies may include the management of food and water that need to be dispatched and managed.

The key driver for implementing Resource Management is primarily to increase operational efficiency and performance. The applicable platforms are the central command units (mobile in some cases) and the resources under its guidance which could include any of the range of available resources.

In some cases the command and control in major incidents will involve several levels of resource management, including mobile command units of multiple services and centralised communications and command facilities. In these cases the management information will need to flow between these management levels to fully support decisions.

Alarm Call

Alarm Call consists of alarms or emergency calls which are tagged with location information to assist in the response to emergency situations. Two types of alarm call are identified.

- Alarm triggered by EM personnel (e.g. police officer) where the location is provided to the command and control centre (or other resources) which determine and action the appropriate response. This represents a special case of Resource Management.
- Emergency calls (112) made by the public where the location of the call is provided by the mobile network operator to a Public Safety Answering Point (PSAP) which then provides the information to appropriate services and resources.

The location of the 112 call will be integrated from PSAP by central command and control facilities of relevant service as the 'target location' for assigned resources. The requirements for E112 are therefore not stated for this application as they do not place direct requirements upon EM platforms or systems.

Feature Mapping

Feature Mapping concerns the active mapping of features, risks or targets by resources in order to assist in operational coordination (and future planning) during incidents. An example scenario where the application could be deployed would be the mapping of a forest fire by resources on the ground. Locations of the fire, vulnerable people, and hazards are sent to a central command facility which combines the information to gain an accurate picture of the situation.

The application has a wide range of possible implementations and is applicable to all user platforms and user groups. Helicopters or aircraft could also use feature mapping to send locations of hazard boundaries communicated accurately and efficiently as mapped features.

Helicopter Operation and Guidance

Helicopter Operation and Guidance concerns the utilising of GNSS for helicopter navigation in performing EM operations.

This specific application is only applicable to helicopter platforms, which places distinct demands on the requirements. The application is also applicable to all user groups employing helicopters for emergency operations.

Alert Broadcast

This application deals with the Broadcast of Alert Messages via GNSS satellites to warn the general public of imminent disasters, or of the evolution of such disasters. It takes a special position within MAGES as it is independent of the previously described emergency operators. Details about this Application can be found in [3] and are not further addressed in this paper.

5. Example of Requirements for Fire Brigades

Ascertaining navigation requirements from users requires translation from an understanding of their needs for operational capability. Studies within MAGES found that Navigation requirements show a considerable degree of commonality across User Groups, platforms and applications.

Emergency operations of Fire Brigades show a great variety in terms of the used platforms and the applicability for various missions in different environments. For that reason, the identified requirements of this emergency operator are presented in detail.

General Assessment of Navigation Needs

The grouping of user needs (see Table 1 and Table 2) has been done on the basis of a small selection of the overall Navigation Performance Parameters assessed within project MAGES. Accuracy, Integrity and Availability/Continuity requirements are compared for all identified fire brigade missions (see Applications in Table 1 and Table 2) and further contrasted by the used platform. Moreover, the needs are differentiated for different environments, i.e. indoor or outdoor use for the application.

	Accuracy (generally 2D)	Integrity		Availability / Continuity	Applications
		Alarm Limit	Time to Alarm		
Vehicle Urban	15 - 20m	25m	20s	99.5%	Route Guidance and Optimisation & Fencing Areas at Risk
Handheld Urban	10 - 20m	20m	20s	99.5%	
Handheld Indoor	5m	5m	6s	99.5%	

Table 1: Identified Navigation User Requirements for specified Missions of Fire Brigades – Part 1

	Accuracy (generally 2D)	Integrity		Availability / Continuity	Applications
		Alarm Limit	Time to Alarm		
Vehicle Urban	10 - 15m	10m - 15m	12 - 20s (60s)[1]	99% (95%)[1]	Situational Awareness & Resource Management & Alarm Call & Feature Mapping
Handheld Urban	5 - 10m	5m – 10m	12s (60s)[1]	99% (95%)[1]	
Handheld Indoor	5m	5m	6 - 12s	99%	

[1] 60s TTA identified for Feature Mapping Application

Table 2: Identified Navigation User Requirements for specified Missions of Fire Brigades – Part 2

The overall trend derived from the user survey shows that the most stringent navigation requirements for fire fighting operations are demanded for indoor applications. It should be pointed out that this is the most difficult environment for the use of GNSS. Furthermore, handheld user terminals require slightly better navigation performance than vehicle based devices.

It is clear, that the navigation requirements for indoor applications cannot be met by GNSS alone. Additional positioning sensors, ideally integrated on a single User Terminal (UT), are indispensable, in order to provide ubiquitous positioning performance as desired for fire brigade operations.

Accuracy is often expressed in relation to an operational scenario. Users will typically express a need to locate within a room, a building, on a street or within a street block. In other cases accuracy is requested up to when location could be confirmed by line-of-sight. Consequently, the stated accuracy demands are graded on the basis of the operational environment and the platform.

Regarding integrity, the specified alarm limit (AL) requirements are closely correlated with the associated accuracy needs. Hence it is less stringent for vehicle platforms than for handhelds, and most demanding for indoor applications. Time to Alarm (TTA) typically does not differ between in-vehicle and handheld use. Note that TTA is the time to alert from when a navigation device may derive erroneous data until when this is detected and the operator alerted. For safety critical indoor missions, the TTA is generally lower than for outdoor cases.

Needs for Fire Brigade "Route Guidance" and "Fencing Areas at Risk"

Today's vehicle implementations for fire engines consist of either stand-alone or integrated GNSS devices. Each of the defined applications has significant dependence on the communication performance available, even though Route Guidance of fire engines can be accomplished without.

However, current limitations in the requirements for manual entry of the target location have been stressed by various user groups, including fire brigades. This can be time consuming and challenging in time critical and fast moving environments.

If communication means are established between the vehicle platform and the command unit, following features have been expressed as being very helpful:

- Target locations communicated directly into the guidance system without manual interaction.
- Traffic information
- Entering information into the guidance system remotely (via central command) to include 'do not use' roads and accurate target location.

Moreover, for most operations personnel GNSS UTs need to be integrated with existing platforms to provide both communication and navigation capabilities.

The results from the user engagement programme clearly show that the two applications ‘Route Guidance & Optimisation’ and ‘Fencing Areas at Risk’ have less stringent navigation requirements for outdoor operations than the rest of the mission applications. However, there is one exception, namely the need for Availability and Continuity with 99.5% for all environments and platforms, which is higher than all other applications.

For both applications of Table 1, it is usually sufficient to provide accuracy to the level of one road to about the length of a building, so that line-of-sight can be used for final precise location. Risk fencing applications usually add a buffer zone to the defined area which explains that an accuracy level of 15 m – 20 m is sufficient.

Fire personnel perceive the greatest scope for potential operational benefits when in poor visibility environments; this may create difficult issues for the device to operate in these environments (particularly in regard of indoor operations).

There is a desire for applications to provide indoor, underground and deep-urban coverage (or heavily forested) for personnel platforms. This requirement would cover the most challenging fire fighting scenarios such as Forest Fire Fighting and indoor Search and Rescue activities.

Needs for other Fire Brigades Applications

The functionality of Situational Awareness requires the location of applicable resources (e.g. other fire fighters in a building) to be known within sufficient bounds (see Table 1 Table 2) in addition to supporting the mapping of features and hazards. Outdoor applications would be well supported by GNSS - likely to be the most common use. Indoor fire-fighting scenarios within large building blocks would provide much greater technology challenges. The integrity level demanded is very high (TTA < 6s, AL 5m) due to the safety critical nature of operations. Poor visibility caused by smoke development within buildings makes it hard to locate and ensure the safety of near-by resources in typically hazardous environments.

In general, the following future navigation-related needs were expressed for the management of Fire Brigade resources:

- Real indoor coverage and improved urban coverage for personnel platforms.
- Greater automation within the management facility
- Automatic logging of arrivals to reduce personnel interaction (pressing buttons),
- Greater accuracy to overcome issues such as logging arrivals when not at location (on the other carriageway of a major road).

The navigation and communication aspects of the Alarm Call application are very closely related to the tracking functionality of the resource management application. However the added safety aspect of the application places greater requirements on ensuring sufficient location information with a very low probability of failure. Locating vehicles issuing an alarm is less demanding than for personnel since line-of-sight should sufficient to facilitate identification of the source once in the immediate vicinity. The need for indoor coverage for fire fighters is less homogenous. For time critical Search and Rescue Activities of Fire Brigades it is often not sufficient to know which building an individual is in. More accurate information (e.g. identification down to which room an individual is trapped in) is crucial and may be life saving.

The navigation aspects of the Feature Mapping application concern the positioning of the feature being mapped. This will in some cases be concurrent with the platform and in some case information such as “50m North from current position” may wish to be communicated. In either case it is the position of the platform that is supplemented with other information. The application for outdoor missions is not a directly safety critical application and thus such requirements are less demanding than other applications in the domain, which can be clearly seen in Table 2. This is reflected by the Integrity as well as Availability and Continuity requirements for outdoor missions.

6. Specific "Delta" Requirements for Other User Groups

This section presents "Delta" requirements identified, i.e. requirements which may be different for User Groups other than those identified for the Fire Services presented in the foregoing material.

Navigation Accuracy Requirements

Navigation accuracy (and related) requirements include many relatively common needs across different User Groups, but also include significance differences, which generally derive from the different operational demands and threats experienced by the different Groups. Below are tabulated example differences for Helicopter Navigation requirements for Situation Awareness and Resource Management compared to other Vehicle and Handheld needs for an "Urban and Rural Environment".

	HELICOPTER	(LAND) VEHICLE	HANDHELD
Different Requirements	**Accuracy:** 20m(H) 20m(V)[1] **Alarm limit:** 30m **TTFF:** <60 s	**Accuracy:** 10-15m(H) 10m(V) **Alarm limit:** 10-15m **TTFF:** <20 s	**Accuracy:** 5-10m(H) 5m(V) **Alarm limit**: 5-10m **TTFF:** <20 s
Common Requirements	**Integrity (TTA) :** < 12 s **Continuity:** High **Availability:** > 99 %		

Table 3: Comparison of requirements of various platforms

High availability, continuity and integrity are demanded in all cases. On the other hand, the requirements on Accuracy and Alarm limit vary significantly. This appears to be a reflection of the comparative absence of airborne obstructions and features relevant for helicopter Situation Awareness and Resource Management. With other vehicles it may be important to know with greater precision in order to be certain, for example, on which of two parallel roads a vehicle is. In the case of handheld units the higher accuracy demand reflects the need to identify which building a user is in (or near) in order to facilitate action at a particular target address rather than at that of an unsuspecting neighbour!

[1] H – Horizontal; V - Vertical

Another example where Navigation accuracy and other requirements vary, this time between different User Groups, was identified for the purposes of both Emergency Alarm Call and for Fencing Risk Areas. Here, the Police and Fire Brigade requirements were found to be rather stringent, requiring 5m positioning accuracy, whereas other Emergency services had less demanding identified needs, with 20m being considered adequate for Health Emergency Services, Disaster Relief and Search and Rescue. As with the above case, this difference is understood to represent operationally different demands from the different services, with the Police and Fire Services potentially more likely to encounter situations where the users' health or even life may be under more immediate threat, perhaps from criminal actions in the former case or from changes in evolution of a fire emergency in the latter case.

Security Requirements

The Police services identified more demanding requirements than other emergency services in the field of what can be termed security. This actually covers quite a broad range of requirements, some outside of a traditional security boundary.

Security needs for Information Management are identified as "very high" for Police services, whereas only "medium" for most other services for many of the identified applications. This requirement is concerned with factors such as ensuring that only authorised personnel get access to information about (active) police operations. The need to block criminal access to information about forces fighting against crime is obvious, and impacts primarily the communications mechanisms used, for example non-public radio bands and encrypted radio channels. TETRA Radio is already widely used by Police and other Emergency Services across Europe and this usage is expected to become ubiquitous. Connected with this need to maintain security on communications links comes a need to manage communications devices so that (a) they don't fall into criminal hands, and (b) that if they do then the lost device can be removed from the service group.

Vulnerability to jamming and or to spoofing of navigation signals were also identified as important for Police services, but were not considered such by other groups addressed. This may partly reflect greater awareness of system vulnerabilities by the Police, but is also a significant reflection of the fact that the Police are likely to have to deal with emergency situations where criminals may seek to deliberately disable the navigation capabilities of the forces of law in order to weaken their operational effectiveness. The converse situation is also worth noting in this section: there can be occasions when Police forces wish to disable the navigation capabilities of criminals whilst retaining their own navigation service.

It is finally noted that possible future evolution of criminal and terrorist activities may be foreseen to increase security-related demands for Police services, and may also precipitate an escalation in security demands for other EM User Groups.

7. Benefits to Emergency Management that may derive from the introduction of European GNSS

Today's baseline performance for navigation systems in EM is provided by GPS, map-matching, dead-reckoning techniques, and low-end INS. These systems facilitate, de-risk or otherwise aid a wide variety of applications. The introduction of European GNSS (i.e. Galileo and EGNOS) will complement existing navigation technologies, thereby providing a number of advantages at user level. For some current and future EM applications this will bring navigation system performance up to, or at least closer to, that desired by users, as well as facilitating further applications.

Although European GNSS can provide benefits in many cases, not all requirements can be met by these space-based services. Notable problem environments are indoor and deep urban environments. Integration with existing and future alternative technologies will be required if applications are to be fully realised in these operational environments.

It should also be noted that other GNSS will continue to develop as Galileo moves towards FOC. These include GPS III and GLONASS. Other technologies such as INS, map-matching and terrestrial location systems (e.g. WLAN) will also continue to develop in this timeframe to provide increased performance. These will collectively enhance the performance available from navigation systems as a whole.

The major points of added value foreseen through the introduction of European GNSS are:

- Navigational performance improvements for EM personnel, notably accuracy and availability, through the use of the enhanced signals planned for transmission by the Galileo satellites, and from the potential for EM user equipment to "see" a second full constellation of satellites (i.e. both GPS and Galileo). The performance enhancement should be particularly dramatic in urban areas where GPS coverage is sometimes inadequate today.

- The Galileo PRS service, planned to be available to certain users, will provide significant benefits for the security needs of these users. The added protection against spoofing, interference and jamming should facilitate more dependence being placed on applications, and permit the applications themselves to be used in more critical operations.

Additionally, performance enhancements in terms of integrity, accuracy, availability and continuity provide benefits across many applications. They are, however, dependent on the operational environment, and the features of the GNSS service only play a part in the overall performance obtainable. For example, the integrity of the navigation message is an important contributor to (but only part of) the performance obtained at user level; other factors such as multipath cannot be ignored in urban environments.

8. Conclusions

This paper has presented navigation and other requirements applicable for the domain of Emergency Management. Some of the requirements are common across many User Groups representing different EM actors.

Navigation needs for Fire Brigades were reported in more detail, showing that the needs for various Mission Applications vary significantly. Safety critical missions, and in particular those in an indoor environment, have very stringent requirements on navigation system performance.

Improved GNSS (and in this context we refer in particular to Galileo and EGNOS) bring a number of benefits to users that can facilitate certain new operations and enhance performance for others. It is however noted that introduction of improved GNSS alone is not sufficient to derive the full potential benefits for a wide range of identified applications in this domain. A number of other enabling factors have also been identified and include:

- Communications: many of the applications listed call for increased communication capacity (e.g. to relay imagery and other data) and for continuity of the application to be maintained the communications links need to be resilience to hostile or natural attack.

- Hybrid positioning: To fully realise positioning needs, implementations are likely to require some hybridisation with other positioning solutions. GNSS alone is unlikely to cost-effectively and reliably meet indoor positioning needs in the foreseeable future.

- GIS: Installation of updated Geographic Information Systems (GIS) with increased overlay of information at central facilities as well as at mobiles would be required to realise the potential of many applications.

- System integration: updates to existing system implementations are required in many cases in order to introduce new applications.

- Changes in operational practice, culture and training will probably be needed in order to effectively introduce many of the new applications.

- Receivers and certification: User equipment and appropriate navigation receivers would be required to implement the applications. A certification framework for equipment and applications (in the EM domain) would also be required if service guaranteed were to be made available to users.

- Introduction of services may in some cases require approval from external bodies (e.g. for airborne platforms) or from central government.

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- Italy: IAI and Tele+Italia;
- Portugal: Critical Software and Skysoft;
- Spain: GMV and GMV Sistemas;

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Authors

Dr. Charles S. Dixon is Head of Future Programmes, Navigation, and Manager of the Navigation Systems Team at EADS Astrium's Portsmouth offices. His work encompasses support to future designs for Galileo and GPS systems, and development of GNSS applications and

augmentations. He has been involved with GNSS Systems for 20 years, including system-level definition and development for Galileo, development of GNSS transmitters, receivers, and augmentations. He has authored publications on many aspects of GNSS, is a Fellow of the Royal Institute of Navigation where he is also a member of both Council and of the Technical Committee and is a Member of the US-based Institute of Navigation. He is also Vice-Chair of the Position and Timing Committee at Intellect.
Email: chaz.dixon@astrium.eads.net

Reinhard Haas is a Navigation Systems Engineer at EADS Astrium, Portsmouth. He works in the Navigation Systems Team on various Navigation Application Projects and is heavily involved in the MAGES project which addresses Emergency Management use of GNSS. His work includes support to the development of future GNSS applications and augmentations, including simulation and modelling of Navigation Systems. Alongside his background in GNSS, he has professional experience in the Development of Geographic Information Systems (GIS).
Email: reinhard.haas@astrium.eads.net