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The EGNOS ALIVE Interface (Alert Interface Via EGNOS) for Disaster Prevention and Mitigation

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1 INTRODUCTION AND MOTIVATION

Disaster prevention and mitigation is a subject to which currently intensive attention is devoted. One of the main goals is to identifying ways to inform people at risk, for instance, through natural events such as earthquakes, tsunamis, hurricanes, storm surges, extreme precipitation and flooding, or volcanic eruptions, so that specification actions can be taken to mitigate the impact of the disaster and ultimately, to save lives. Moreover, the same information channels would be valuable tools to support rescue and aid operations in the aftermath of disasters thus reducing the total loss of human lives. This discussion is motivated by the obvious principle that ***disaster prevention, mitigation and preparedness are better than mere disaster response.***

Those most affected by disasters are often the poor and the socially disadvantaged in developing countries as they are the least equipped to cope with the situation. In large regions of the Earth, loss of life and capital caused by disasters is increased by the lack of sufficient communication infrastructure for warning, preparation and rescue. For instance, in countries like Africa and the Indian Ocean, where the lack of communication is a severe limitation for efficient warning systems, additional communication paired with a positioning service could be of great help.

In this context, the possibility to use Satellite Based Augmentation Systems (SBAS) message broadcast capability is of considerable interest.

Indeed, SBAS systems (EGNOS, for the case of Europe) are associated with a number of inherent characteristics, which make the SBAS solution very attractive:

- The three existing SBAS together provide a global coverage;
- SBAS receivers are based on GPS receivers and share the same worldwide accepted standards;
- SBAS GPS combine the possibility of warning with the ability to determine the location of the receiver in the same equipment (key feature);
- The SBAS systems, having been conceived as safety of life systems with integrity, include the necessary built-in features to guarantee adequate message broadcast, integrity of messages, confirmation of transmission; acknowledge messages to sending organizations, etc;
- It is estimated that there is enough transmission Bandwidth (BW) available to accommodate the proposed function;
- SBAS are institutionally controlled, do include security features and are operated for safety of life (i.e. all days all hours of the year with Safety of Life operational standards).

This note aims at presenting this ESA ALIVE initiative, to explain why it is considered to be of interest and societal value, and to provide written material to relevant International groups and communities for their consideration and feedback, including, for instance, the ‘Geohazards’ Theme of the Integrated Global Observing Strategy Partnership (IGOS-P), the relevant United Nations agencies, relevant Non-Governmental Organizations (NGO), the European Sea Level Service (ESEAS), the Global Monitoring for Environment and Security (GMES) Programme of the European Commission, as well as the Group of Earth Observation (GEO) and the institutions contributing to the Global Earth Observing System of Systems (GEOSS).

2 DISCUSSION ON DISASTER MITIGATION ALERT MISSION

The term "disaster" denotes intense perturbation of people, goods, services and environment, due to natural causes or generated by human being, which exceed the reaction capacity of the affected community.

Disasters can be classified as:

- Natural disasters;
- Biological disasters;
- Technological disasters.

- **Natural disasters** are those produce by natural environmental forces. These can be classified as follows:

  - **Disasters generated by dynamic processes inside the Earth**, including, for instance; earthquakes, tsunamis or volcanic eruptions.

  - **Disasters generated by dynamic processes at the Earth's surface,** including, for instance, land slides, rock avalanches, subsidence and collapses, and avalanche.

  - **Disasters generated by meteorological or hydrological phenomena,** including, for instance, storm surges, inundation, extreme frost and snow fall, storms, hailstorms, tornadoes, hurricanes, and wild fires.

- **Disasters of Biological nature** also exist such as plagues or epidemics.

- Finally, **disasters of Technological nature encompass** fire, explosions, spill of chemical substance spills, environmental contamination, wars, subversion, and terrorism.

Obviously, the ALIVE mission will not necessarily focus on all types of calamities listed above. A detailed mission assessment will be necessary as a first step, identifying (at least):

- The available observation and sensing elements for each kind of disaster, principally focusing on existing professional world-wide networks.
- The kind of information that, derived from observation and information systems, can be timely provided to end users to avoid personal damage and save lives.
- The reaction time requirements.
- The added value of the position information.
- The associated information mission requirements (necessary BW; time to send; acknowledgement mechanisms; format; etc.).
- The potential recipients of the messages and requirements to restrict general access to the messages.

In general terms, the ALIVE system shall be able to:

- Sense primary variables relevant to inform on the severity of a risk for a disaster prior to the event and on the extent of the impact after the event as well as to provide information for their mitigation in real-time;
- Provide complementary information that can help saving human lives, such as the necessary action to be taken;
- Broadcast this information through SBAS systems, via Geostationary satellites, with a global coverage. In the case of EGNOS, this information can also be broadcast through other means thanks to the EDAS (EGNOS Data Access System) dissemination system.

For the mission consolidation, it is therefore necessary to consolidate with the relevant experts and involved institutions the mission constraints, mission requirements (in terms of transmission requirements), adequate international formatting, etc. This is considered by ESA as the necessary first step of this potential EGNOS mission. Then, ESA will need to analyse which of those mission requirements could be covered by EGNOS taking into account the existing available BW (see Section 4) and possible implementation considerations. This should in turn, be converted into potential EGNOS ALIVE System requirements (SRD) for which a detailed definition could be performed in the frame of the ESA GNSS Accompanying Program (GAP), planned to be launched early 2006.

3 THE EGNOS ALIVE INTERFACE CONCEPT

3.1 Available EGNOS Bandwidth for the ALIVE mission

In this section we briefly provide some information on the current estimated available BW for additional EGNOS messages. This analysis is based on the RTCA DO229C MOPS standards, which define the minimum update rate that needs to be respected by EGNOS to comply with the safety of life requirements.

Table 1 lists all current EGNOS broadcast messages and the minimum necessary BW to comply with the International Standards. In this table we have assumed that MT0 (which is today sent every 6 seconds) is removed (as it will be the case when transmitting Safety of Life messages early in 2007) or combined with MT2 –MT0/2 (as planned to be implemented during 2005).

This analysis reveals that assuming GPS safety of life transmission the BW available for additional messages will be of the order of 35% of the total BW, i.e. equivalent to 75 bps. Since the transmission of EGNOS messages is made in block messages of 250 bits, this opens up for the transmission of about 1 message of 250 bits per second each 3 to 4 seconds. Part of this extra BW could be used to provide information on disaster management through the ALIVE interface.

Although the typical mission rate needs for ALIVE messages is not yet known to the authors, it is believed the potentially available transmission capacity should be more than enough for the ALIVE transmission requirements. This allows to use additional available BW for EGNOS extensions, or other communications functions like Search&Rescue return link or specific information to aviation users on interferences (RFI) or similar. Concerning S&R return link, it is of interest to note that a preliminary mission analysis based on Galileo revealed that the bandwidth required to fulfil the mission requirements was 3.33% (7bps) i.e. an EGNOS message is sent every 30 seconds (thus only consuming about 1/10 of the total available extra BW). Being the ALIVE mission is a service of similar nature, and it is believed (though this needs to be confirmed by the relevant disaster management experts) that the ALIVE mission may require a bandwidth in the same order of magnitude. Therefore, the ALIVE mission is considered fully compatible with EGNOS existing margins. Moreover, the excess bandwidth can be used for other EGNOS message broadcasting services, such as aviation tailored information.

Message Type	Maximum Update Interval	Number of Messages Transmitted over ECAC	% BW required over ECAC
MT 0	6	0	0
MT 1	120	1	0.83
MT 2 or MT0/2	6	1	16.67
MT 3	6	1	16.67
MT 4	6	0	0.00
MT 5	6	0	0.00
MT 6	6	0	0.00
MT 7	120	1	0.83
MT 9	120	1	0.83
MT 10	120	1	0.83
MT 12	300	1	0.33
MT 17	300	1	0.33
MT 18	300	4	1.33
MT 24	6	1	16.67
MT 25	120	4	3.33
MT 26	300	18	6.00
Free BW			**35.34 (75bps)**

Table 1: EGNOS Message Bandwidth Utilization, with the MOPS specified update intervals with MT0/2 (or no MT0)

It is also worth to note that the available EGNOS BW may still be much larger if the fact that the GPS Selective Availability (SA) has been removed in May 2000 is taken into account. Indeed, actual DO229C standards do allow the relaxation of the update of the fast clock corrections from the 6 seconds to be used in the case of SA activated (which is the current adopted baseline in EGNOS) to up to 60 seconds when SA is off (which is the current situation). Table 2 shows the equivalent available extra BW for EGNOS for the case of SA off, which reaches a value of 63% (equivalent to 140 bps). Thus, approximately one extra EGNOS message of 250 bps could be sent every 2 seconds for extra services, such as ALIVE for disaster prevention. This is believed to be a very comfortable BW for these kind of services.

Message Type	Maximum Update Interval	Number of Messages Transmitted over ECAC	% BW required over ECAC
MT 0	6	0	0
MT 1	120	1	0.83
MT 2 or MT0/2	60	1	1.67
MT 3	60	1	1.67
MT 4	60	0	0.00
MT 5	60	0	0.00
MT 6	6	1	16.67
MT 7	120	1	0.83
MT 9	120	1	0.83
MT 10	120	1	0.83
MT 12	300	1	0.33
MT 17	300	1	0.33
MT 18	300	4	1.33
MT 24	60	1	1.67
MT 25	120	4	3.33
MT 26	300	18	6.00
Free BW			**63.68 (140bps)**

Table 2: EGNOS Message Bandwidth Utilization, with the update intervals of the fast corrections increased to 60 seconds

3.2 *Architectural Concept and Preliminary Identification of Operational Interfaces*

The implementation of the ALIVE concept is based on the more general concept of using the available EGNOS BW to broadcast spatially related information from an originator to EGNOS users through dedicated SBAS messages.

Fig. 1 indicates the architectural implementation of such communication function embedded within the EGNOS system.

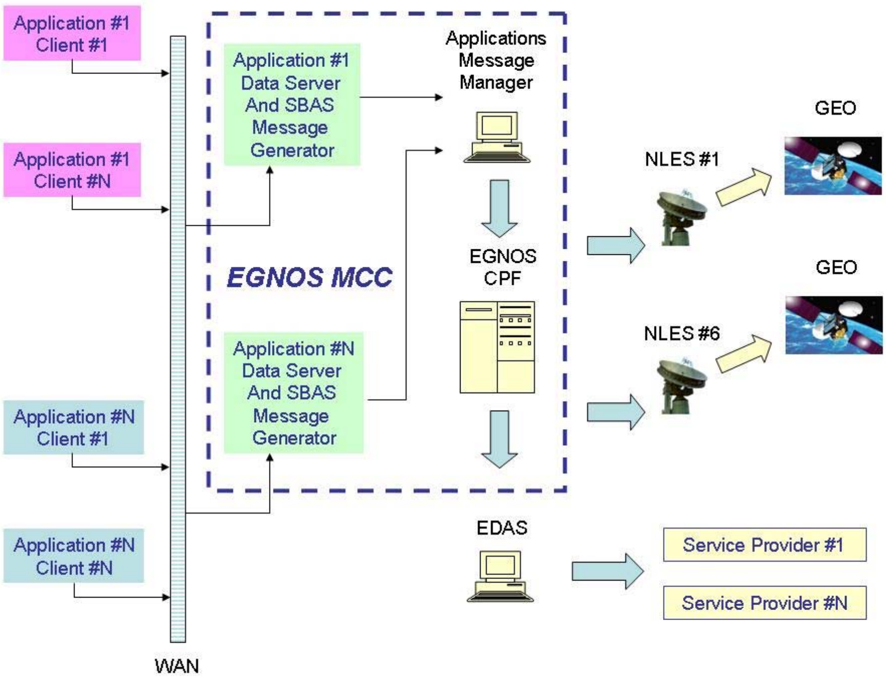

Figure 1 - Broadcast of information though EGNOS

Independently from the application considered, the information to transfer to EGNOS users is made available to the EGNOS computing platform (CPF) through links and pre-processing stages. This information is then broadcast as an SBAS message. Users having the possibility to process these specific messages can then extract the enclosed information and use it in the way they need.

A more generic separate Technical Note will detail the architecture and the work logic of the EGNOS communication function.

The added value of this process it the opportunity to provide reliable information to users equipped with an EGNOS terminal within the entire EGNOS geostationary coverage as indicated in Fig. 2.

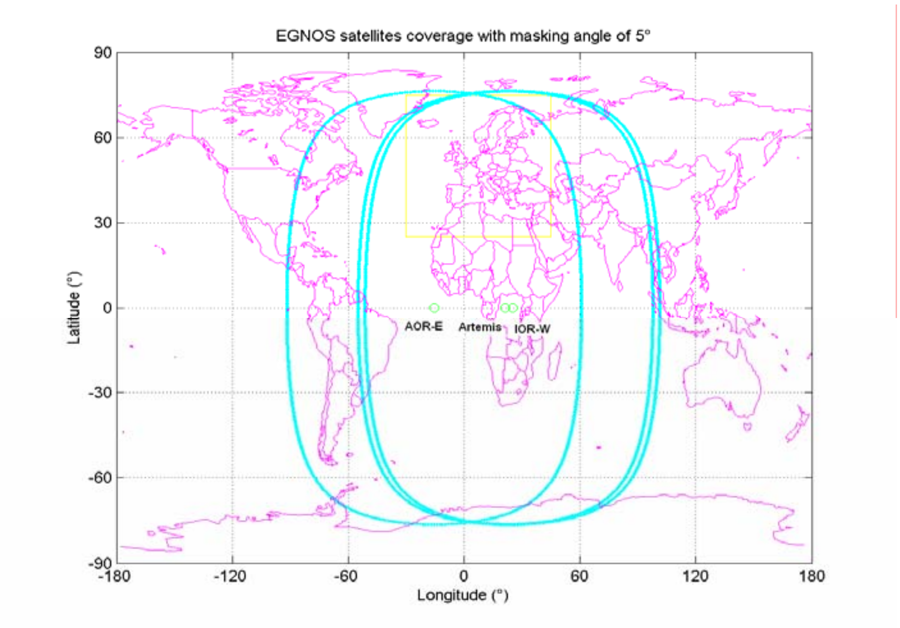

Figure 2 – EGNOS Geostationary Satellites Cover

Safety critical information (event, recommended action) is typically associated to spatial information (location). This will be of particular importance for the functions of ALIVE.

Organizations at national and international level in charge of disasters management or for the provision of civil protection services make use of infrastructures for monitoring, communication and control. Here we denote such infrastructures as Disaster Management Centres.

The architectural implementation of the ALIVE concept on the basis of the EGNOS system is illustrated in Fig. 3.

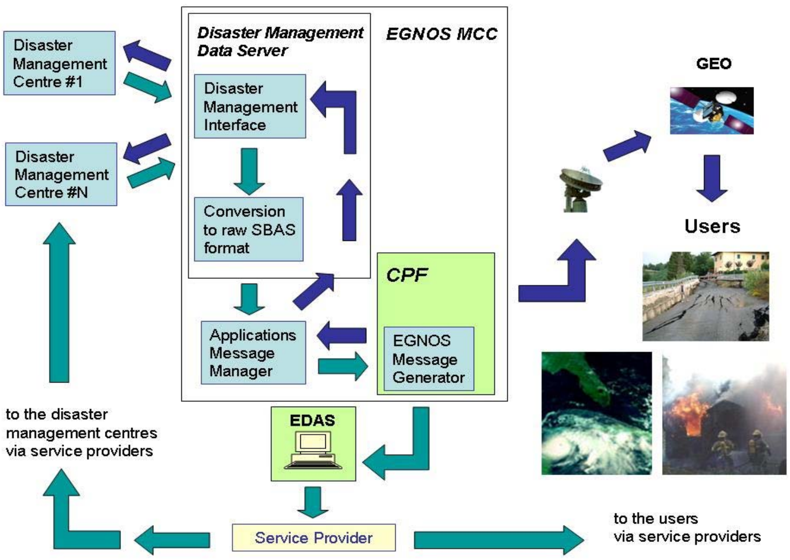

Figure 3 – Architectural implementation of ALIVE function

Disaster Management Centres have the task to collect and generate relevant information (e.g.: event, location, status, action) required to fulfill all the missions for which they have been designed. The information generated by Disaster Management Centres is sent to a dedicated Disaster Management Data Server (Specific Application Data Server) within the EGNOS MCC. Disaster Management Centres receive through the Disaster Management Data Server the acknowledgement that the information has been sent with the typical EGNOS guarantee of service. The information is converted in a row SBAS format and is sent to an Applications Message Manager.

The Applications Message Manager has the following tasks:

1. to receive the row SBAS messages from all Applications Data Servers;
2. to put the row SBAS messages in a preliminary sequence according the mission requirements of each application;
3. to send the SBAS messages to the CPF;
4. to receive the acknowledge from the CPF that the message has been sent;
5. to return the acknowledgement to the Disaster Management Data Server that the message has been sent.

The EGNOS computing platform (CPF) rearranges the broadcast sequence of the SBAS messages according to the input provided by the Applications Message Manager.

The analysis of the preliminary mission requirements of ALIVE revealed that there is no problem to allocate additional SBAS messages among the broadcast of EGNOS current messages. These aspects will be further explained in the TN on the EGNOS communication function.

Once the broadcast sequence is ready, the message (or messages) containing the information generated by the Disaster Management Centres, is included in the EGNOS up-link and down-link loop in the same way as other messages. Any user (within the EGNOS satellites footprint) equipped with an EGNOS receiver capable of processing these additional messages is made aware of the problem, location, status and action. Again, the EGNOS link loop guarantees the delivery of the information to enabled users.

More specific recommendations for the implementation of the ALIVE function within EGNOS receivers will be provided in the TN on the EGNOS communication function.

4 SBAS AN IDEAL SOLUTION TO CONTRIBUTE TO DISATER ALERT PREVENTION

The provision of disaster warning messages through SBAS is considered by the authors as a very adequate solution for disaster management. The SBAS systems (EGNOS, for the case of Europe) have a number of inherent characteristics, which make the SBAS solution very attractive. This is explained and justified in this Section from different perspectives.

4.1 Global coverage

There are currently three SBAS systems available, which will provide operations in 2005: In Europe the EGNOS System developed by the European Space Agency in tri-partite with the European Commission and Eurocontrol, in the United States of America, the WAAS (Wide Are Augmentation System) developed by the Federal Aviation Administration, and in Japan the Multi-function Transport Satellite (MTSAT) Satellite Augmentation System or MSAS. Other regions are also interested in providing SBAS services although their plans are less advanced than those in Europe, the US and Japan (e.g. India's SBAS, GAGAN, GPS and GEO Augmented Navigation).

The three existing systems (EGNOS, WAAS and MSAS) provide service with a global worldwide coverage, thanks to their complementary SBAS GEOs broadcast areas footprints. This is illustrated in Fig. 4, where the existing EGNOS, WAAS and MSAS GEOs Broadcast areas are just illustrated (note that SBAS L1 broadcast is done through a global GEO beam). The resulting coverage on the Earth is therefore complete with the only exception of the poles. Consequently, when working together, the SBAS systems are a viable way of broadcasting disaster alert/mitigation messages worldwide, for users using the same frequency and signal standards, and therefore fully compatible receivers.

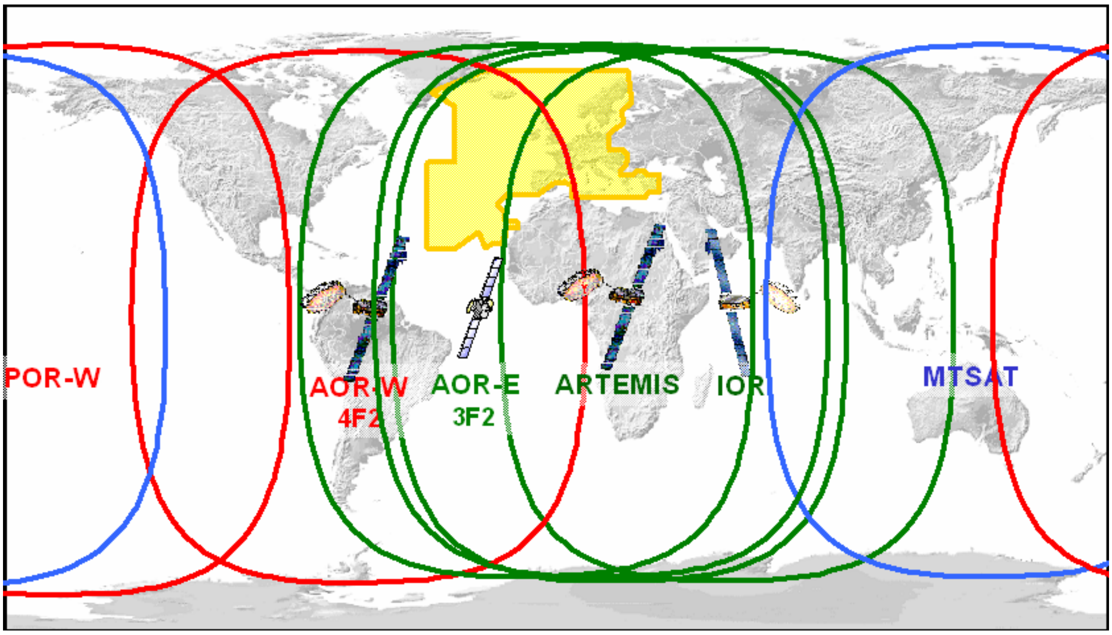

Fig. 4 GEO Broadcasting areas of the three existing operational SBAS

4.2 SBAS GPS receivers do provide also positioning

Another interesting feature of the SBAS provision for alert management is that in addition to the global coverage provided, the SBAS receiver (needed to demodulate the SBAS Alert disaster message) also provide, through their embedded GPS receiver, precise position information. In this way, while an alarm is send globally, only those receivers concerned with the disaster area will be activated (e.g. to take a given action or be prepared for rescue). Knowing then the area of the possible disaster location, the users inside the disaster warning area could be warned. Other receivers, providing a position outside the disaster area, would instead be transparent to the call and not activated.

When conceiving an SBAS dedicated message for warning and mitigation, it may be of considerable interest to include geographical information on the area of concern. This, together with the SBAS generated position information, may allow then to activate only those receivers on the concerned area and indicate to them the alarm and the action to take. This is illustrated in Fig 5, where a possible conception (for the sake of illustration) of the SBAS Alert prevention message is described:

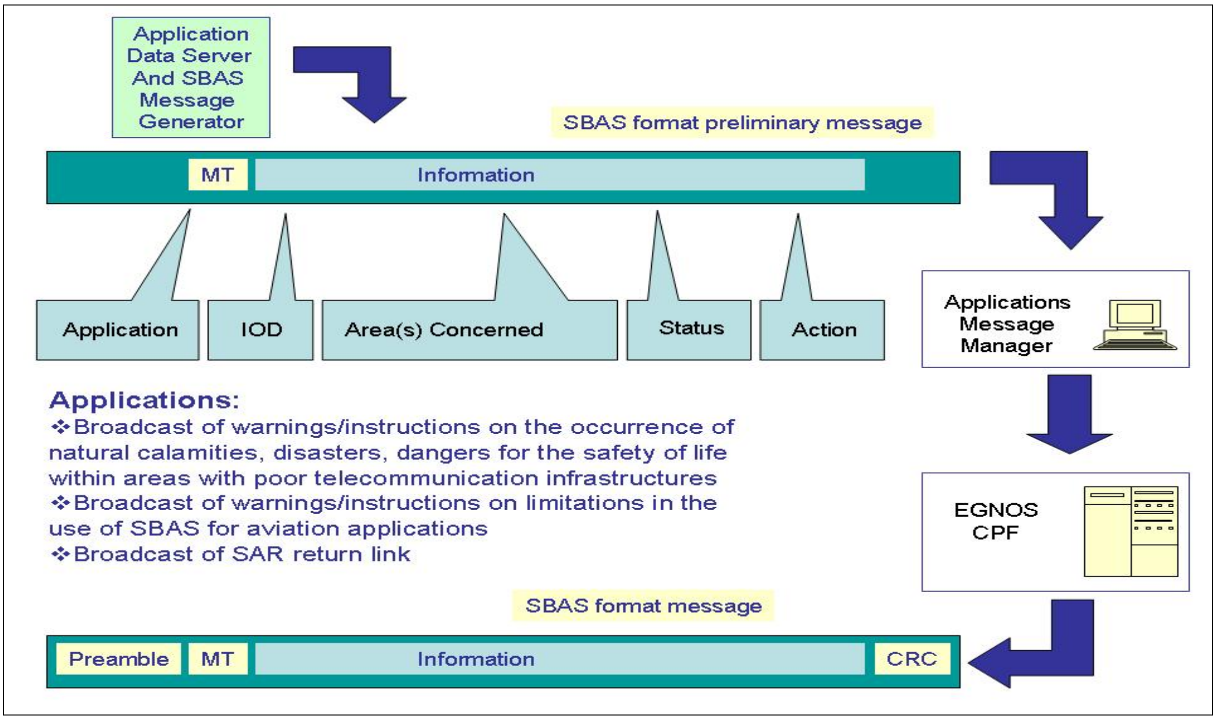

Fig. 5: Illustration of a possible SBAS communication message for Alert prevention

That is considered a key unique feature of the SBAS system. It is to be noted that nowadays, there are a large number of GPS/SBAS receivers available on the market. Indeed, basically, because of the similarity between GPS and the SBAS-GPS-like send signals, almost all developed GPS receivers are also made SBAS compatible receivers. Therefore, the reception worldwide of the SBAS alert message could be easily implemented.

4.3 Unique standard for common receiver

It is important to note that all the SBAS receivers follow the same international standards, and therefore any SBAS receiver works anywhere in the world in the SBAS coverage area. If a new SBAS message for disaster prevention/mitigation is conceived, this may well be standardized worldwide. The standardization groups and the procedures to follow that are well known to ESA and the Galileo Joint Undertaking. This is considered an important feature allowing a global worldwide standardized SBAS alert prevention system, and therefore, if all the SBAS systems could implement this functionality, a worldwide Disaster Alert System could be possible.

4.4 SBAS provide all guarantees

The SBAS systems, having been conceived as safety of life systems with integrity, include all the following built-in features which are crucial for the considered alert information message, and which are quite unique to SBASs:

- EGNOS has built-in mechanism that guarantees that a message has been sent with the adequate content and on the adequate time. This information may also be provided back to the alarm center interfacing with SBASs.
- SBASs have built-in mechanism to make sure that a message went out in good conditions with no errors.
- SBASs are safety of life systems operated 24 hours a day and 7 days a week. SBASs are operated with Safety of life standards (i.e. no service interruptions, in case of failure quick recovery; etc)

4.5 Can be implemented in very short term

For the case of EGNOS, the implementation of this ALIVE interface is very well suited to the existing EGNOS architecture. This is believed to be true also for the other SBAS but is unknown to the authors. In the case of EGNOS, the system upgrade to provide the anticipated facility could be done in a short time frame, with low risk and with a simple approach, provided adequate political and institutional support is given. As further explained in Section 14, it is believed this function could be readily available in EGNOS in a timeframe of 2 years after programme approval.

4.6 Under institutional control

The SBAS systems have all been developed and will all be operated under institutional control. In the case of EGNOS, the system is currently owned by the European Space Agency member states, and ownership is planned to be transferred to the Galileo Supervisory Authority, a European Institutional Organization in charge of EGNOS operations and exploitation. WAAS and MSAS are also under institutional control through their respective Governmental Departments of transportations.

For the mission intended, having institutional control is considered a key feature since it guarantees service provision, no service interruption, and system necessary future upgrades.

4.7 Long system life time when combined with Galileo

Current SBAS systems have been conceived for a typical operation life time of 15 years (i.e. for a time frame around 2020). In addition, there are plans to further modernize SBAS systems and to adapt them to GPS and Galileo modernization plans. EGNOS is currently integrated in the GALILEO overall strategy, and therefore the complement to this SBAS function through Galileo will also be smoothed and will ensure further long-term duration.

This long-term issue is considering a very important feature of the SBAS system with ensures continuity of the proposed ALIVE system.

5 POSSIBLE IMPLEMENTATION STRATEGY

STEP	ACTIVITY	ACTORS	POSSIBLE TIMEFRAME
Step 1	Presentation of the ALIVE concept to relevant Disaster Management authorities for their consideration	ESA, GJU, GEOS, IGOP, etc.	Q2/Q3 2005
Step 2	Feasibility assessment of generic SBAS communication functionality, including ALIVE (Phase A)	ESA and EGNOS Industry	Q3/Q4 2005
Step3	Consolidation of ALIVE Mission Requirements	Disaster management expert groups	Q3/Q4 2005
Step 4	Propose the SBAS communication functionality (incl. ALIVE) in the context of the GNSS Accompanying Program for ESA delegations consideration	ESA Executive	Q3/Q4 2005
Step 5	Detailed specifications; message standardization; detailed definition study; test services through the ESA/EC EGNOS test Bed; detailed technical / operational interface assessment of the EGNOS ground segment with the various Disaster Alerting Systems; SBAS ALIVE enabled receiver detailed design; detailed definition of the general SBAS communication function.	ESA, GSA, EGNOS and EGNOS industries, Relevant Standardization bodies	Q1/Q2 2006
Step 6	SBAS communication function (incl ALIVE mission) Implementation Phase and development of SBAS ALIVE enabled receivers	ESA	Q3/Q4 2006
Step 7	Operational integration of the SBAS communication functionality (inc ALIVE mission) in EGNOS	ESA, GSA and Galileo Concessionaire	Q1 2007
Step 8	Disaster prevention/mitigation qualification and start of operations	Relevant institutions	Mid 2007 onwards

These steps should be performed in parallel with discussions at International level (during 2005 and 2006) including but not limited to:

- Institutional organizations involved in disaster management,
- the Interoperability Working Group with WAAS and MSAS for their consideration of a possible parallel implementation path;
- relevant standardization groups;
- receiver manufacturers;

6 SUMMARY

Disaster prevention, mitigation and preparedness are better than disaster response. The possibility to use Satellite Based Augmentation Systems (SBAS) message broadcast capability as a means for disaster announcements has been discussed in this document. Specifically, the implementation of a dedicated interface in EGNOS for disaster alarm messages prevention (ALIVE: Alert Interface Via EGNOS for disaster prevention/mitigation) has been proposed.

As explained through this document the SBAS systems (such as EGNOS) have a number of inherent characteristics which make the SBAS solution very attractive, including the possibility of global coverage, provision of a combined warning and positioning system, availability of worldwide common receiver with the common standards, SBAS built-in features that guarantee adequate message broadcast (e.g. integrity of message, confirmation of transmission), and the fact that SBAS are operated with safety of life guarantees and under institutional governmental control.

This note provides a preliminary analysis of the ***mission concept*** at stake, the ***interest of a possible SBAS solution*** for this alarm prevention function, as well as an outline of the ***potential architectural concept***; and a ***possible implementation path strategy.***

This note is intended to be used as a reference to support the discussion of the ESA ALIVE concept for adequate disaster management with relevant International groups and communities, including, for instance, the 'Geohazards' Theme of the Integrated Global Observing Strategy Partnership (IGOS-P), the relevant United Nations agencies, relevant Non-Governmental Organisations (NGO), the European Sea Level Service (ESEAS), the Global Monitoring for Environment and Security (GMES) Programme of the European Commission, as well as the Group of Earth Observation (GEO) and the institutions contributing to the Global Earth Observing System of Systems (GEOSS).

The authors consider the ESA ALIVE concept as a meaningful and viable concept, which may be implemented in a reasonable short time frame, contributing to save lives in the event of disasters.

APPENDIX A : LIST OF ACRONYMS

ALIVE	ALert Interface Via EGNOS
AOC	Advance Operational Capability
AOR-E	Inmarsat Atlantic Ocean Region - East
AOR-W	Atlantic Ocean Region - West
BW	BandWith
CPF	Central Processing Facility
EDAS	EGNOS Data Access System
EGNOS	European Global Navigation Overlay System
ESA	European Space Agency
ESEAS	European SEA level Service
ESTB	EGNOS System Test Bed
GAGAN	GPS And GEO Augmented Navigation
GAP	GNSS Accompanying Program
GEO	Group of Earth Observation
GEOSS	Global Earth Observing System of Systems
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IGOS-P	Integrated Global Observing Strategy Partnership
MCC	Monitoring Control Centre
MT0	Message Type 0 (MOPS DO 229C)
MT2	Message Type 2 (MOPS DO 229C)
MT0/2	Message Type 0/2 (MOPS DO 229C)
NGO	Non Governmental Organisation
MTSAT	Multifunction Transport Satellite
MSAS	Multifunction Satellite Augmentation System
NLES	Navigation Land Earth Station
RFI	Radio Frequency Interference
RTCA	Radio Technical Commission for Aviation
SA	Selective Availability
SBAS	Satellite Based Augmentation System
S & R	Search and Rescue
SRD	Ssytem Requirements Document
WAN	Wide Area Network
WAAS	Wide Area Augmentation System