ETSI TR 103 338 V1.1.1 (2015-05)

TECHNICAL REPORT

**Satellite Earth Stations and Systems (SES);
Satellite Emergency Communications (SatEC);
Multiple Alert Message Encapsulation over Satellite (MAMES)
deployment guidelines**

Reference
DTR/SES-00342

Keywords
emergency, satellite

ETSI

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

Contents

Intellectual Property Rights

IPRs essential or potentially essential to the present document may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (http://ipr.etsi.org).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

1 Scope

The present document provides guidelines for integrating the MAMES alert message encapsulation scheme specified in [i.1] into communications networks. Starting from an outline of the overall integration framework in terms of the entities and actors involved in an end-to-end alerting system, a set of generic integration scenarios are developed. These considerations apply to both satellite-based and terrestrial networks.

The actual integration guidelines are formulated by providing a mapping of the MAMES entities onto the entities of common types of SatCom and SatNav networks. For each class of SatCom and SatNav network considered, the interconnection points between the MAMES and the SatCom/SatNav networks are identified, highlighting also the respective lower-layer technologies of the satellite-based networks.

In order to illustrate the operation of integrated MAMES-enabled networks, a number of representative end-to-end alerting scenarios are developed and the key procedures involved are described.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

Not applicable.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 103 337: "Satellite Earth Stations and Systems (SES); Satellite Emergency Communications; Multiple Alert Message Encapsulation over Satellite (MAMES)".

[i.2] ETSI EN 300 421: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services".

NOTE: Referred to as DVB-S.

[i.3] ETSI EN 302 307-1: "Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications; Part 1: DVB-S2".

[i.4] ETSI EN 302 307-2: "Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications; Part 2: DVB-S2 Extensions (DVB-S2X)".

[i.5] ETSI TS 102 585: "Digital Video Broadcasting (DVB); System specifications for satellite services to handheld devices (SH) below 3 GHz".

[i.6] ETSI EN 302 550-1-1: "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) Systems; Part 1: Physical Layer of the Radio Interface; Sub-part 1: Outer Physical Layer".

[i.7] ETSI EN 302 550-1-2: "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) Systems; Part 1: Physical Layer of the Radio Interface; Sub-part 2: Inner Physical Layer Single Carrier Modulation".

[i.8] ETSI EN 302 550-1-3: "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) Systems; Part 1: Physical Layer of the Radio Interface; Sub-part 3: Inner Physical Layer Multi Carrier Modulation".

[i.9] ETSI TR 102 525: "Satellite Earth Stations and Systems (SES); Satellite Digital Radio (SDR) service; Functionalities, architecture and technologies".

[i.10] ETSI EN 301 790: "Digital Video Broadcasting (DVB); Interaction channel for satellite distribution systems".

NOTE: Referred to as DVB-RCS.

[i.11] ETSI TS 101 545-1: "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 1: Overview and System Level specification".

[i.12] ETSI EN 301 545-2: "Digital Video Broadcasting (DVB); Second Generation DVB Interactive Satellite System (DVB-RCS2); Part 2: Lower Layers for Satellite standard".

[i.13] ETSI TS 101 376-1-2: "GEO-Mobile Radio Interface Specifications (Release 3); Third Generation Satellite Packet Radio Service; Part 1: General specifications; Sub-part 2: Introduction to the GMR-1 family; GMR-1 3G 41.201".

[i.14] ETSI TS 101 377-1-2: "GEO-Mobile Radio Interface Specifications; Part 1: General specifications; Sub-part 2: Introduction to the GMR-2 family of specifications; GMR-2 01.201".

[i.15] ETSI TR 101 865: "Satellite Earth Stations and Systems (SES); Satellite component of UMTS/IMT-2000; General aspects and principles".

[i.16] ETSI TS 102 721-1: "Satellite Earth Stations and Systems (SES); Air Interface for S-band Mobile Interactive Multimedia (S-MIM); Part 1: General System Architecture and Configurations".

[i.17] "Communication system for the dissemination of alert messages: Architecture and design document", Deliverable D3.6, Alert for All (A4A) project.

[i.18] Recommendation ITU-T X.1303: "Common alerting protocol (CAP 1.1)".

[i.19] OASIS Standard: "Common Alerting Protocol Version 1.2".

[i.20] ETSI TS 102 182: "Emergency Communications (EMTEL); Requirements for communications from authorities/organizations to individuals, groups or the general public during emergencies".

[i.21] ETSI TS 102 900: "Emergency Communications (EMTEL); European Public Warning System (EU-Alert) using the Cell Broadcast Service".

[i.22] ETSI TR 102 850: "Emergency Communications (EMTEL); Analysis of Mobile Device Functionality for PWS".

[i.23] ETSI TS 122 268: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Public Warning System (PWS) requirements (3GPP TS 22.258 Release 12)".

[i.24] Recommendation ITU-R M.584-2: "Codes and formats for radio paging".

[i.25] Flex™ technology overview.

NOTE: Available at:
http://web.archive.org/web/20031211033436/www.motorola.com/MIMS/MSPG/FLEX/overview/overview.html#introduction.html

[i.26] ETSI TS 123 041: "Digital cellular telecommunications system (Phase 2+); Universal Mobile Telecommunications System (UMTS); Technical realization of Cell Broadcast Service (CBS) (3GPP TS 23.041)".

[i.27] http://www.gdacs.org/.

[i.28] http://www.fcc.gov/guides/emergency-alert-system-eas.

[i.29] http://www.fcc.gov/encyclopedia/wireless-emergency-alerts.

[i.30] https://www.fema.gov/integrated-public-alert-warning-system.

[i.31] Satellite-based warning system - SatWaS.

NOTE: Available at:
http://www.bbk.bund.de/DE/AufgabenundAusstattung/Krisenmanagement/WarnungderBevoelkerung/Warnmittel/SatWaS/AatWaS_node.html (in German).

[i.32] Modular Warning System (MoWaS).

NOTE: Available at:
http://www.bbk.bund.de/DE/AufgabenundAusstattung/Krisenmanagement/WarnungderBevoelkerung/Warnmittel/MoWaS/MoWaS_node.html (in German).

[i.33] http://www.nl-alert.nl/ (in Dutch).

[i.34] http://www.umsalert.com/.

[i.35] http://www.gripweb.org/gripweb/?q=countries-risk-information/databases-information-systems/pacific-tsunami-warning-system-ptws.

[i.36] http://ptwc.weather.gov/.

[i.37] http://www.jma.go.jp/jma/en/Activities/eew.html.

[i.38] http://www.nws.noaa.gov/nwr/info/nwrsame.html.

[i.39] http://www.oasis-emergency.org/specifications.

[i.40] http://www.w3.org/TR/2002/REC-xmldsig-core-20020212/.

[i.41] http://cap-cp.ca/.

[i.42] http://capan.ca/index.php?/en/npas/.

[i.43] http://www.siriusxm.com.

[i.44] http://www.solarismobile.com.

[i.45] http://www.inmarsat.com.

[i.46] http://www.thuraya.com.

[i.47] http://www.globalstar.com.

[i.48] http://www.iridium.com.

[i.49] http://www.navipedia.org.

[i.50] http://www.navipedia.org/index.php/Category:GALILEO.

[i.51] http://www.navipedia.net/index.php/Galileo-Navigation-Message.

[i.52] "Galileo's Commercial Service: Testing GNSS High Accuracy and Authentication", by I. Fernandez Hernandez et al., InsideGNSS (www.insidegnss.com), January/February 2015.

[i.53] http://www.navipedia.org/index.php/Category:EGNOS.

[i.54] http://www.navipedia.org/index.php/The_EGNOS_SBAS_Message_Format_Explained.

[i.55] Recommendation ITU-R BT.1774-1 (04/2007): "Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief".

[i.56] Recommendation ITU-R M.1854-1 (01/2012): "Use of mobile-satellite service in disaster response and relief".

[i.57] Recommendation ITU-R S.1001-2 (01/2010): "Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations".

[i.58] Recommendation ITU-R M.2149-1 (10/2011): "Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies".

[i.59] Recommendation ITU-R S.2151-1 (09/2012): "Use and examples of systems in the fixed satellite service in the event of natural disasters and similar emergencies for warning and relief operations".

[i.60] IETF Internet Draft: "draft-barnes-atoca-escape-02" (now expired).

NOTE: Available at: https://www.ietf.org/archive/id/draft-barnes-atoca-escape-02.txt.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

Alert Intermediary System: telecommunications network or node that is located at the user side of the Alert Network and that forwards alert-related (MAMES or non-MAMES) messages

Alert Issuer: entity that generates Alert Messages and forwards them to a MAMES Alert Provider for MAMES Encapsulation; more generally, an entity that terminates an Alert Protocol at the alerter side of an Alert Network

NOTE: Depending on the Alert Protocol used, an Alert Issuer may be capable of updating or cancelling a previously issued Alert Message, and of requesting and accepting acknowledgement messages.

Alert Message: Alert Protocol Message containing data to alert and/or inform Alert Users about an impending or on-going emergency

Alert Network: in the context of the present document, a telecommunications or navigation network that supports Alert Protocol Messages

Alert Protocol: protocol used to exchange Alert Protocol Messages

NOTE 1: In its most basic form, an Alert Protocol is a simple, mutually agreed rule for encoding alert-related information (e.g. by specifying an Internet media type).

NOTE 2: An advanced Alert Protocol typically includes, in addition to an Alert Message, other specially formatted messages for the purpose of updating, cancelling or acknowledging a previous Alert Protocol Message. An example of an advanced Alert Protocol is CAP.

NOTE 3: The termination points of an Alert Protocol are the Alert Issuer (at the alerter side) and the Alerting Device or the Mediation Device (at the user side).

Alert Protocol Message: message conforming to an Alert Protocol

NOTE: The term Alert Protocol Message comprises messages designed to alert or update Alert Users, as well as messages designed to cancel or acknowledge a previously transmitted Alert Protocol Message.

Alert User: entity that consumes the rendered content of an Alert Protocol Message

NOTE 1: A typical Alert User is a physical person that (e.g.) reads an Alert Message text on a display; an Alert User may also be a technical system that is triggered by the contents of an Alert Message to perform certain tasks (e.g. close a floodgate).

NOTE 2: Alerting Devices are not considered to be Alert Users, since they do not consume, but in fact render the contents of Alert Messages.

Alerting Device: device that receives an Alert (Protocol) Message and renders its content to one or more Alert User(s) according to its rendering capabilities; more generally, an entity that terminates an Alert Protocol at the user side of an Alert Network

NOTE 1: Depending on the Alert Protocol used, an Alerting Device may be capable of returning acknowledgement messages.

NOTE 2: An Alerting Device contains one or more Alerting Function(s) and it may contain one or more Mediation Function(s).

NOTE 3: An example of an Alerting Device is a siren that activates the proper tone for alerting the population; another example is a smartphone that displays the Alert Message content.

Alerting Function: logical function within an Alerting Device that receives the alert indication or information and renders these data according to its capabilities

Alerting Services Regulator: authority that regulates the implementation and provision of alerting services within its area of authority

CAP Capable Device: Alerting Device or Mediation Device that is capable of processing a CAP-compliant Alert Protocol Message; more generally, a device that terminates the CAP protocol at the user side of a CAP-based Alert Network

Direct MAMES Alerting: MAMES-based alerting scheme whereby the Satellite Terminal and the MAMES Receiver are co-located, i.e. either integrated into a single device or interconnected via a direct physical link

Indirect MAMES Alerting: MAMES-based alerting scheme whereby the Satellite Terminal and the MAMES Receiver are interconnected via a network, referred to as an Alert Intermediary System

MAMES Agent: software module that executes the MAMES Protocol

NOTE: Two types of MAMES Agents exist: The MAMES Alerter-Side Agent and the MAMES User-Side Agent.

MAMES Alert Provider: entity that generates MAMES Messages; more generally, an entity that terminates the MAMES Protocol at the alerter side of a MAMES Network

NOTE: A MAMES Alert Provider is also capable of requesting and accepting MAMES-based acknowledgement (ACK) messages.

MAMES Alert Receiver: entity that is capable of receiving MAMES Messages; more generally, an entity that terminates the MAMES Protocol at the user side of a MAMES Network

NOTE: A MAMES Alert Receiver is also capable of generating MAMES-based acknowledgement (ACK) messages.

MAMES Alerter-Side Agent: MAMES Agent serving the MAMES Alert Provider

MAMES Alerter-Side Controller: entity within the MAMES Alert Provider that configures, monitors and controls a MAMES Alerter-Side Agent

NOTE: The MAMES Alerter-Side Controller may be a software module operated by a physical person in charge of initiating and configuring a MAMES Alerter-Side Agent, and of controlling its operation in coordination with the Alert Issuer; alternatively, it may be an autonomous software algorithm performing these tasks.

MAMES Decapsulation: process of decapsulating a MAMES Frame to obtain the message(s) contained in the MAMES Payload

NOTE: Both the MAMES User-Side Agent and the MAMES Alerter-Side Agent are capable of MAMES Decapsulation.

MAMES Encapsulation: process of encapsulating one or more Alert Protocol Message(s) into a MAMES Frame

NOTE: Both the MAMES Alerter-Side Agent and the MAMES User-Side Agent are capable of MAMES Encapsulation.

MAMES Frame: used interchangeably with the term MAMES Message

MAMES Governing Body: authority that governs and regulates the operations and communications of all MAMES entities

MAMES Message: message conforming to the MAMES format

NOTE: MAMES Messages consist of a MAMES Header and (optionally) a MAMES Payload.

MAMES Network: Alert Network that supports the distribution and exchange of MAMES Messages

MAMES Payload: Alert Protocol Message(s) contained within a MAMES Frame

MAMES Protocol: Alert Protocol that supports the distribution and exchange of MAMES Messages

MAMES Provider: used interchangeably with the term MAMES Alert Provider

MAMES Receiver: used interchangeably with the term MAMES Alert Receiver

MAMES User-Side Agent: MAMES Agent serving the MAMES Alert Receive

MAMES User-Side Controller: entity within the MAMES Alert Receiver that configures, monitors and controls a MAMES User-Side Agent

NOTE: Once initiated, the MAMES User-Side Controller is an autonomously running software algorithm.

Mediation Device: device hosting one or more Mediation Function(s)

Mediation Function: in the context of the present document, a logical function that performs a protocol conversion between two different Alert Protocols

NOTE 1: A Mediation Function is required in cases when the Alerting Device (e.g. a siren) is not capable of processing the incoming Alert Message (e.g. a CAP message).

NOTE 2: A Mediation Function may be implemented as a stand-alone device (Mediation Device), or it may be embedded within an Alerting Device.

SatCom/SatNav/Com Network: communications network based on satellite communications, satellite navigation or terrestrial communications (wired, wireless, or mobile) technology

SatCom/SatNav/Com Regulator: authority that regulates the deployment and provision of SatCom/SatNav/Com Networks and services

SatCom/SatNav/Com Service Provider: entity that provides a satellite communications, a satellite navigation or a terrestrial communications service to its subscribers

SatCom/SatNav/Com Subscriber: entity that subscribes to and/or uses a satellite communications, a satellite navigation or a terrestrial communications service offered by a SatCom/SatNav/Com Provider

SatCom/SatNav/Com User Segment: satellite communications, satellite navigation or terrestrial communications subsystem that comprises all SatCom/SatNav/Com network entities at the user side of the SatCom/SatNav/Com Network

SatCom/SatNav Ground Segment: satellite communications or satellite navigation subsystem comprising all SatCom/SatNav network entities at the provider side of the SatCom/SatNav Network

SatCom/SatNav Network: communications network based on satellite communications or satellite navigation technology

SatCom/SatNav Space Segment: communications or navigation satellite(s)

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

A4A	Alert-For-All (Alert4All)
AFSK	Audio Frequency-Shift Keying
AM	Alert Message
ASN.1	Abstract Syntax Notation One
ATWC	Alaska Tsunami Warning Center
BBK	Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (*German*)
BEIDOU	BEIDOU Navigation Satellite System
BGAN	Broadband Global Area Network
BTS	Base Transceiver Station
CAP	Common Alerting Protocol
CAP-CP	CAP Canadian Profile
CBS	Cell Broadcast Service
CD	Compact Disc
CDDS	Commercial Data Distribution Service
CDLC	Civil Defence Liaison Centre
CMAS	Commercial Mobile Alert System
CPF	Central Processing Facility
CS	Commercial Service
DVB	Digital Video Broadcasting
DVB-S	Digital Video Broadcasting - Satellite
DVB-SH	Digital Video Broadcasting - Satellite services to Handheld devices (SH) below 3 GHz
EAS	Emergency Alert System
EBS	Emergency Broadcast System
EDXL	Emergency Data Exchange Language
EEW	Earthquake Early Warning System
EGNOS	European Geostationary Navigation Overlay Service
FCC	Federal Communications Commission
FEC	Forward Error Correction
FEMA	Federal Emergency Management Agency
FLEX	Flexible wide area paging protocol
GCC	Ground Control Center
GDACS	Global Disaster Alert and Coordination System
GEO	Geostationary
GMR	GEO Mobile Radio
GNSS	Global Navigation Satellite System
GPRS	General Packet Radio Service
GPS	Global Positioning System
GS	Generic Stream
GSC	GNSS Service Center
GSM	Global System for Mobile communications
GSS	GALILEO Sensor Station
I/F	Interface
INRSS	Indian Regional Navigation Satellite System
IP	Internet Protocol
IPAWS	Integrated Public Alert and Warning System
ITU	International Telecommunications Union
JMA	Japan Meteorological Agency
LAN	Local Area Network
LEO	Low Earth Orbit
MAMES	Multiple Alert Message Encapsulation over Satellite
MCC	Mission Control Center
MEO	Medium Earth Orbit
MF	Multiple Frequency

MMS	Multimedia Messaging Service
MPE	Multi-Protocol Encapsulation
MPEG	Moving Picture Experts Group
MSAS	MTSAT Satellite Augmentation System
MSS	Mobile Satellite Services
NAV	Navigation
NAWAS	National Warning System
NLES	Navigation Land Earth Station
NOAA	National Oceanic and Atmospheric Administration
NPAS	National Public Alerting System
NWS	National Weather Service
OASIS	Organization for the Advancement of Structured Information Standards
OCHA	Office for the Coordination of Humanitarian Affairs (United Nations)
OS	Open Service
OSI	Open Systems Interconnection
PAS	Population Alert System
PEP	Primary Entry Point
PHY	Physical Layer
PLAN	Personal Localized Alerting Network
PLMN	Public Land Mobile Network
POCSAG	Post Office Code Standardization Advisory Group
PRN	Pseudo-Random Noise
PRS	Public Regulated Service
PSTN	Public Switched Telephone Network
ptmp	point-to-multipoint
ptp	point-to-point
PTWC	Pacific Tsunami Warning Center
PTWS	Pacific Tsunami Warning System
PWS	Public Warning Service
QZSS	Quasi-Zenith Satellite System
RCS	Return Channel via Satellite
RDS	Radio Data System
RIMS	Ranging & Integrity Monitoring Stations
SAME	Specific Area Message Encoding
SAR	Search and Rescue Service
SatCom	Satellite Communication
SatNav	Satellite Navigation
SBAS	Satellite-Based Augmentation Systems
SBD	(Iridium) Short Burst Data
SDR	Satellite Digital Radio
SIS	Signal In Space
S-MIM	S-band Mobile Interactive Multimedia
SMS	Short Message Service
SoL	Safety-of-Life Service
S-UMTS	Satellite UMTS
TDMA	Time Division Multiple Access
TETRA	Terrestrial Trunked Radio
TS	Transport Stream
TT&C	Telemetry, Tracking and Control
TWS	Tsunami Warning System
ULS	Uplink Station
UMS	Unified Messaging System
UMTS	Universal Mobile Telecommunications System
UTC	Coordinated Universal Time
VBI	Voice Break-In
VHF	Very High Frequency
VSAT	Very Small Aperture Terminal
W3C	World Wide Web Consortium
WAAS	Wide Area Augmentation System
WAN	Wide Area Network
WEA	Wireless Emergency Alerts
XML	Extensible Markup Language

4 Overall Integration Framework

4.1 Objective and Overview

The objective of this clause is to outline the overall conceptual framework for integrating MAMES entities into SatCom/SatNav/Com Networks. The role of MAMES entities within the end-to-end Alert Network is also illustrated.

Clause 4.2 schematically illustrates the alerting hierarchy and introduces the employed notation. Clause 4.3 presents the key actors and entities involved, which are further detailed in clause 4.4.

NOTE: Inmarsat, Thuraya, Globalstar, Iridium Burst, XM WX Satellite Weather and Sirius XM are trade names of the respective suppliers. Throughout the present document where mentioned, this information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of the products named. Equivalent products may be used if they can be shown to lead to the same results.

4.2 Alerting Hierarchy and Notation

Figure 4.1 presents the basic alerting hierarchy in terms of the involved key entities and messages. For simplicity, only the primary alert flow (forward direction) is shown in the figure, and no assumptions are made as to the physical location (or possible co-location) and connectivity details of the displayed entities.

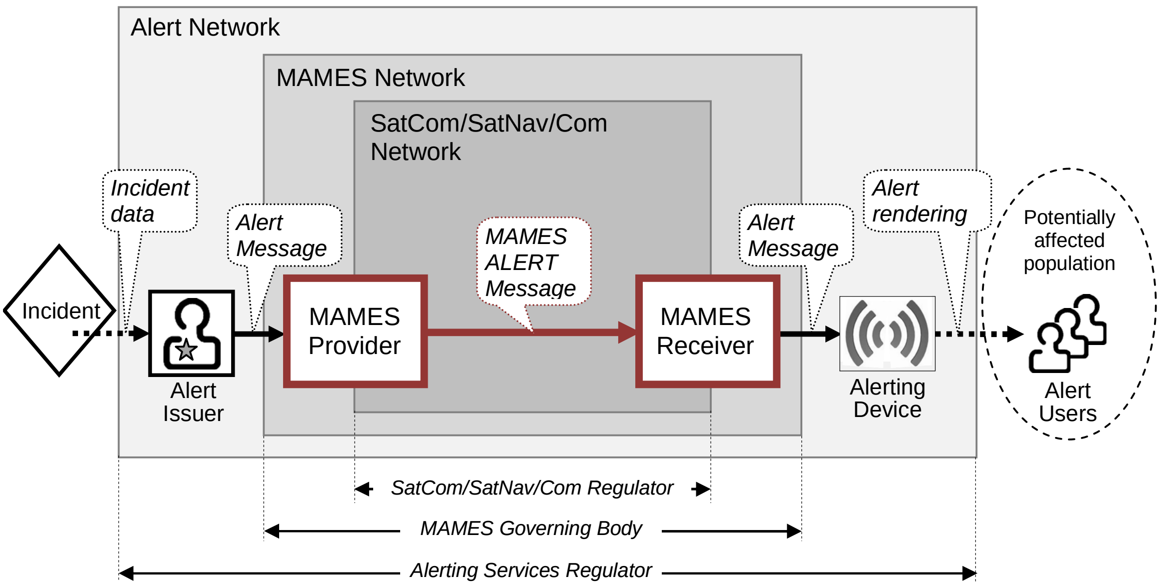


Figure 4.1: Schematic illustration of the alerting hierarchy (see text)

As shown in figure 4.1, the alert flow starts at the site of the incident, where relevant data are collected and brought to the attention of the Alert Issuer. Upon reception of this information, the Alert Issuer formulates an Alert Message, which generally specifies both the incident and the population or area to be alerted and informed, and which may also contain instructions for the targeted population. (A wide variety of alerting systems and technologies exists today to distribute alert-related information. An overview of selected systems and technologies is provided in annex A.)

The Alert Message is sent to the MAMES Provider for distribution to the notification area. For this purpose, the MAMES Provider encapsulates the Alert Message to obtain the MAMES ALERT Message. Using its connectivity to a SatCom/SatNav/Com Network, the MAMES Provider initiates the dissemination of the MAMES ALERT Message towards the notification area.

Upon reception of a MAMES ALERT Message, the MAMES Receiver determines (e.g. based on location data) whether or not it is permitted to further process the message. In the affirmative case, the received MAMES ALERT Message is decapsulated and the resulting Alert Message is forwarded to Alerting Devices, which in turn render its content to Alert Users.

Figure 4.1 also illustrates the three-layered hierarchy of the networks involved in the alerting chain:

i) the Alert Network, which contains the Alert Issuer and the Alerting Device;

ii) the MAMES Network, which contains the MAMES Provider and the MAMES Receiver; and

iii) the SatCom/SatNav/Com Network, which provides the physical connectivity between MAMES Provider and MAMES Receiver.

It is important to emphasize that the MAMES entities may be physically interconnected via a Satellite Communications ("SatCom"), a Satellite Navigation ("SatNav"), or via any arbitrary terrestrial (wired, wireless or mobile) communications ("Com") network. Due to their inherent broadcast capability, however, satellite-based networks are ideally suited for distributing alert information, especially to large areas or to regions with a poor (or a possibly compromised) terrestrial communications infrastructure. On the other hand, a purely terrestrial ("Com")-based distribution of MAMES messages may be advantageous in cases where a suitable terrestrial network is already in place to support MAMES messages. In such cases, MAMES provides a standardized mechanism and interface to transport (MAMES-encapsulated) Alert Messages. The required capabilities of both the MAMES Provider and the MAMES Receiver are independent of the specific communications technology employed.

The present document focuses primarily on satellite-based networks, even though most provisions apply also to the generic case. When explicit reference is made to a satellite-based network/technology, the term "SatCom/SatNav" network/technology will be used.

To conclude the description of figure 4.1, it is noted that the bottom portion of the figure indicates the regulatory and governing actors that supervise their associated networks:

i) the Alerting Services Regulator;

ii) the MAMES Governing Body; and

iii) the SatCom/SatNav/Com Regulator. These actors will be further characterized and described in the following clauses.

4.3 Actors and Entities

Figure 4.2 presents an alternative view of the end-to-end alerting system, emphasizing the service layering paradigm on top of the physical SatCom/SatNav Network. Here, the involved actors and entities are structured into conceptual layers according to the type of service that is provided at each particular layer.

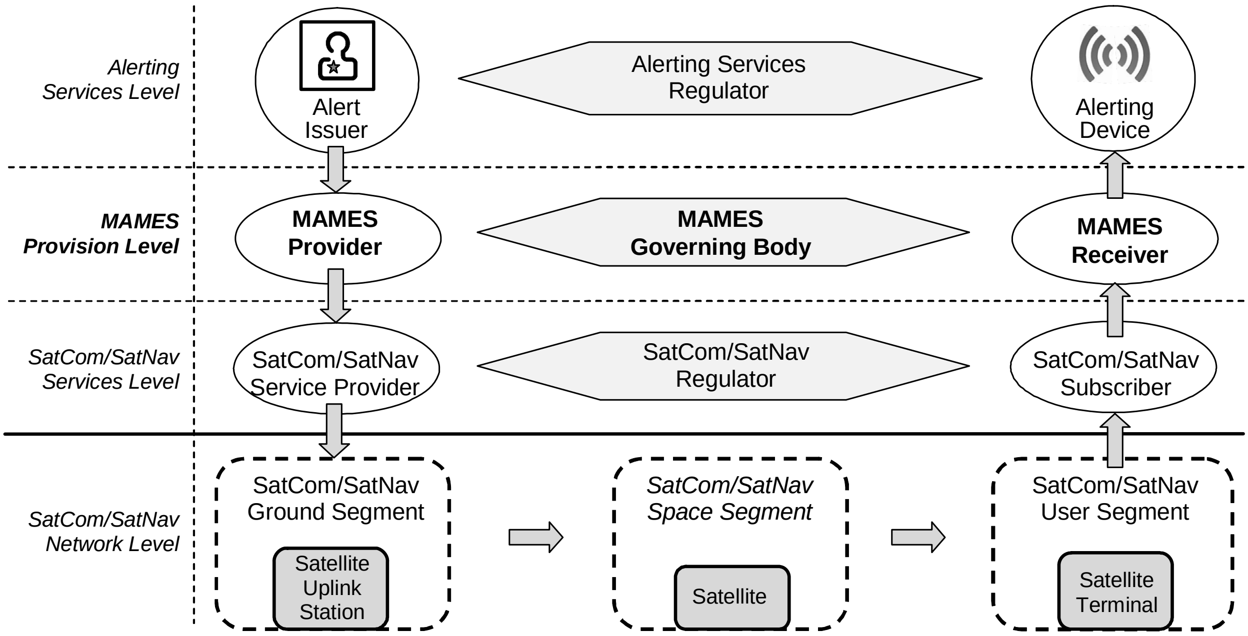


Figure 4.2: Actors and entities within the overall Alert Network (see text)

At the Alerting Services Layer, the Alert Issuer sends alert information to the Alerting Device, whereby this communication is regulated by an authority called Alerting Services Regulator. Note that - as can also be seen in figure 4.1 - the Alerting Device (rather than the Alert User) is the counterpart to the Alert Issuer in the present scheme.

At the MAMES Provision Level, the MAMES Provider encapsulates the original alert information and sends the so obtained MAMES Frame to the MAMES Receiver. This MAMES-level communication is regulated by an authority referred to as the MAMES Governing Body.

At the SatCom/SatNav Services Level, the SatCom/SatNav Service Provider incorporates the MAMES Frame into an appropriate SatCom/SatNav Service, which it offers to the SatCom/SatNav Subscriber. This SatCom/SatNav-specific communication is regulated by the authority overseeing satellite-based communications, referred to here as the SatCom/SatNav Regulator.

Finally, at the SatCom/SatNav Network Level, the ground segment (Satellite Uplink Station) is in charge of transmitting the service to the User Segment (Satellite Terminal).

The chain of vertical arrows appearing in the figure symbolizes the flow of alert information within the end-to-end alerting system, from the Alert Issuer to the Alerting Device. Note that, as in figure 4.1, only the primary alert flow (forward direction) is considered in the discussion of figure 4.2, ignoring any possible alert update, cancel or acknowledgement messages for simplicity.

The specific roles and responsibilities of the actors and entities introduced in figure 4.2 are described in the following clause.

4.4 Roles and Responsibilities of Actors and Entities

Tables 4.1 - 4.3 describe the roles and responsibilities of the various actors and entities introduced above. These descriptions are not intended to be exhaustive or general, but rather assume a MAMES-centred perspective.

Table 4.1: Actors and Entities at the Alerting Services Level

Actor or Entity Name	Description	Responsibilities	Remarks
Alerting Services Regulator	An authority that regulates all alert communications within its geographical or administrative area of authority.	• To designate and certify Alert Issuers. • To establish the rules for creating and distributing Alert (Protocol) Messages according to a pre-existing legal framework. • To establish a (regulatory and technical) framework for deploying Alerting Devices. • Generally, to govern the relationship between all actors and entities involved in the alerting chain.	The Alerting Services Regulator derives its authority from political bodies at a regional, national, EU, or international level. This is the legal basis for alerting the population within and/or across political or administrative boundaries.
Alert Issuer	A (civil protection) authority that issues Alert (Protocol) Messages for distribution within its geographical or administrative area of authority.	• To create and transmit Alert (Protocol) Messages to authorized MAMES Providers. • To instruct the MAMES Provider with respect to alert-specific details of the MAMES Message to be generated (e.g. concerning optional MAMES elements or whether or not an Ultra-Short MAMES ALERT is to be transmitted). • To accept feedback (e.g. acknowledgements) from the MAMES Provider concerning the status/result of the Alert Protocol Message distribution.	An Alert Issuer may be a local, regional or national civil protection authority or agency. Accordingly, its area of authority may range from small municipalities up to the national or supranational level. For geographically extended incidents, it is expected that several authorities will coordinate the issuing of an Alert Protocol Message.
Alerting Device	A device that receives Alert (Protocol) Messages and alerts and informs Alert Users according to its rendering capabilities.	• Upon reception of an Alert Protocol Message from a MAMES Receiver, to render its content for consumption by Alert Users. • If required by the Alert Protocol and subject to the availability of a return link, to send back an acknowledgement message.	Alerting Devices can be personal user devices or publically accessible devices that display or otherwise render alarm information or signals for public consumption.

Table 4.2: Actors and Entities at the MAMES Provision Level

Actor or Entity Name	Description	Responsibilities	Remarks
MAMES Governing Body	An authority that governs and regulates all operations and communications of MAMES actors and entities.	• To designate the MAMES Providers that are permitted to create and distribute MAMES Messages. • To certify MAMES Providers and MAMES Receivers. • To establish the rules for creating and distributing MAMES Messages. • To assign Alert Issuer IDs to all certified Alert Issuers. (Note that the Alert Issuer IDs are unique identifiers that have only MAMES-internal significance.) • To assign unique MAMES Provider IDs to all authorized MAMES Providers within the entire MAMES domain. • To specify and maintain the set of permitted algorithms and associated keys to be used for authentication and encryption (as applicable).	The MAMES Governing Body derives its authority from an Alerting Services Regulator.
MAMES Provider	An entity within the MAMES Network that generates MAMES Messages.	• To assign MAMES Receiver IDs to its associated MAMES Receivers. • Upon reception of an Alert Protocol Message from an Alert Issuer, to encapsulate that message for subsequent transmission via its associated SatCom/SatNav Provider. • Subject to rules and regulations established by the MAMES Governing Body and depending on the capacity available within the SatCom/SatNav Network, to determine if an Ultra-Short MAMES ALERT Message is to be transmitted. • Subject to rules and regulations established by the MAMES Governing Body, to set the parameters within the MAMES Mandatory Header. • Subject to rules and regulations established by the MAMES Governing Body, to select the appropriate Extension Headers and set their parameters. • Upon reception of a MAMES ACK Message from a MAMES Receiver, to act according to the rules and regulations established by the MAMES Governing Body; in particular, if the ACK Message contains an alert acknowledgement message from the underlying Alert Protocol, the MAMES Provider will forward this alert acknowledgement message to the Alert Issuer.	When composing a MAMES Message, the MAMES Provider may need to consult with the Alert Issuer in real-time.

Actor or Entity Name	Description	Responsibilities	Remarks
MAMES Receiver	An entity within the MAMES Network that receives and decapsulates MAMES Messages.	• Upon reception of a MAMES Message from a MAMES Provider, to parse its header in order to determine whether or not the MAMES Message is to be accepted and further processed. • If it is determined that the MAMES Message is to be further processed, to perform decapsulation; otherwise, to discard the MAMES Message. • Upon successful decapsulation, to proceed as required by MAMES Header parameters and, in particular, to send the decapsulated Alert Protocol Message to its interconnected Alerting Device(s). • If requested and subject to the availability of a return link, to return a MAMES ACK Message to the MAMES Provider. • Upon reception of an alert acknowledgement message from the Alerting Device and subject to the availability of a return link, to encapsulate that acknowledgement message in a MAMES ACK Message and send the MAMES ACK to the MAMES Provider.	MAMES Receivers can be integrated or co-located with Alerting Devices.

Table 4.3: Actors and Entities at the SatCom/SatNav Services Level

Actor or Entity Name	Description	Responsibilities	Remarks
SatCom/SatNav Regulator	An authority that regulates the deployment and provision of SatCom/SatNav Networks and services.	• To regulate the deployment and operation of SatCom/SatNav Networks. • To regulate the integration of MAMES functions with SatCom/SatNav Networks in coordination with the MAMES Governing Body.	
SatCom/SatNav Service Provider	An entity within the SatCom/SatNav Network that provides SatCom/SatNav services to its subscribers.	• To provide SatCom/SatNav services via the SatCom/SatNav Ground Segment and its associated satellite(s). • To host or interconnect to the MAMES Provider so that MAMES Messages can be supported.	The SatCom/SatNav Service Provider is located within the SatCom/SatNav Ground Segment.
SatCom/SatNav Subscriber	An entity within the SatCom/SatNav Network that subscribes to SatCom/SatNav services.	• To receive SatCom/SatNav services. • To host the MAMES Receiver so that MAMES Messages can be received and processed.	The SatCom/SatNav Subscriber is located within the SatCom/SatNav User Segment.

5 Integration Scenarios

5.1 Objective and Overview

The objective of this clause is to establish scenarios for integrating MAMES entities into SatCom/SatNav Networks. For this purpose, clause 5.2 first develops a generic integration model that identifies the relevant entities and defines their integration in a generic fashion. The resulting integration options are highlighted and further elaborated in terms of so-called *Direct* (clause 5.3) and *Indirect* (clause 5.4) MAMES Alerting Scenarios.

The purpose of the generic integration model developed here is:

i) to identify all relevant alert-related (MAMES and non-MAMES) entities; and

ii) to map them onto generically defined components of a satellite-based network.

This step is necessary in order to obtain a common integration framework that is independent of the specific characteristics of the satellite-based network. This common framework will later serve as the basis for developing the concrete satellite-network specific mapping and integration specifications (see clauses 6 and 7).

5.2 Generic Integration Model

5.2.1 MAMES Provider and MAMES Receiver

Figure 5.1 specifies how the MAMES Provider and the MAMES Receiver are to be integrated into the (generically defined) SatCom/SatNav Ground and User Segments. As can be seen, the MAMES Provider resides within the SatCom/SatNav Ground Segment, whereas the MAMES Receiver can either reside inside or outside the SatCom/SatNav User Segment (*Direct*, respectively *Indirect* MAMES Alerting).

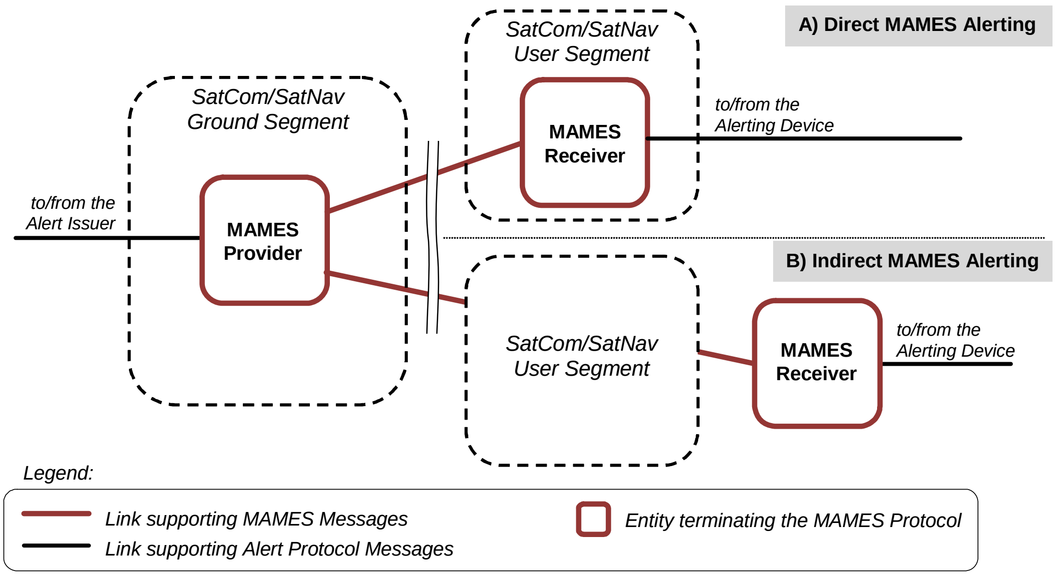


Figure 5.1: The generic model for MAMES integration into SatCom/SatNav Entities

The rationale for placing the MAMES Provider inside the Ground Segment lies in the need of the MAMES Provider to closely interact with the SatCom/SatNav Ground Segment. In particular, when encapsulating an Alert Message and specifying the values of the MAMES Header parameters, the MAMES Provider should have (near) real-time access to the status of SatCom/SatNav-specific resources in nodes and links.

On the other hand, as regards the MAMES Receiver, there is no need to insist on placing that entity inside the SatCom/SatNav User Segment. Note that the MAMES Receiver's primary task is simply to decapsulate the received MAMES Frames and to forward the resulting Alert Messages towards its associated Alerting Device(s). In fact, by placing the MAMES Receiver outside the SatCom/SatNav User Segment (Indirect MAMES Alerting), that segment can remain free on any MAMES capabilities. Indirect MAMES Alerting also implies that the MAMES Receiver may be placed at a location far from the Satellite Terminal, and that it may possibly be integrated with the Alerting Device.

When referring to an entity as being inside the SatCom/SatNav Ground or User Segment, reference is being made to the type of physical interconnection. Specifically, when an entity is said to be inside (or co-located with) another entity, the two entities are either physically integrated or directly attached to one another (i.e. via a direct physical link). By contrast, when an entity is said to be outside (or not co-located with) another entity, these entities are interconnected via a network, i.e. they communicate via nodes and links, employing OSI layers above Layer 1. In the context of the present document, that intermediary network is referred to as an Alert Intermediary System.

5.2.2 MAMES Agents and MAMES Controllers

After having established the basic integration scheme for the MAMES Provider and the MAMES Receiver, it is worth highlighting the internal structure of these entities. Figure 5.2 shows that both entities contain a MAMES Agent and a MAMES Controller, whereby the MAMES Agents execute and terminate the MAMES Protocol on their respective side.

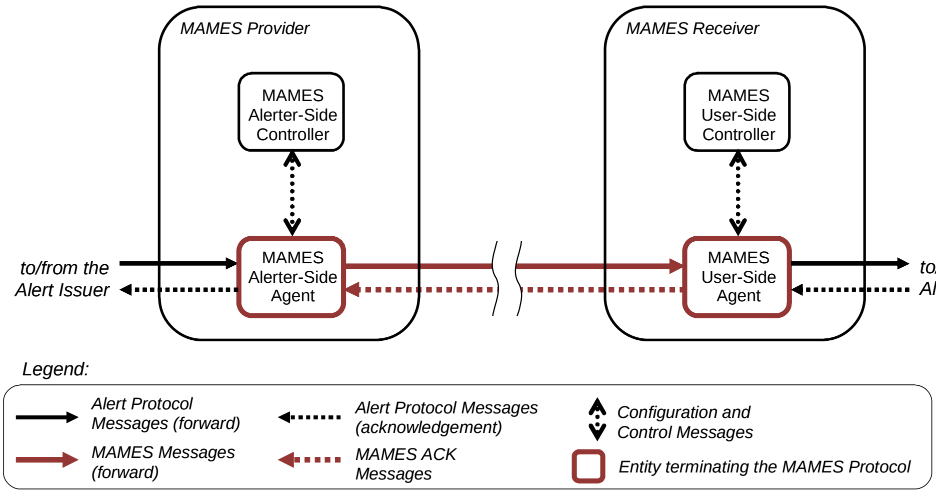


Figure 5.2: Embedding of MAMES Agents and MAMES Controllers

Specifically, the MAMES Alerter-Side Agent (inside the MAMES Provider) terminates the MAMES Protocol at the alerter side of the Alert Network and handles the communication with the Alert Issuer. Analogously, the MAMES User-Side Agent (inside the MAMES Receiver) terminates the MAMES Protocol at the user side of the Alert Network and is in charge of communicating with the Alerting Device.

The horizontal arrows in the figure indicate the exchange of alert-related messages, which include MAMES Messages (between the MAMES Agents) and Alert Protocol Messages (to/from the Alert Issuer respectively the Alerting Device). Solid arrows - pointing to the right - represent forward messages, and dashed arrows - pointing to the left - represent return (acknowledgement) messages.

The MAMES Controllers, also shown in the figure, act as supervisory entities for their respective Agent. In particular, the MAMES Alerter-Side Controller is a software module that configures, monitors and controls a MAMES Alerter-Side Agent on behalf of either a human operator or an autonomous algorithm. The task of the human operator (or the algorithm) is to implement a pre-established alerting policy, in terms of deciding, on a case-by-case basis, how to select and set the MAMES header fields. This task requires knowledge of and real-time access to certain satellite-system specific details such as services, resources, access scheme, and load conditions. It may also involve coordination with the Alert Issuer, e.g. to jointly set certain header values, to include certain optional headers or to decide whether or not the MAMES Payload can be omitted (due to resource constraints).

The MAMES User-Side Controller is a software module that, once initiated and configured, executes an autonomous algorithm, possibly with some (limited) user interaction. Its task is to monitor and control the operation of the MAMES User-Side Agent.

The monitoring task of the MAMES Controllers also involves the recording of any non-nominal events that may occur during MAMES-related operations, and the subsequent handling of such issues. For example, if the MAMES User-Side Agent detects a failure of its attached Alerting Device, it may send a corresponding error indication up to the MAMES User-Side Controller. Depending on the implemented capabilities and policy, the user or operator of the MAMES Receiver would thus be enabled to take action.

5.2.3 Alerting Function and Mediation Function

Even though the Alerting and Mediation Functions are not directly involved in the MAMES Protocol, their role within the overall Alert Network is briefly highlighted for completeness. Figure 5.3 sketches the possible configurations of these functions with respect to the corresponding devices.

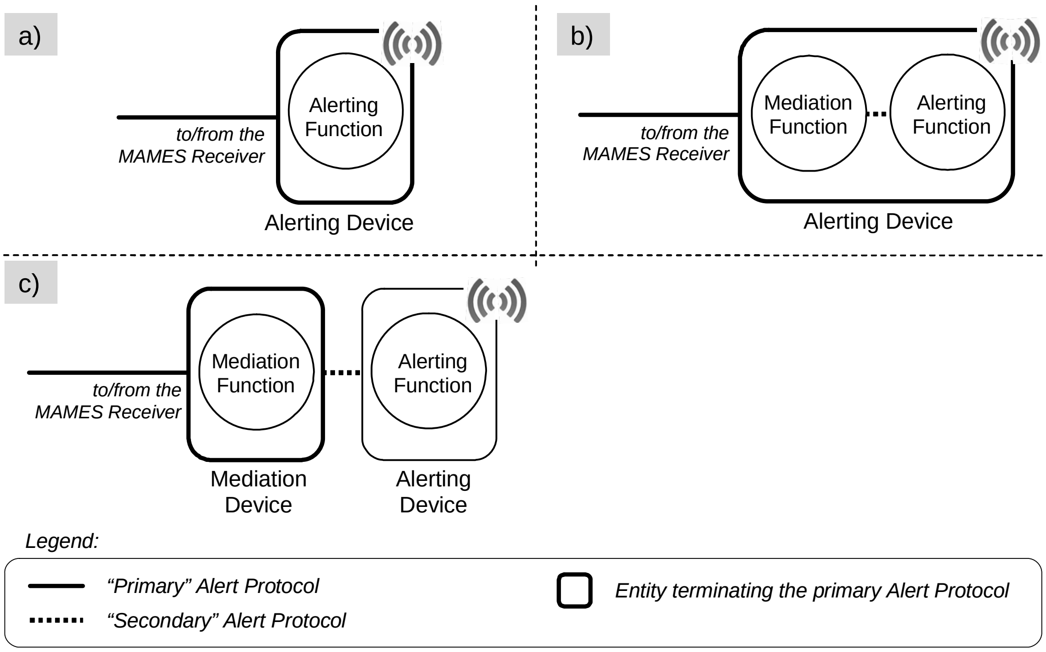


Figure 5.3: Embedding scenarios for the Alerting and Mediation Functions (see text)

Part a) in the figure shows the case when the incoming "primary" Alert Protocol (the protocol used by the Alert Issuer) is understood by the Alerting Function, so that no Mediation Function is needed for protocol conversion. The Alerting Device thus contains only the Alerting Function.

Part b) shows the case when the Alerting Function does not understand the primary Alert Protocol. In this case, a Mediation Function is needed to convert the primary Alert Protocol into another, "secondary" Alert Protocol (dashed line) in order to address and trigger the Alerting Function. In this configuration, both functions are integrated into a single device, also referred to as the Alerting Device.

Finally, in Part c), the same functions as in Part b) are required, but the Mediation Function and the Alerting Function are implemented as separate devices.

Since these different configurations have no impact on MAMES, they will not appear separately in the classification of MAMES Alerting Scenarios (see the following clause). Rather, to simplify the notation without loss of generality, the term "Alerting Device" will be used collectively from now on to capture all three configurations shown in figure 5.3.

5.2.4 MAMES Alerting Scenarios

Having established the configuration options for the various MAMES and Alert Protocol entities individually, the overall MAMES Alerting Scenarios can now be constructed. Figure 5.4 presents the resulting classification.

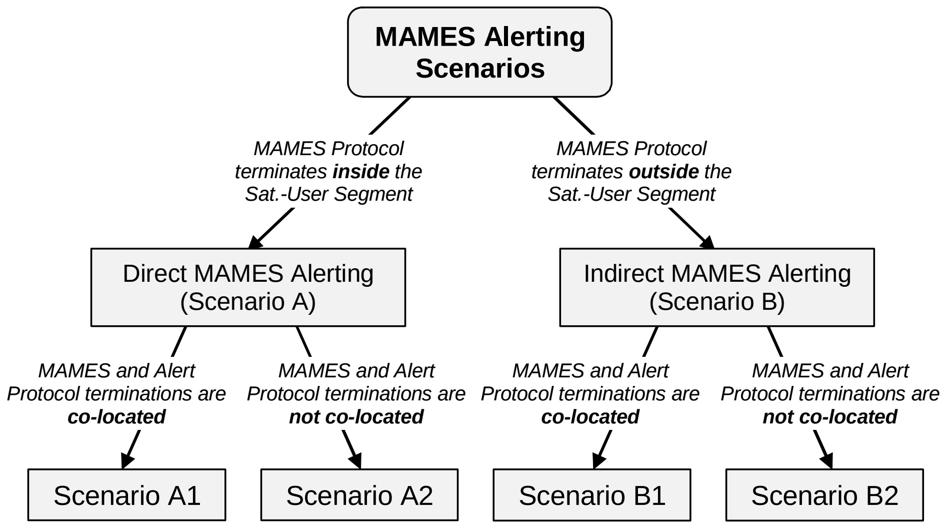


Figure 5.4: Classification of MAMES Alerting Scenarios

As can be seen in the figure, the MAMES Alerting Scenarios are constructed according to the locations of the termination points of the MAMES Protocol (primary criterion) and the Alert Protocol (secondary criterion). In Scenario A, referred to as the Direct MAMES Alerting Scenario, the MAMES Protocol terminates *inside* the SatCom/SatNav User Segment, and thus the MAMES Receiver is part of the User Segment (see figure 5.1, Part A). In Scenario B, referred to as the Indirect MAMES Alerting Scenario, the MAMES Protocol terminates *outside* the User Segment, so that the MAMES Receiver is not part of the User Segment (see figure 5.1, Part B).

In a next step, applying the secondary criterion, the question arises whether the Alert Protocol terminates inside the same entity as the MAMES Protocol, or outside. The resulting scenarios are labelled A1 and A2 in the Direct MAMES Alerting case, and B1 and B2 in the Indirect MAMES Alerting case, respectively.

The four MAMES Alerting Scenarios derived in this way are analysed in more detail in the following two clauses.

5.3 Direct MAMES Alerting Scenarios (Type A)

5.3.1 Scenario A1

Scenario A1 is defined in terms of the configuration shown in figure 5.5. Here both the MAMES Receiver and the Alerting Device are located inside the SatCom/SatNav User Segment.

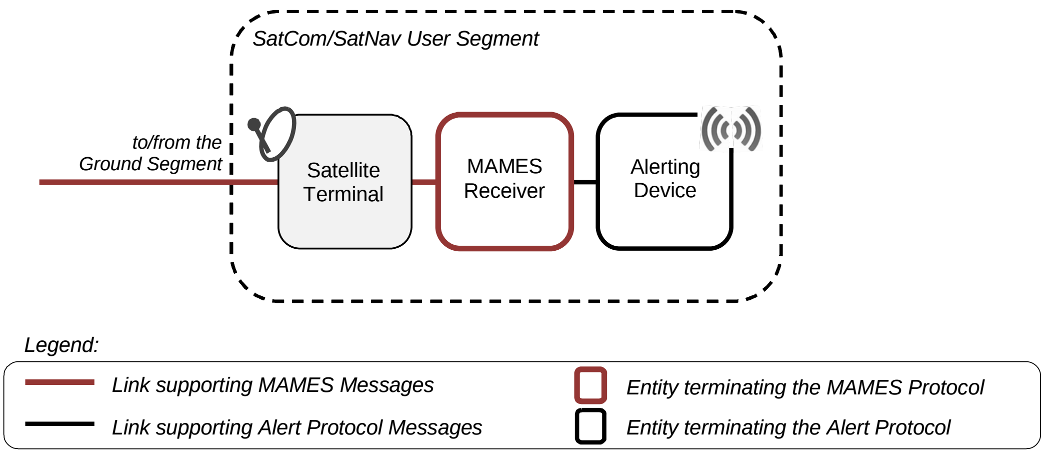


Figure 5.5: Scenario A1

A Scenario A1 configuration can be realized in terms of the following physical arrangements:

a) integrate both the MAMES Receiver and the Alerting Device into the Satellite Terminal; or

b) integrate the MAMES Receiver into the Satellite Terminal, and attach the Alerting Device via a local interface; or

c) integrate the Alerting Device into the MAMES Receiver, and attach the combined device to the Satellite Terminal via a local interface.

An example of a device according to (a) would be a handheld mobile satellite terminal (or a SatNav receiver) with an installed MAMES application, whereby the terminal's display and/or loudspeaker would play the role of the Alerting Device.

An arrangement of type (b) could e.g. be realized by employing a rooftop-mounted satellite dish, whose indoor unit would contain a software-based MAMES Receiver. Several Alerting devices would be attached to the indoor unit via direct (wired or wireless) links.

A type (c) arrangement could e.g. be realized by employing a rooftop-mounted satellite dish, whose indoor unit would be directly connected to a number of MAMES-capable Alerting Devices.

5.3.2 Scenario A2

Scenario A2 is defined in terms of the configuration shown in figure 5.6. Here the MAMES Receiver is located inside the SatCom/SatNav User Segment, whereas the Alerting Device is at a separate location, interconnected via an Alert Intermediary System.

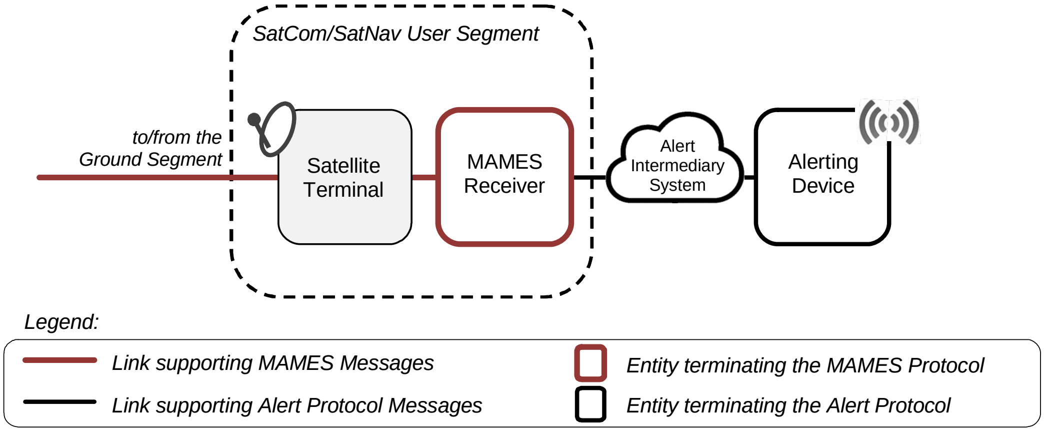


Figure 5.6: Scenario A2

An example of such a configuration could be a rooftop-mounted satellite dish, whose indoor-unit contains a software-based MAMES Receiver. That unit would be connected to a (wired or wireless) local area network that distributes the Alert Message to a number of Alerting Devices (e.g. sirens or displays) within the local area network.

5.4 Indirect MAMES Alerting Scenarios (Type B)

5.4.1 Scenario B1

Given that the Satellite Terminal and the MAMES Receiver are at separate locations, the question arises as to the location of the Alerting Device. In Scenario B1, shown in figure 5.7, the Alerting Device is integrated (or directly attached) to the MAMES Receiver.

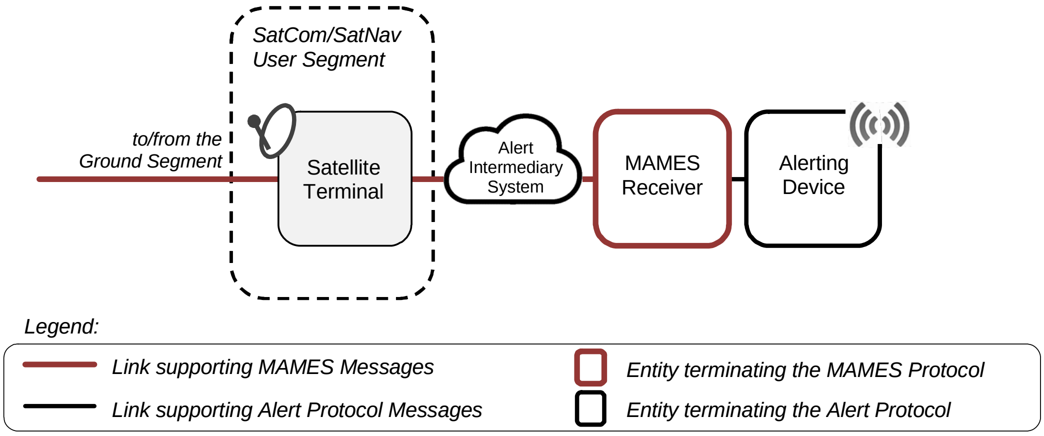


Figure 5.7: Scenario B1

An example of such a configuration could be a rooftop-mounted satellite dish, whose indoor unit would *not* be MAMES capable. Instead, that unit would be connected to a (wired or wireless) local area network that distributes the Alert Message to a number of integrated, MAMES-capable Alerting Devices (e.g. sirens or displays) that are also connected to that local area network.

5.4.2 Scenario B2

Finally, in Scenario B2, shown in figure 5.8, the Alerting Device is *not* co-located with the MAMES Receiver, but rather interconnected via another Alert Intermediary System.

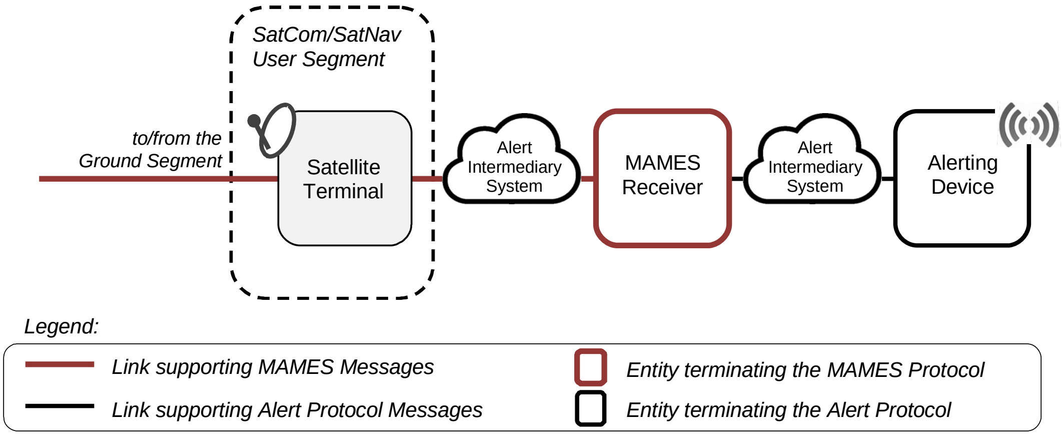


Figure 5.8: Scenario B2

An example of such a configuration could be a rooftop-mounted satellite dish, whose (non-MAMES capable) indoor-unit would be interconnected, via a wired local area network, to a stand-alone MAMES Receiver (dedicated device), which in turn would be interconnected to several Alerting Device via a wireless local or wide area network. In this setup, the MAMES Receiver could be located inside an office, whereas the (non-MAMES capable) Alerting Devices (e.g. sirens, loudspeakers, displays) could be placed in a several well-frequented locations throughout the town.

6 Mapping of MAMES Entities onto SatCom Entities

6.1 Objective and Overview

This clause is devoted to the mapping of the MAMES entities onto the entities of candidate SatCom networks. Starting from the generic integration model and the MAMES alerting scenarios developed in clause 5, the following analysis identifies, for each candidate SatCom network, the appropriate network entities that are required to implement MAMES functions. The candidate SatCom network types considered here are presented and described in clause B.1. These networks are the broadcast fixed satellite systems, the broadcast mobile satellite systems, the bidirectional fixed satellite systems, and the bidirectional mobile satellite systems.

6.2 Broadcast Fixed Satellite Systems

As outlined in clause B.1.2, broadcast fixed satellite systems provide robust, high-capacity unidirectional satellite links that are typically used to distribute satellite TV programming, as well as other media and data, to dish-based fixed satellite terminals (comprising outdoor and indoor units). These systems are thus ideally suited for applications where alert information is broadcast to extended geographical regions, whereby large amounts of data (text, maps, data files, audio, video; streaming) are supported.

Figure 6.1 illustrates how MAMES entities are to be mapped and interconnected/integrated to network entities of a broadcast fixed satellite system. The upper portion of the figure sketches a typical configuration that is used to offer the fixed satellite broadcast service. The lower portion displays the entities of the Alert Network, including the MAMES entities, and shows how the MAMES entities are to be interconnected to the SatCom entities so that the MAMES-based alerting service can be offered over the SatCom network.

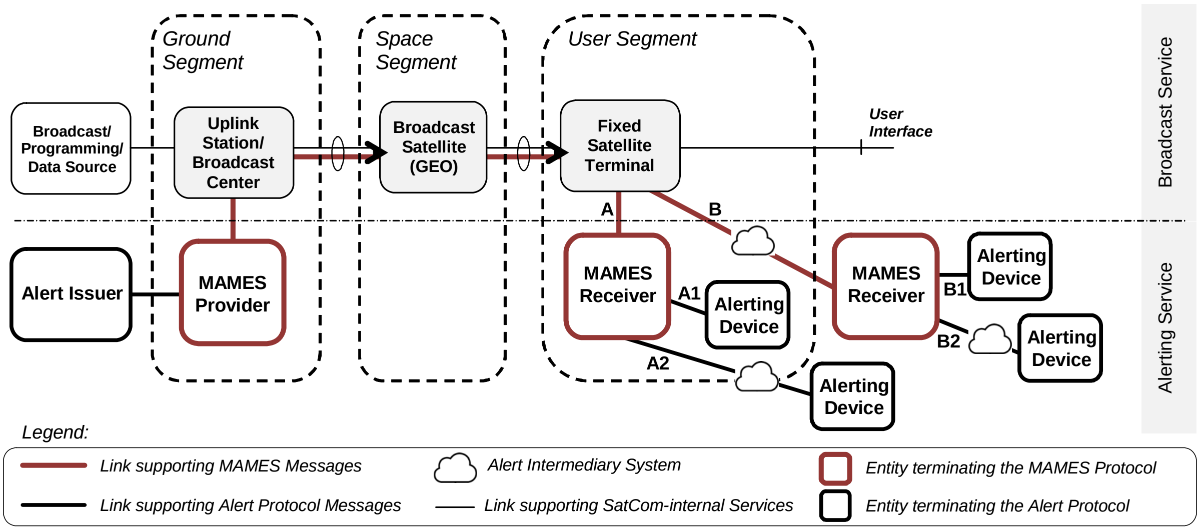


Figure 6.1: MAMES integration into a broadcast fixed satellite system (see text)

The following aspects are noted in the figure:

- In the *SatCom Ground Segment*, the broadcast fixed satellite system's Uplink Station should support a close interconnection to the MAMES Provider to allow for the efficient embedding of the MAMES Frames into the SatCom system's lower-layer technology. In fact, the Uplink Station should offer a direct, local interface to the MAMES Provider, which would (ideally) involve real-time access to the SatCom system's live uplink resource status. This is necessary to enable the MAMES Provider to properly adapt the MAMES Frames before transmission, in particular to ensure that the MAMES Frame's size does not exceed the system's capacity.

- In the *SatCom User Segment*, the type of connectivity between the Satellite Terminal and the MAMES Receiver depends on the MAMES Alerting Scenario employed (Direct or Indirect). For these scenarios, including the sub-scenarios A1, A2, B1 and B2, the analysis of clauses 5.2 and 5.3 above directly applies here. It should again be emphasized that the direct (uninterrupted) lines between entities in figure 6.1, User Segment, indicate either physical integration or direct physical attachment. Thus, e.g. in sub-scenario A1, both the MAMES Receiver and the Alerting Device may actually be software modules inside the Satellite Terminal, the Broadcast Receiver's set-top box, or even in the TV set. On the other hand, if an Alert Intermediary System is involved (cloud symbol in the figure), the MAMES Receiver and/or the Alerting Device are external to the SatCom User Segment, and interconnected via a suitable network.

As regards the broadcast fixed satellite systems' lower-layer technologies, the most common standards in use today are the satellite-specific members of the DVB family. These are defined in the ETSI documents ETSI EN 300 421 (DVB-S) [i.2], ETSI EN 302 307-1 (DVB-S2) [i.3], and ETSI EN 302 307-2 (DVB-S2X) [i.4]. While providing increasingly powerful coding, modulation and error correction mechanisms, this series of standards is also evolving to improve its support of data (IP) traffic. In particular, while DVB-S mandates an overlaid MPEG-TS transport stream, DVB-S2 and DVB-S2X support, in addition to MPEG-TS, also a flexible native stream format referred to as the Generic Stream (GS). Generic Streams may be used to efficiently carry IP-based data.

The preferred method of embedding a MAMES Frame into a broadcast fixed satellite system's lower-layers obviously depends on a variety of factors, including the SatCom system's transmission standard, its capabilities, configuration and typical mode of operation, as well as SatCom operator policies and preferences. In any case, for efficient MAMES operation over a broadcast fixed satellite system, the MAMES Provider should be offered an appropriate interface to the SatCom system's Uplink Station so that optimal use can be made of the SatCom system's resources. The details of this interface are out of scope of the present document.

6.3 Broadcast Mobile Satellite Systems

As outlined in clause B.1.3, broadcast mobile satellite systems provide satellite-based broadcast services to mobile, nomadic and portable receivers, including handheld devices as well as vehicle-mounted radio/TV and data receivers. These systems are capable of delivering high-quality audio and multimedia contents to users on the move, which makes them ideal candidates for alert distribution to populations without access to stationary receivers. This includes in particular car drivers and remote workers or people engaging in out-door recreational activities.

Figure 6.2 illustrates how MAMES entities are to be mapped and interconnected/integrated to network entities of a broadcast mobile satellite system. As in the previous figure, the upper portion of the figure sketches a typical configuration that is used to offer a mobile satellite broadcast service. The lower portion displays the entities of the Alert Network, including the MAMES entities, and shows how the MAMES entities are to be interconnected to the SatCom entities.

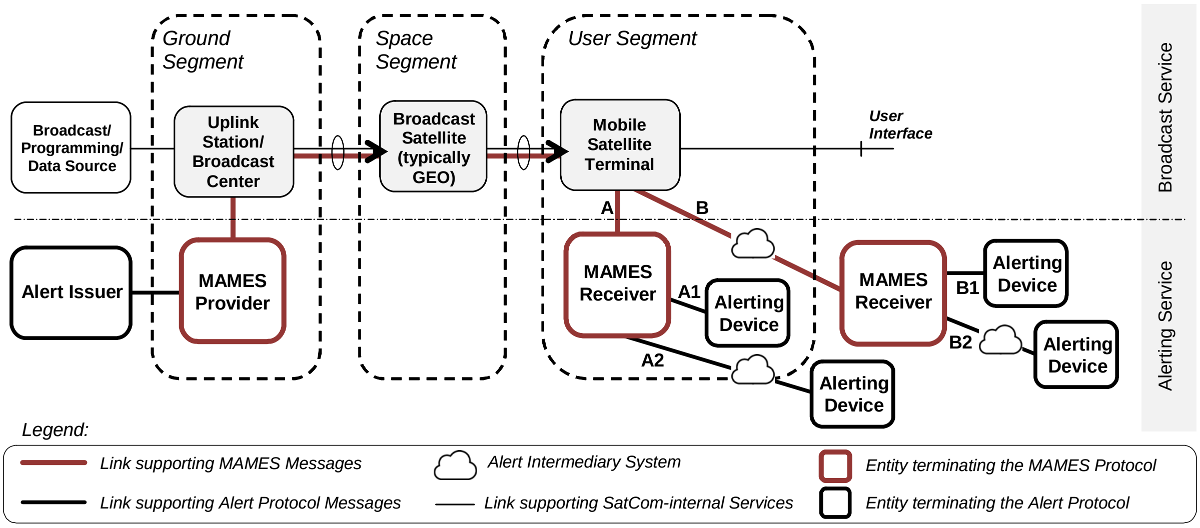


Figure 6.2: MAMES integration into a broadcast mobile satellite system (see text)

The following aspects are noted in figure 6.2 (note the analogy to figure 6.1):

- In the *SatCom Ground Segment*, the broadcast mobile satellite system's Uplink Station should support a close interconnection to the MAMES Provider to allow for the efficient embedding of the MAMES Frames into the SatCom system's lower-layer technology. As in the case of the broadcast fixed satellite systems, the Uplink Station should offer a direct, local interface to the MAMES Provider, which would involve real-time access to the SatCom system's capacity and live uplink resource status.

- In the *SatCom User Segment*, the same considerations as in the case of the broadcast fixed satellite systems apply. Accordingly, the type of connectivity between the Satellite Terminal and the MAMES Receiver depends on the MAMES Alerting Scenario employed (Direct or Indirect). For these scenarios, including the sub-scenarios A1, A2, B1 and B2, the analysis of clauses 5.3 and 5.4 above directly applies here. It should again be emphasized that the direct lines drawn between entities in figure 6.2, User Segment, indicate either physical integration or direct physical attachment. Thus, e.g. in sub-scenario A1, both the MAMES Receiver and the Alerting Device may actually be software modules inside the mobile satellite terminal or the display (or other output) module. On the other hand, if an Alert Intermediary System is involved (cloud symbol in the figure), the MAMES Receiver and/or the Alerting Device are external to the SatCom User Segment and interconnected via a suitable network.

As regards the broadcast mobile satellite systems' lower-layer technologies, typical standards are DVB-SH [i.5] and ETSI's SDR [i.6] [i.7] and [i.8]. Both technologies employ a hybrid architecture, whereby the satellite broadcast is complemented by a (local) terrestrial component that extends the service provision to zones which are difficult to reach via satellite (in-door, urban areas, tunnels). The terrestrial repeaters (not shown in the figure) are considered to be part of the User Segment.

The DVB-SH architecture [i.5] comprises at set of components at the physical, link and service layers that constitute a robust and flexible system for providing reliable multimedia and data services, including IP services. In particular, the DVB-SH link layer offers support of MPEG2 TS packets and allows for the introduction of a Generic Stream. IP datagrams are encapsulated using Multi-Protocol Encapsulation (MPE).

The SDR reference architecture [i.9] splits the SDR system into two sets of layers: The higher layers (Service Component Layer and Service Layer) comprise the aggregation of the service content into a transport stream, while the lower layers (Outer-PHY and Inner-PHY) define the transport mechanism of both the satellite and the terrestrial transmitter/receiver. Of particular relevance for the present application is the interface between the higher and lower layers, called the S-TS interface (Service-Transport Stream). At this interface, a variety of technology choices are provided by the SDR standard, including MPEG TS (e.g. DVB-MPE), Packet Stream (e.g. IP Data Stream), and Continuous Bit Stream.

For both DVB-SH and SDR, the preferred method of embedding a MAMES Frame into the lower layers obviously depends on a variety of factors, including the SatCom network's choice of transmission standard, its capabilities, configuration and typical mode of operation, as well as SatCom operator policies and preferences. In any case, in analogy to the broadcast fixed satellite system, for efficient MAMES operation over a broadcast mobile satellite system, the MAMES Provider should be offered an appropriate interface to the SatCom system's Uplink Station so that optimal use can be made of the SatCom system's resources. Again, the details of this interface are out of scope of the present document.

6.4 Bidirectional Fixed Satellite Systems

As outlined in clause B.1.4, bidirectional fixed satellite systems provide two-way interactive (mainly data) communications services to remote users at fixed locations. These systems - often referred to as VSAT systems - typically offer several Mbps in the forward direction, and terminal-category dependent (smaller) speeds on the return link. Owing to these characteristics, VSAT systems are thus well suited for both broadcast-based (one-way) as well as interactive alert distribution. In the latter case, MAMES ACK messages can be sent back on the return link.

Figure 6.3 illustrates how MAMES entities are to be mapped and interconnected/integrated to network entities of a bidirectional fixed satellite system. The upper portion of the figure sketches a typical configuration used to offer the interactive fixed satellite service. The lower portion displays the entities of the Alert Network, including the MAMES entities, and shows how the MAMES entities are to be interconnected to the SatCom entities so that the MAMES-based alerting service can be offered over the fixed SatCom network.

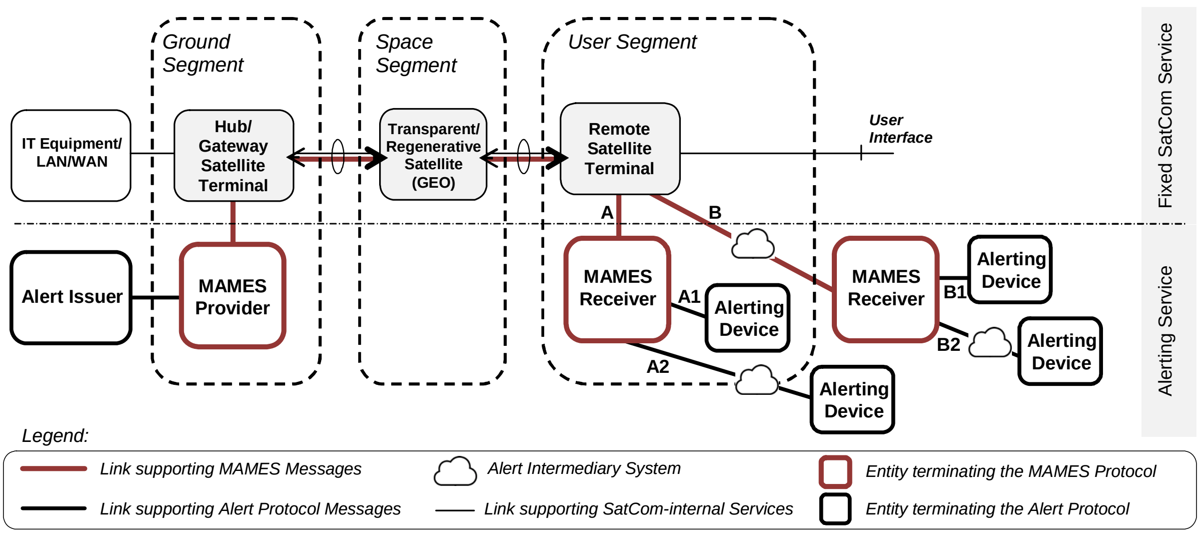


Figure 6.3: MAMES integration into a bidirectional fixed satellite system (see text)

The following aspects are noted in figure 6.3:

- In the *SatCom Ground Segment*, the bidirectional fixed satellite system's Hub or Gateway Satellite Terminal should support a close interconnection to the MAMES Provider to allow for the efficient embedding of the MAMES Frames into the SatCom system's lower-layer technology. Here, the same considerations apply as in the case of the broadcast fixed satellite system. Additionally, when a MAMES ACK Frame arrives on the return channel, that message should be routed to the MAMES Provider for further processing.

- Similarly, in the *SatCom User Segment*, analogous considerations apply as in the case of the broadcast fixed satellite system. The difference to those systems, however, lies in the ability of the interactive system to support acknowledgements. These return messages may originate either in the Alerting Device (according to the Alert Protocol), or in the MAMES Receiver itself. In both cases, the MAMES Receiver is responsible for generating the appropriate MAMES ACK message (with or without payload) and for embedding that message into the appropriate service/channel offered by the bidirectional fixed satellite system.

As regards these systems' lower-layer technologies, common standards in use today are DVB-S/S2 [i.2] and [i.3] in the forward direction and DVB-RCS/RCS2 [i.10], [i.11] and [i.12] in the return direction. Since the forward direction is based on the same lower-layer technologies as in the broadcast case, the same considerations as above apply (see clause 6.2). On the return link, both DVB-RCS and DVB-RCS2 use an MF-TDMA based transmission scheme to provide high bandwidth efficiency for multiple users. MAMES ACK messages (with or without payload) thus need to be embedded into an appropriate VSAT service that carries data from the remote VSAT terminal back to the Hub or Gateway terminal. If such a higher-layer function is not available in the VSAT system, it would have to be implemented to enable the transmission of MAMES ACK messages. Alternatively, an existing VSAT service may be reused or adapted to carry such return messages. In any case, the initiation of MAMES ACK messages is within the responsibility of the MAMES Receiver which, depending on the integration scenario, may be integrated into or lie outside the VSAT terminal.

6.5 Bidirectional Mobile Satellite Systems

As also outlined in clause B.1.5, bidirectional mobile satellite systems - also referred to as MSS (Mobile Satellite Services) systems - provide two-way interactive communications services to remote mobile users. Due to their limited bitrates, MSS systems are well suited for small MAMES messages, whereby (small) MAMES ACK messages are supported on the return channel.

Figure 6.4 illustrates how MAMES entities are to be mapped and interconnected/integrated to network entities of a bidirectional mobile satellite system. The upper portion of the figure sketches a generic configuration used to offer the interactive mobile satellite service; although representative of a typical MSS system, the network architecture has been simplified to highlight the essential network elements. The lower portion displays the entities of the Alert Network, including the MAMES entities, and shows how the MAMES entities are to be interconnected to the SatCom entities so that the MAMES-based alerting service can be offered over the MSS network.

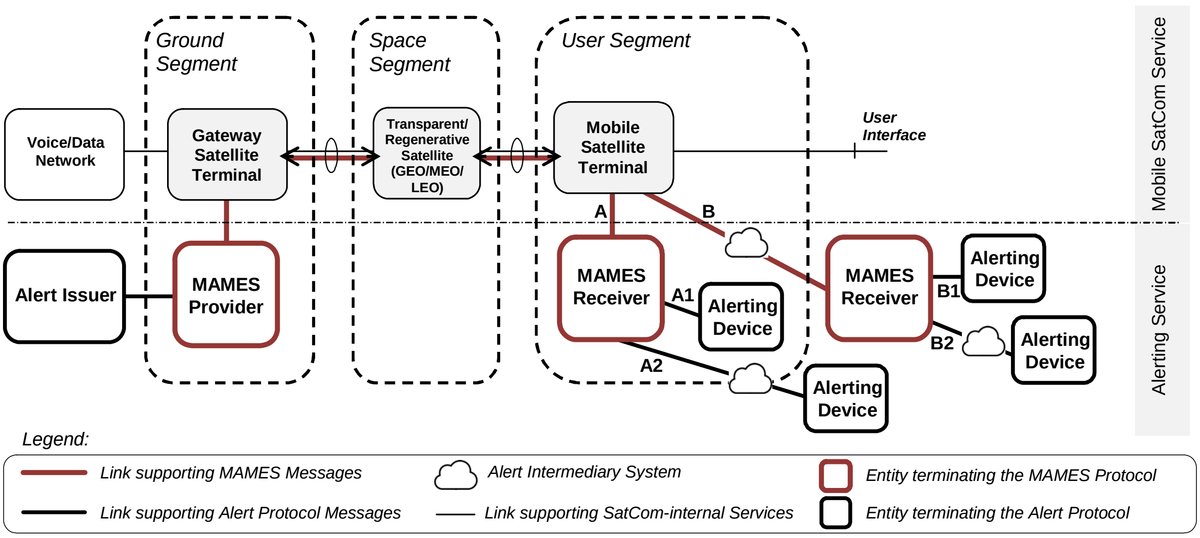


Figure 6.4: MAMES integration into a bidirectional mobile satellite system (see text)

The following aspects are noted in figure 6.4:

- In the *SatCom Ground Segment*, the MSS system's Gateway Satellite Terminal should support a close interconnection to the MAMES Provider to allow for the efficient embedding of the MAMES Frames into the SatCom system's appropriate data service. Although the details of this embedding depends on the particular MSS system considered, it is generally expected that the MAMES Provider's role will be analogous to that of any other user of the MSS system's data service; the MAMES Provider will act as a special type of user whose data packets are MAMES Frames. In the reverse direction, when MAMES ACK Messages arrive on the data service's return channel, these packets will be routed to the MAMES Provider for further processing.

- In the *SatCom User Segment*, upon arrival of a MAMES Frame over the satellite link, this special data packet will be detected and routed to the MAMES Receiver for further handling according to the employed integration scenario. Furthermore, any MAMES ACK Messages generated by the MAMES Receiver will be embedded into the data service's return channel and transmitted back to the Gateway.

As regards the communications technologies employed by MSS systems, common standards are GMR-1 (GEO Mobile Radio-1) [i.13], GMR-2 [i.14], S-UMTS (Satellite-Universal Mobile Telecommunications System) [i.15], and S-MIM (S-band Mobile Interactive Multimedia) [i.16]. While GMR and S-UMTS are based on terrestrial standards (GSM resp. UMTS), with satellite-specific adaptations at the lower layers, S-MIM uses DVB-SH in the forward direction and a specially designed return link technology.

To transmit MAMES Frames in both the forward and return directions over GMR and S-UMTS networks, data services are available that closely correspond to their terrestrial counterparts (e.g. SMS or GPRS-based services such as MMS). As regards S-MIM, a range of data services are provided, including messaging services (optionally) in combination with GNSS applications as well as real-time emergency services [i.16]. In all cases, it is the responsibility of the MAMES Provider (resp. Receiver) to embed the MAMES Frames into the appropriate data service.

It should finally be noted that some MSS operators offer services specifically designed for emergency or alert purposes (see clause B.1.5). For example, the Iridium Burst™ Service is a one-to-many global data broadcast service with high signal penetration capabilities, which enables the transmission of data to a large number of remote Iridium devices. One of the primary uses of the Iridium Burst™ Service would be alert distribution. This service could be used to address MAMES-capable Alerting Devices at remote locations behind Iridium receivers. For this purpose, MAMES Frames would be imbedded in the Iridium Burst™ Service's user payload (capacity: 248 bits), and the remote Iridium device would forward the MAMES Frames to a MAMES Receiver, which in turn would extract and forward the encapsulated Alert Message(s) to the appropriate remote Alerting Device(s). Note that, in this application, the satellite-based geographic targeting would be performed by the Iridium system itself, rather than by means of MAMES features.

Further details on MSS capabilities and services relevant for MAMES are provided in clause B.1.5.

7 Mapping of MAMES Entities onto SatNav Entities

7.1 Objective and Overview

In analogy to the previous clause, the present clause is devoted to the mapping of the MAMES entities onto the entities of candidate SatNav networks. The candidate SatNav networks considered are presented in clause B.2; they are the GALILEO system and the EGNOS system.

7.2 GALILEO

As outlined in clause B.2.2, the GALILEO system transmits, apart from the satellite-derived positioning and timing signals, a set of navigation messages that serve different purposes in providing the GALILEO services. For the GALILEO Commercial Service (CS), e.g. a dedicated message type, called C/NAV is used.

Figure 7.1 illustrates how MAMES entities are to be mapped and interconnected/integrated to GALILEO entities. As in the previous figures, the upper portion of the figure sketches some of the key entities needed to offer the GALILEO services. The lower portion displays the entities of the Alert Network, including the MAMES entities, and shows how the MAMES entities are to be interconnected to the GALILEO entities.

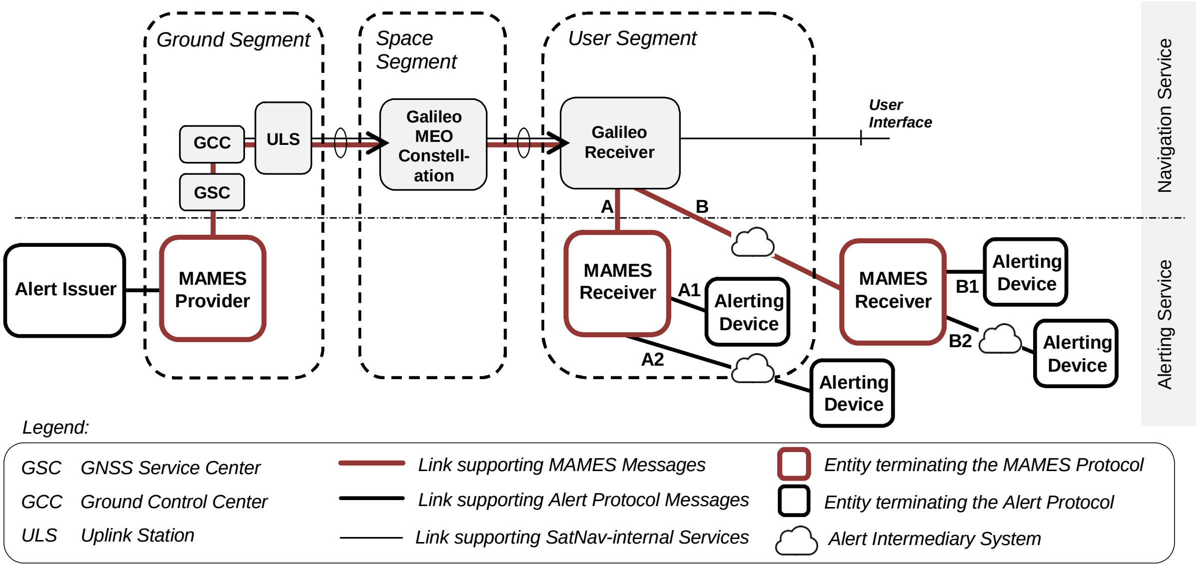


Figure 7.1: MAMES integration into the GALILEO satellite navigation system (see text)

The following aspects are noted in figure 7.1:

- In the *GALILEO Ground Segment*, the GSC is responsible for providing an external interface, and thus implements the interconnection to the MAMES Provider. MAMES Messages (representing e.g. CS data), once received by the GSC, are incorporated into the appropriate GALILEO messages (C/NAV) and forwarded to the GCC, which in turn forwards them to the ULS for uplinking.
- In the *GALILEO User Segment*, upon arrival of a CS message containing a MAMES Frame, the GALILEO receiver will detect this special data packet and route it to the MAMES Receiver for further handling according to the employed integration scenario. Note that, since these messages are encrypted, the GALILEO receiver should first invoke the decryption procedure. Since no return channel is available within the GALILEO system, successful reception of a MAMES Frame cannot be acknowledged (no MAMES ACK can be sent).

In summary, the above analysis shows that the MAMES-GALILEO interface differs substantially from the corresponding MAMES interfaces to SatCom networks. On the one hand, this is due to the fact that GALILEO is primarily a SatNav system, allowing users to insert only small amounts of data under technically restrictive conditions. On the other hand, being a critical component of the public infrastructure, extraordinary standards of safety, security and confidentiality exist.

As regards the available capacity within the CS, a gross data rate of 500 bps (per GALILEO satellite) has been specified (see clause B.2.2.1). The actual user payload size per C/NAV message is 448 bit (56 Byte). This is sufficient to carry small MAMES Messages, including Ultra-Short MAMES Messages and MAMES Messages containing compressed payloads.

The above description refers mainly to MAMES integration into the GALILEO CS. As regards MAMES integration into the PRS, analogous considerations apply, except that the gross PRS data rate is only 50 bps. Due to the confidential nature of the PRS specifications, details remain for further study.

7.3 EGNOS

As outlined in clause B.2.3, the EGNOS system transmits a set of navigation messages that serve different purposes in providing the EGNOS service. In analogy to the GALILEO system, these messages are generated by a ground segment entity (CPF) and uplinked by NLESes. It is possible to insert MAMES-related user data into the data fields of such messages. According to the analysis in annex B (clause B.2.3.2), it is proposed to define a new EGNOS message type that is dedicated exclusively to the transport of MAMES Messages.

Figure 7.2 illustrates how MAMES entities are to be mapped and interconnected/integrated to EGNOS entities. As in the previous figures, the upper portion of the figure sketches some of the key entities needed to offer the usual (in this case EGNOS) service. The lower portion displays the entities of the Alert Network, including the MAMES entities, and shows how the MAMES entities are to be interconnected to the EGNOS entities.

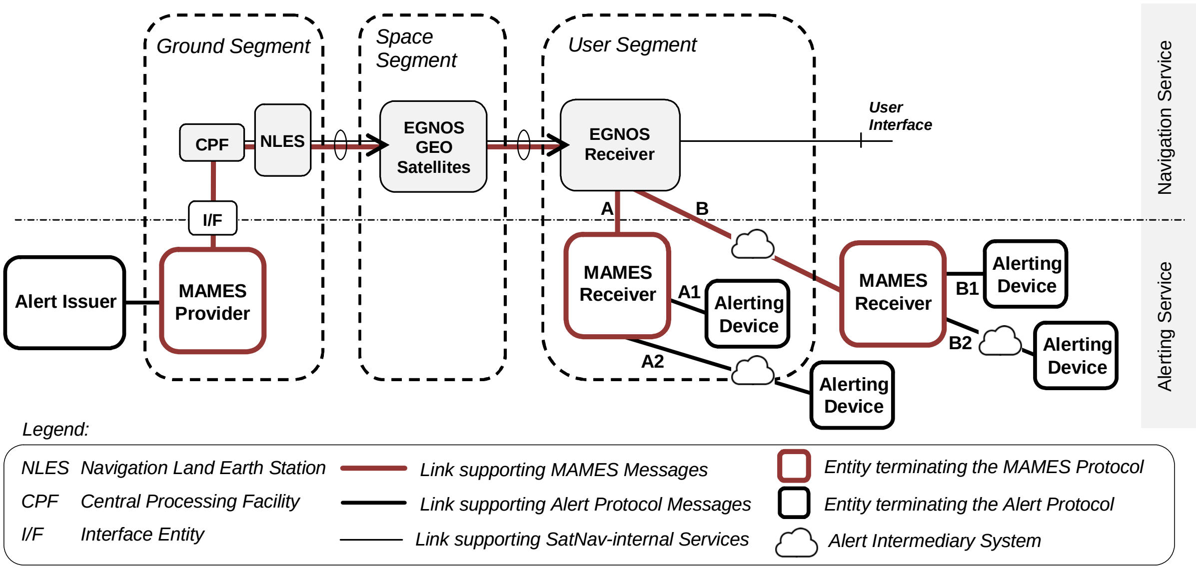


Figure 7.2: MAMES integration into the EGNOS system (see text)

The following aspects are noted in figure 7.2:

- In the *EGNOS Ground Segment*, the key entities directly involved in the generation and transmission of the navigation messages are the CPF (for message generation) and the NLES (for message uplinking). As indicated in the figure, it is proposed that the MAMES Provider does not directly interface the CPF, but instead interconnects to the EGNOS system via a dedicated Interface Entity (I/F). This entity should implement the security and confidentiality constraints and protections that the EGNOS system requires.

- In the *EGNOS User Segment*, upon arrival of a navigation message containing a MAMES Frame, the EGNOS receiver will detect this special data packet and route it to the MAMES Receiver for further handling according to the employed integration scenario. Since no return channel is available within the EGNOS system, successful reception of a MAMES Frame cannot be acknowledged (no MAMES ACK can be sent).

As regards the usable capacity of EGNOS navigation messages, the data field can carry a user payload of 212 bit (see clause B.2.3). This is sufficient for carrying the smallest MAMES Messages, including Ultra-Short MAMES Messages and MAMES Messages containing strongly compressed payloads. Another issue concerns the frequency with which EGNOS messages containing MAMES content can be transmitted. Since only one EGNOS message (of any type) can be transmitted every second, the EGNOS navigation performance may be degraded if the fraction of MAMES-specific EGNOS messages becomes too large. For example, transmitting one EGNOS message containing a MAMES Message every 10 seconds implies that the transmission frequency of the other EGNOS messages is reduced by 10% on average. The EGNOS service provider can however mitigate this effect by prioritizing the most vital EGNOS navigation-related messages in a specific situation. The optimal transmission strategy will thus be a compromise between the urgency of a specific MAMES broadcast and the EGNOS service performance.

8 Examples of Operational Scenarios

8.1 Objectives

The objective of this clause is to provide examples of realistic end-to-end alert scenarios with a view to illustrate the role and capabilities of MAMES. The scenarios were chosen such that a broad spectrum of possible events, situations and circumstances are covered. This includes an industrial accident, a natural disaster, alert distribution to authorities, alert update, alert acknowledgements, and finally the handling of MAMES errors.

8.2 Industrial Accident in a Suburban Area

8.2.1 Description of the Situation

An accident with potentially severe consequences for the affected population occurs in the early afternoon at a chemical plant in a suburban area, with the following characteristics:

- The resulting high-intensity fire causes toxic substances to be carried up into the atmosphere.
- Wind and weather conditions are expected to favour the large-scale spreading of the toxic substances.
- The potentially affected region includes urban areas, suburban areas, as well as rural and nearby mountainous areas.
- There is an international border about 100 km from the site of the incident.

8.2.2 Alert Issuer Considerations and Actions

The appropriate regional civil protection authority, which is authorized to act as an Alert Issuer, becomes aware of the situation and carries out these assessments and actions:

- The authority evaluates the nature and extent of the accident and its potential impact; this includes consultations with the competent emergency personnel close to the site of the accident as well as with local weather centers. Reports from local citizens (via telephone and social media) are also taken into account.
- Once a reliable image of the accident and its likely evolution has emerged, the civil protection authority proceeds to generating Alert Messages based the following considerations:
  - The diversity of the potentially affected areas implies that a wide spectrum of alerting mechanisms is to be employed to maximize the alert penetration among the potentially affected population.
  - Due to the nature of the incident, people in certain areas should be instructed to seek immediate shelter inside buildings, while e.g. car drivers in other areas should be instructed to drive towards safer areas. People in safe areas should not be alerted at all.
  - It is considered critical to also alert unprotected persons in remote areas, e.g. hikers or forest workers in the mountains, who may only be reachable via their (SatNav-enabled) mobile phones, satellite phones, or paging networks.
  - Since an international border is nearby, a contact is established with the corresponding civil protection authority of the neighbouring country. It is agreed that the neighbouring country will only use its own means to inform its population; Alert Messages should thus not be distributed across the border.
- Based on these considerations, the civil protection authority may decide that Alert Messages are to be distributed by means of the following techniques:
  - For users with CAP-enabled devices: CAP-compliant Alert Messages, which typically contain considerable syntax overheads and various types of (media) data and links to additional resources, are only suitable for distribution networks offering sufficient transmission capacity. The targeted users should thus be subscribers of (broadcast or bidirectional) fixed satellite services, and their Alerting Devices (e.g. TV receivers, personal computers) have to be CAP-capable.
  - Users with access to fixed satellite services who do not own CAP capable Alerting Devices will receive the alert content, including images, video, audio or large data files in any of the formats supported by MAMES.
  - To target Alert Users in public areas, e.g. on highways or in urban or suburban areas (shopping malls, pedestrian zones, information points), simple text, image, audio or short video messages may be issued by the Alert Issuer for rendering on public displays, loudspeakers or video walls. To distribute these messages, lower-capacity (bidirectional) fixed satellite systems such as VSAT systems may be used.

- In order to reach remote users without access to terrestrial, land mobile or fixed satellite telecommunications services, mobile SatCom (MSS) or SatNav based networks may be employed. For this purpose, the Alert Issuer composes concise Alert Messages, e.g. based on the Alert4All protocol [i.17] or, alternatively, containing pure text only.
- Finally, in order to reach subscribers of paging systems, the Alert Issuer composes short Alert Messages, e.g. containing text only.

After having composed these specifically targeted Alert Messages for MAMES-based distribution, the Alert Issuer forwards these messages, together with the appropriate instructions and authorizations, to the relevant MAMES Providers with access to the respective satellite-based networks that cover the intended notification area.

8.2.3 MAMES Provider Actions

Upon reception of these specifically targeted Alert Messages, each MAMES Provider proceeds by formulating MAMES ALERT Messages as follows:

- MAMES Providers with access to a (broadcast or bidirectional) **fixed satellite system**: Knowing that a large number of fixed satellite receivers with interconnected CAP and non-CAP capable Alerting Devices exist within the notification area, these MAMES Providers may decide to bundle some of the received Alert Messages and encapsulate them in a single MAMES ALERT Frame. For example, a MAMES ALERT Frame may contain different (language and/or media and/or size) variants of a notification referring to a given incident. In this way, the distribution of the various Alert Messages to the appropriate Alerting Devices at the user side of the Alert Network is delegated to the MAMES Receivers.
- MAMES Providers with access to a (broadcast or bidirectional*)* **mobile satellite system**: Realizing the limited capacity of their associated networks, these MAMES Providers will encapsulate only simple text, image (maps), audio or short video messages in a MAMES ALERT Frame.
- MAMES Providers with access to a **SatNav system** are only capable of distributing short packets of user data. Thus, only the most essential MAMES Headers (the mandatory plus key extension headers) can be broadcast. The shortest possible MAMES Frame is the MAMES Ultra-Short Message, which essentially contains only the mandatory header fields. Alternatively, using optimized Alert Protocols such as Alert4All [i.17], significantly reduced MAMES Payloads may be achieved without loss of information.
- In order to distribute the Alert Messages directed at subscribers of **paging systems**, the MAMES Provider encapsulates these messages and transmits them to the central paging stations of the respective paging providers by means of an appropriate SatCom system.
- When formulating a MAMES Message, the MAMES Provider has to decide (i) how to set the mandatory header fields, and (ii) which (optional) Extension Headers to include. These decisions will largely be based on instructions received from the Alert Issuer.
- Examples of **Mandatory Header fields** include the *Notification Area* (defined as a circular region), the *Alert Issuer ID* (identifying the Alert Issuer), and the *ACK Request Indicator* (requesting an acknowledgement from the MAMES Receiver, applicable only if a return channel is available).
- Examples of (optional) **Extension Headers** include the *Validity Header* (specifying the validity time window of the MAMES Message), the *Administrative Areas Header* (constraining the *Notification Area* to certain administrative areas), and the *Authentication/Integrity Header* (providing MAMES Provider authentication and/or MAMES Message integrity).
- For the present example of an industrial accident close to an international border, the capability to restrict the MAMES Message distribution to *certain administrative areas* (inside the country where the Alert Issuer resides) is of particular importance.
- To maximize the alert penetration, all MAMES Providers may retransmit their respective MAMES Messages periodically. MAMES also offers the capability to update or cancel a previously transmitted MAMES Message.

After having completed their MAMES Messages, the MAMES Providers forward them to their respective satellite uplink stations, where they are integrated into the uplink frames and transmitted.

NOTE: Terrestrial-based networks may also be used to distribute MAMES Messages. In this case, the MAMES Provider needs to have access to an appropriate terrestrial service center, which assumes the role of a satellite uplink station.

8.2.4 SatCom/SatNav/Com Systems Involved

Due to the diversity of the potentially affected region, the Alert Issuer has determined that the following network types should be employed for MAMES-based alert distribution:

- Broadcast fixed satellite systems, to reach the users of digital broadcast services using (e.g.) TV and radio receivers.
- Bidirectional fixed satellite systems, to reach customers of (e.g.) VSAT services in homes, office buildings and public (indoor and outdoor) places.
- Broadcast mobile satellite systems, to reach consumers of (e.g.) DVB-SH based programming and streaming services on mobile devices.
- Bidirectional mobile satellite systems, to reach subscribers of mobile satellite communications systems such as Inmarsat™, Thuraya™, Iridium™, and Globalstar™ in remote areas.
- SatNav systems such as EGNOS and Galileo, to reach the users of SatNav-enabled handheld devices in remote areas.
- Finally, terrestrial-based broadcast or communications networks (e.g. terrestrial TV, Internet, land mobile networks) may be used as well for MAMES Message distribution.

8.2.5 Processing at MAMES Receivers

The various satellite transmissions summarized in the previous clause are seen by all active receivers of the respective SatCom/SatNav/Com system within each system's coverage area. The following key steps take place at MAMES Receivers connected to these satellite terminals:

- Upon detection of an incoming MAMES Frame, the MAMES Receiver determines if its own (current) location matches the area indicators contained in the MAMES Header(s). The MAMES Frame is only processed further if the MAMES Receiver's location falls both inside the (mandatory) *Notification Area* and the (optional) *Administrative Area(s)*. If this is not the case, the MAMES Frame is discarded.
- After some further checks to establish e.g. the validity, correctness and integrity of the MAMES Frame, the MAMES Receiver performs decapsulation to obtain the actual Alert Message(s). The type of each Alert Message is hereby denoted within each Alert Message Header's *Alert Message Type* field. This allows the MAMES Receiver to forward each Alert Message to the appropriate Alerting Device that is able to interpret and render the alert content.
- Subject to the specific MAMES Alerting Scenario realized at the user side of the Alert Network (see clause 5), the Alert Messages are finally forwarded and distributed to their respective Alerting Devices. As discussed in clauses 5.2 and 5.3, this can either occur via direct attachment or through integration, or via Alert Intermediary Systems such as wired or wireless networks including, e.g. paging networks.

8.2.6 Alert Rendering by Alerting Devices

Upon reception of an Alert Message, Alerting Devices will render the alert content according to their capabilities. In the present example, this involves the following actions:

- CAP-capable Alerting Devices parse the received CAP messages, extract the contained parameters, text, media and links, and present these data to the user via the attached device.

- Alert Messages received by non-CAP capable Alerting Devices are directly interpreted by an alert-specific function and rendered. For example, if the Alerting Device is integrated with a TV receiver, the alert-specific (software) module inside the TV receiver will recognize the Alert Message and present its content accordingly. Similarly, if the Alerting Device is integrated into or attached to a handheld navigation device, the alert-specific function will recognize the Alert Message and alert its user accordingly. In the case of a paging network, the Alerting Devices are represented by the pagers.

8.3 Tsunami Warning

8.3.1 Description of the Situation

A severe earthquake occurs in the Mediterranean Sea. The tremors are detected by a network of autonomous sensor stations located throughout the region, including on the sea floor. These data are instantaneously transmitted to a central earthquake monitoring station, where they are processed with a view to predict the likely effects. It is determined that a tsunami wave will be generated with potentially catastrophic consequences for certain coastal areas. The nearest coastline is expected to be hit within 10-15 minutes.

NOTE: Although devastating tsunamis are rare in the Mediterranean Sea, smaller, localized events are generated more frequently by moderate marine earthquakes. The present scenario was chosen to highlight the capability of MAMES to reach a large number of potentially affected persons in a timely manner. Similar timeliness requirements exist also for other rapidly developing emergencies such as certain geological phenomena or violent industrial incidents.

8.3.2 Alert Issuer Considerations and Actions

The appropriate civil protection authority, which is authorized to act as a supranational Alert Issuer for such an event, is informed of the situation and carries out the following assessments and actions:

- The authority evaluates the computed predictions and assesses the potential impact; this may include consultations with other authorities. Efforts are made to obtain reports about early signs of an emerging tsunami to exclude a false alarm.

- Once a reliable image of the emerging natural disaster and its likely evolution has emerged, the authority proceeds to generating Alert Messages based on the following considerations:

  - Due to the high speed of a tsunami wave in the open sea (500-1 000 km/h), the first waves will reach a certain coastline within about ten minutes. Alerts should thus be transmitted as soon as feasible, targeting that costal area with the highest priority. Frequent alert updates will furthermore be necessary for all potentially affected areas to track the evolution of the tsunami for a period of up to a few hours.

  - Since the expected effects will be limited to (low-lying) coastal areas and boats/ships at or near the shoreline, it is important to select the appropriate communications channels available to the affected population, including sailors.

  - If feasible within the available timeframe, people should be informed about the expected point in time when the tsunami wave will reach their specific location, so that they can react accordingly.

  - If feasible within the available timeframe, people should also be informed about the expected severity of the impact (e.g. height of the tsunami wave) in their specific area, so that they can protect themselves accordingly.

- Based on these considerations, the civil protection authority may decide that Alert Messages are to be distributed by means of the following techniques:

  - SatNav systems: SatNav receivers (EGNOS or GALILEO-based), implemented either as stand-alone devices or integrated in smartphones or on-board instruments, are expected to be widespread within the affected population. However, only very short Alert Messages - in particular Ultra-Short MAMES ALERT Messages - can be supported.

  - Paging systems: This distribution channel will be chosen if a significant number of such receivers are expected to be in use in the targeted areas; again, only very short Alert Messages can be supported.

- MSS networks: The corresponding user terminals (handheld, portable, or installed on-board boats) are common in some of the affected communities (e.g. commercial and recreational sailors). Due to MSS network capacity and time constraints, these Alert Messages should be small or of medium size.
- Broadcast and bidirectional fixed satellite systems: These types of distribution channels may be used to target Alert Users in public areas, e.g. on highways or in urban or suburban areas (shopping malls, pedestrian zones, information points). Simple text, image, audio or short video messages may be issued by the Alert Issuer for rendering on public displays, loudspeakers or video walls.

After having composed these specifically targeted Alert Messages for MAMES-based distribution, the Alert Issuer forwards these messages, together with the appropriate instructions and authorizations, to the relevant MAMES Providers with access to the respective satellite-based networks that cover the notification area.

In addition, the Alert Issuer may explicitly instruct MAMES Providers to also transmit, with highest priority and without delay, Ultra-Short MAMES ALERT Messages via any of the above distribution channels. Due to their small size, these messages do not consume much network capacity, and they can be generated and transmitted quickly. These capabilities are considered especially beneficial for the present type of rapidly developing natural disaster.

8.3.3 MAMES Provider Actions

Upon reception of these specifically targeted Alert Messages, each MAMES Provider proceeds by formulating MAMES ALERT Messages as follows:

- MAMES Providers with access to low-capacity networks (**SatNav, paging or MSS systems**): Realizing the limited capacity of their associated networks, these MAMES Providers can transmit only very limited information via a MAMES ALERT Message, e.g. attach only certain Extension Headers to the Mandatory Header. Alternatively or additionally, Ultra-Short MAMES ALERT Messages may be employed.
- MAMES Providers with access to a (broadcast or bidirectional) **fixed satellite system**: Knowing that a large number of fixed satellite receivers with interconnected CAP and non-CAP capable Alerting Devices exist within the notification area, these MAMES Providers may decide to bundle certain received Alert Messages and encapsulate them in a single MAMES ALERT Frame. In this way, the distribution of the contained Alert Messages to the appropriate Alerting Devices at the user locations is delegated to the MAMES Receivers.
- When setting the mandatory *Notification Area Field* in the MAMES Mandatory Header (a circular region), the MAMES Provider is able to limit the distribution of certain MAMES Messages to specific areas. This feature may e.g. be used to alert the most acutely threatened populations (those closest to the earthquake's epicentre) first, advising immediate evacuation of beach and harbour areas.
- Extension Headers (which are optional) may be used by the MAMES Provider to specify a validity window for the MAMES Message (*Validity Header*), to specify the targeted administrative areas (*Administrative Areas Header*), or to enable the user to authenticate the MAMES Message (*Authentication/Integrity Header*).
- To maximize the alert penetration, MAMES Providers may re-transmit their MAMES Messages periodically. MAMES also offers the capability to update or cancel a previously transmitted MAMES Message.

If instructed by the Alert Issuer, MAMES Providers may build and transmit Ultra-Short MAMES ALERT Messages in addition or instead of the standard MAMES Messages (typically) containing a payload.

After having completed their MAMES Messages, the MAMES Providers forward them to their associated satellite uplink stations, where they are integrated into the appropriate uplink frames and transmitted.

8.3.4 SatCom/SatNav/Com Systems Involved

As indicated in the previous clauses, the following data distribution systems are involved:

- SatNav, paging and MSS systems, which are expected to reach a high penetration within the potentially affected populations.
- Broadcast fixed satellite systems, to reach users of digital broadcast services using (e.g.) TV and radio receivers.

- Bidirectional fixed satellite systems, to reach customers of (e.g.) VSAT services in homes, office buildings and public (indoor and outdoor) places.

- Finally, terrestrial-based broadcast or communications networks (e.g. terrestrial TV, Internet, land mobile networks) may be used as well for MAMES Message distribution to increase the alert penetration.

8.3.5 Processing at MAMES Receivers

The processing of received MAMES Messages by MAMES Receivers is carried out as described in clause 8.2.5 above (industrial accident).

8.3.6 Alert Rendering by Alerting Devices

The rendering of alert content by Alerting Devices is carried out as described in clause 8.2.6 above (industrial accident).

8.4 Alert Distribution to Authorities and Emergency Personnel

8.4.1 Description of the Situation

Although primarily designed to alert the general public, MAMES includes features that enable a MAMES Provider to specifically address (emergency) authorities and emergency personnel.

In the present scenario, it is assumed that an Alert Issuer intends to inform a number of local authorities of a potentially threatening situation that is developing in their area (e.g. a volcanic eruption or a landslide). In order to prevent this information from becoming public prematurely, the communication should remain confidential.

8.4.2 Alert Issuer Considerations and Actions

Since the scientific (e.g. geophysical) data on the potential threat are not yet conclusive, the Alert Issuer decides to inform only local authorities within the potentially affected area using a secure and confidential communications channel.

The Alert Issuer formulates an Alert Message and forwards it to a MAMES Provider with access to a (satellite-based) communications network that covers the potentially affected area. For redundancy, the Alert Issuer may employ more than one MAMES Provider.

8.4.3 MAMES Provider Actions

Upon reception of the Alert Message, the MAMES Provider(s) receiving the Alert Message proceed(s) to formulating MAMES ALERT Messages as follows:

- Within the Mandatory Header, the *Notification Area* parameter is set such that the potentially affected area is fully covered. The *MAMES Transport Priority* parameter is set to the highest value.

- Within the (optional) Alert and Response Type Header, the *MAMES Status* parameter is set to "Actual", and the *MAMES Alert Scope* parameter is set to "Restricted". The setting of the latter parameter ensures that the MAMES Message is only received and processed by matching MAMES Receivers (i.e. those owned by authorities).

- The received Alert Message is appended to the MAMES Headers together with its associated Alert Message Header (indicating the Alert Message's media type, language ID and length).

- To provide authentication, the so-obtained dataset is signed by means of a specified MAMES procedure, and the corresponding Authentication/Integrity Header is added. (For CAP-encoded Alert Messages that already contain signed data, this procedure may be omitted.)

- Finally, the MAMES Payload is encrypted by means of the specified MAMES procedure, and the corresponding Encryption Header is appended. (For CAP-encoded Alert Messages that already contain encrypted data, this procedure may be omitted.)

After having completed their MAMES Messages as described, the MAMES Providers forward them to their associated satellite uplink stations, where they are integrated into the uplink frames and transmitted.

8.4.4 SatCom/SatNav/Com Systems Involved

Any communications network that the addressed local authorities have access to may be used to distribute these MAMES ALERT Messages.

8.4.5 Processing at MAMES Receivers

Upon detection of an incoming MAMES Message, a MAMES Receiver will perform the following key procedures:

- The MAMES Receiver determines if its own location matches the area indicator(s) contained in the MAMES Header(s). The MAMES Frame is only processed further if the MAMES Receiver's own location falls both inside the (mandatory) *Notification Area* and the (optional) *Administrative Area(s).* If this is not the case, the MAMES Frame is discarded.

- Further examination of the Mandatory Header shows that the *MAMES Transport Priority* parameter has been set to the highest value. The MAMES Receiver thus treats the present MAMES Message with highest priority.

- When examining the Extension Headers, the MAMES Receiver detects that the *MAMES Alert Scope* parameter has been set to "Restricted". The MAMES Frame is thus only processed further if the MAMES Receiver belongs to the class of "Restricted MAMES Receivers" (for use by authorized persons/entities only). If there is no match, the MAMES Frame is discarded.

- Finally, the MAMES Payload is decrypted using the information contained in the Encryption Header together with the locally stored secret key(s). Subsequently, the entire MAMES Frame (without the Authentication/Integrity Header and the Encryption Header) is authenticated using the information contained in the Authentication/Integrity Header together with the applicable locally stored secret code associated with the MAMES Provider (the MAMES Provider ID is present in the Mandatory Header). If the authentication fails, the device's user is informed accordingly.

The MAMES Receiver finally forwards the decapsulated Alert Message to the Alerting Device(s).

8.4.6 Alert Rendering by Alerting Devices

Upon reception of an Alert Message, the Alerting Device will render its content to the Alert User, in this case the remote authority. If that message had been signed and/or encrypted at Alert Protocol level (e.g. CAP), the Alerting Device will carry out the corresponding reverse procedure.

8.5 Updating Alert Information

8.5.1 Description of the Situation

About one hour after the public has been alerted and informed about an industrial accident, the situation in the plant improves unexpectedly: The fire could be put under control earlier than anticipated, so that the damaging effects are now expected to be less severe.

8.5.2 Alert Issuer Considerations and Actions

The Alert Issuer is informed of these developments and re-evaluates the situation. It is determined that the public should be updated accordingly. The Alert Issuer thus formulates a corresponding update message and sends it to the MAMES Provider (e.g. via email), requesting that this information be communicated as an explicit update to the previously distributed alert information, rather than as a new Alert Message.

NOTE 1: The same considerations apply in the case when the Alert Issuer determines that the alert should be cancelled. The text informing the public of the cancellation will be distributed in the same way as the text informing the public about any other new developments concerning the incident. Also a false alert will be cancelled by the Alert Issuer in this way.

NOTE 2: If the Alert Issuer runs an advanced Alert Protocol (e.g. CAP) that provides a dedicated end-to-end update message (e.g. the CAP msgType "Update" or "Cancel"), that protocol message would be employed instead of (e.g.) email.

8.5.3 MAMES Provider Actions

Upon reception of the update information as described above, the MAMES Provider composes a MAMES UPDATE Message that contains the following key data:

- The Mandatory Header Field *MAMES Message Type* is set to the code for the MAMES UPDATE Message, and the Mandatory Header Field *MAMES Reference* is set to the value of the original MAMES ALERT Message's *MAMES Message ID*.
- The Mandatory Header Fields *MAMES Protocol Version*, *MAMES Alert Provider ID*, *Notification Area*, and *Alert Issuer ID* will remain unchanged from the original MAMES ALERT Message. (If any of these parameters change, a new MAMES ALERT would be required.)
- Any other Mandatory Header Fields as well as fields in the Extension Headers may either remain unchanged or be updated as desired. According to the MAMES specification, any modified Mandatory Header Field replaces the corresponding original field, and any modified Extension Header replaces the corresponding original Extension Header. The MAMES specification also allows new Extension Headers to be added in an UPDATE Message.
- Finally, the updated Alert Message, as received from the Alert Issuer, is appended to the above described MAMES Headers together with its associated Alert Message Header. From the three essential fields in the Alert Message Header (*AM Type*, *Language ID* and *Alert Message Length*), only the *Alert Message Length* may differ from the original MAMES ALERT Message, since only then is it possible to identify and replace the original Alert Message in the original payload. (If more than one Alert Message with the same *AM Type* and *Language ID* had been present in the original payload, all of them would have to be included in the update to avoid any ambiguity.)

This completes the formulation of the MAMES UPDATE Message, which is subsequently distributed using the MAMES Provider's associated communications system.

NOTE 1: As mentioned above, the Mandatory Header parameter *Notification Area* (and, if present, the *Administrative Areas* Header) are not allowed to differ from the original ALERT Message. If they were different, the UPDATE Message would not reach the same set of MAMES Receivers as the original ALERT Message. In that case, some MAMES Receivers would thus not receive the UPDATE Message at all, while others would receive the UPDATE Message without having received the corresponding original ALERT Message.

NOTE 2: In the scenario described above, the Alert Issuer does not employ an advanced Alert Protocol that would allow it to generate its own, dedicated end-to-end "Alert Update Message". If the Alert Issuer runs such an advanced Alert Protocol (e.g. CAP), a dedicated CAP message with msgType "Update" would be used to communicate the updated information. Upon reception of that CAP message, the MAMES Provider would encapsulate it into a MAMES ALERT Message and distribute it as usual. In fact, according to the MAMES specification, all received protocol messages belonging to an advanced protocol are distributed by MAMES as an ALERT payload. In this way, it is ensured that the MAMES Protocol Layer remains decoupled from the Alert Protocol Layer. As a result, the Alert Protocol (whose MAMES *AM Type* is known to MAMES) may be upgraded at any time, even by adding new Alert Protocol messages, without any impact on MAMES.

8.5.4 SatCom/SatNav/Com Systems Involved

This scenario is independent of the SatCom/SatNav/Com system used for distributing MAMES Messages.

8.5.5 Processing at MAMES Receivers

Upon reception of a MAMES UPDATE Message, the MAMES Receiver recognizes (from the *MAMES Message Type* parameter) that previously received alert information is to be updated or corrected. The previously received MAMES Message to be updated is identified by the *MAMES Reference* parameter.

The MAMES Receiver then performs actions as instructed by the contents of the various header fields present, independent of the contents of the original ALERT Message.

In the present scenario, the UPDATE Message contains only updated text inside the MAMES payload (plus the corresponding Alert Message Header). The MAMES Receiver thus extracts that text and transmits if to the corresponding Alerting Devices that have also received the original alert information. Depending on the capabilities of the interface to the Alerting Device, the new text may be explicitly denoted as updated information so that the Alerting Devices are enabled to render/display the updating aspect when replacing the old text with the new one.

8.5.6 Alert Rendering by Alerting Devices

The updated text received from the MAMES Receiver replaces the previously received text on the Alerting Device's display.

Any other Alerting Devices which had been triggered by the original ALERT Message but did not receive the update will continue to operate as originally instructed; they are not affected by the update. This includes Alerting Devices that may have received text in a language that has not been updated.

8.6 Acknowledging Reception of Alert Messages

8.6.1 Description of the Situation

In certain situations, the Alert Issuer may wish to receive a feedback from the targeted population that would indicate whether or not the alert information has been delivered successfully. Depending on the capabilities of the Alert Protocol used, two cases are distinguished:

Case A **Acknowledgement-capable Alert Protocol** - The Alert Protocol used by the Alert Issuer supports an end-to-end signalling feature by which the Alerting Devices are solicited to return a dedicated acknowledgement message upon successful reception of an Alert Message; depending on the capability or configuration of the Alerting Devices, unsolicited acknowledgements may also be supported.

NOTE: CAP contains facilities that allow acknowledgement requests to be incorporated into a CAP message. This feature is however not part of the baseline CAP specification (see [i.18] and [i.19]).

Case B **Non-Acknowledgement-capable Alert Protocol** - The Alert Protocol does not support acknowledgement requests and/or the Alerting Devices are not capable of returning acknowledgements. No end-to-end alert -acknowledgement cycle is thus possible. In this case, the MAMES-based ALERT - ACK cycle may take over if activated.

These two cases are described separately in the following.

8.6.2 Case A - Acknowledgement-capable Alert Protocol

The steps performed in Case A are the following:

1) The **Alert Issuer** employs the acknowledgement request feature provided by the Alert Protocol. This is done by setting the appropriate parameter within the Alert Message whose reception is to be acknowledged.

2) Upon reception of this Alert Message, the **MAMES Provider** proceeds as he would with any other such message: It encapsulates the message within a MAMES ALERT Frame and sets the MAMES Header parameters accordingly. In particular, in order for MAMES to be allowed to carry the requested acknowledgement message on the return channel (if available), the MAMES Provider will set the *MAMES ACK Request Indicator* to "1". Note that a value of "0" for this parameter would indicate to the MAMES Receiver that it is not allowed to return any MAMES ACK Messages. It is ultimately the responsibility of the MAMES Provider to decide with value to set, based on Alert Issuer requests as well as on its assessment of the expected traffic load on the return link resulting from the MAMES ACK Messages.

3) Upon reception of the MAMES ALERT Message, the **MAMES Receiver** proceeds independent of the contents of the message's payload and forwards the encapsulated Alert Message to the Alerting Device(s) that understand the specific Alert Protocol.

4) Upon reception of the Alert Message containing the acknowledgement request, **Alerting Devices** interpret its content and renders it accordingly. If this action could be completed successfully, a (positive) acknowledgement is returned to the MAMES Receiver; in the unsuccessful case, either no acknowledgement or - subject to signalling, configuration and/or capabilities - a negative acknowledgement is generated by the Alerting Device.

5) In the present case (assuming that the *MAMES ACK Request Indicator* has been set to "1"), upon reception of this Alert-Protocol based acknowledgement message, the **MAMES Receiver** encapsulates it inside a MAMES ACK Message and sends it back to the originating MAMES Provider. On the other hand, if the *MAMES ACK Request Indicator* has been set to "0", no MAMES ACK Message will be returned.

6) Finally, upon reception of the MAMES ACK Message (assuming that such a message arrives), the **MAMES Provider** extracts the encapsulated acknowledgement message and sends it back to the Alert Issuer.

This completes the acknowledgement request and response cycle in the case of an acknowledgement-capable Alert Protocol.

8.6.3 Case B - Non-Acknowledgement-capable Alert Protocol

The steps performed in Case B are the following:

1) The **Alert Issuer** formulates a basic Alert Message (e.g. containing text only) and sends it to the MAMES Provider (e.g. via email). Since the Alert Protocol does not support any end-to-end signalling, the Alert Issuer instructs the MAMES Provider to employ the MAMES-internal ACK scheme instead.

2) Upon reception of the Alert Message, the **MAMES Provider** encapsulates it within a MAMES ALERT. In order to request acknowledgements from the MAMES Receivers, the MAMES Provider sets the *ACK Request Indicator* to "1" (provided that the corresponding resources exist on the return link). Note that in this case the acknowledgement request and response procedure is restricted to the level of the MAMES Protocol.

3) Upon reception of the MAMES ALERT, the **MAMES Receiver** notes from the *ACK Request Indicator* field that an acknowledgement is required. If the procedures to decapsulate and forward the contained Alert Message to the Alerting Device(s) could be completed successfully, it returns a MAMES ACK Message (without a payload) to the originating MAMES Provider.

4) Upon reception of the MAMES ACK Message, the **MAMES Provider** knows that the Alert Message has been successfully decapsulated and delivered to the Alerting Device. The MAMES Provider may then inform the originating Alert Issuer by any agreed (out-of-band) communications means.

This completes the acknowledgement request and response cycle in the case of a non-acknowledgement-capable Alert Protocol.

8.7 Handling of MAMES Errors

8.7.1 Description of the Situation

After having sent out a MAMES Message, the **MAMES Provider** realizes that the message has been transmitted erroneously or that it contains faulty data. The MAMES Message should thus be declared as obsolete by instructing the **MAMES Receivers** accordingly.

Note that this situation differs from the situation described in clause 8.5 above, where the **Alert Issuer** determined that the **Alert Users** needed to be updated on new developments concerning the incident - including developments that would require the alert to be cancelled; such information would be transmitted by means of a MAMES UPDATE Message (assuming the Alert Protocol does not contain its own update messages, see clause 8.5).

8.7.2 Procedures

To cancel the faulty MAMES Message, the **MAMES Provider** composes a MAMES CANCEL Message whose *MAMES Reference* field is set to the *MAMES Message ID* of the faulty message. As in the case of the MAMES UPDATE, it is important to emphasize that, compared with the original MAMES Message, precisely the same set of MAMES Receivers is to be targeted by the MAMES CANCEL. This implies that certain MAMES Header fields, such as in particular the *Notification Area* and (if present) the fields in the *Administrative Areas Header* are not allowed to differ from the original MAMES Message.

Upon reception of the MAMES CANCEL Message, the **MAMES Receivers** recognize that the referenced previous MAMES Message is to be cancelled, i.e. declared as obsolete. To implement this instruction, the MAMES Receivers will thus stop any (possibly still on-going) relaying of alert information to **Alerting Devices**. Subject to the capabilities of the interfaces to the Alerting Devices, the MAMES Receivers will also instruct their attached or interconnected Alerting Devices to stop rendering the (now obsolete) alert information.

Annex A: Overview of Public Alerting Systems and Technologies

A.1 Overview of Alerting Techniques

A.1.1 General

The purpose of public alerting mechanisms and systems is to inform the general population of an imminent or ongoing danger or (potential) emergency situation. Typically, public warnings are issued in case of significant natural or man-made incidents that could lead to loss of life or property.

Depending on the technology employed for the alerting system, reception of the warning message may require a specific (electronic) device or no device at all. The content of the warning message itself may be very specific (e.g. a TV broadcast) or rather unspecific (e.g. a siren alarm). In view of the present objective, it is thus important to classify the existing alerting techniques in such a way that a determination can be made as to which types of alerting technique should be considered and which are out of scope.

The following clauses in this annex provide such a classification. Later clauses will be devoted to a detailed presentation of selected relevant alerting systems and technologies.

As regards available standards for public alerting applicable in Europe, the following list mentions some key ETSI and 3GPP specifications:

- ETSI TS 102 182 [i.20] - specifies operational and organizational requirements as a basis for a common notification service with a focus on pan-European standardization.
- ETSI TS 102 900 [i.21] - specifies the system requirements for a European Public Warning Service using the CBS Service as a means of message distribution and delivery to user devices.
- ETSI TR 102 850 [i.22] - presents an overview of existing requirements and recommendations for mobile devices able to receive messages used in a Public Warning Service (PWS).
- ETSI TS 122 268 [i.23] - defines the stage one description of PWS requirements, covering the core requirements for the PWS that are sufficient to provide a complete service as seen primarily from the users' and service providers' points of view.

A.1.2 Basic Traditional Alerting Techniques

A.1.2.1 Overview

Sirens: Emergency warning sirens are still the most common alerting devices in use today in a wide variety of countries. Sirens are typically capable of producing several alert tones, thus signalling the type or status of an emergency situation. Sirens can be used to alert both the general population in the affected area(s), and/or emergency response teams. Activation is performed by authorized personnel either on-site or remotely over a telecommunications network such as the PSTN, a direct wired connection, or radio broadcast.

Loudspeakers: In contrast to sirens, loudspeakers are capable of transmitting voice messages, so that they are ideally suited for making announcements in public places. They can be placed both indoors and outdoors, thus reaching a narrowly defined group of people in an affected location, e.g. inside a building or in urban areas. Very specific and targeted alert information can be conveyed in this way. Voice messages can be generated in real time, either by an authorized on-site speaker or from a remote location.

Public displays: Detailed alert information can also be conveyed via (large) electronic displays located in public places such as airports, railway stations, stadia, town squares or on highways. Such displays are capable of informing and instructing the population in an efficient and detailed manner. The alert information, which can take the form of text, graphics, pictures or video (incl. sound), is typically transmitted to the display by vendor-specific means.

Audible-Visual signals: An example of this type of combined signal are maroons, a type of rocket that alerts the local population (and/or response crews) by producing an audible and visual warning signal several hundred meters above ground. This technique is typically deployed in some coastal areas and is used in combination with other basic communications devices such as pagers. Activation is typically performed locally by authorized personnel.

A.1.2.2 Assessment & MAMES Applicability

While ubiquitous and well-proven throughout the world, these basic traditional alerting techniques have a number of limitations and shortcomings. Being rather localized in nature, they are expensive to deploy and maintain, do not scale well, and lack consistent and secure authorization, oversight, activation and control channels. Moreover, there is also very little standardization, both in terms of alert message format and content as well as (local and remote) telecommunications and activation interfaces and procedures.

As to the applicability of these basic traditional alerting techniques for the present objectives, it is noted that all systems (though certainly not all implementations) that generate audio or visual alert signals for the public can in principle be activated via a telecommunications network. However, directly addressing these various proprietary alerting devices over a network is certainly not feasible and out of scope here. System and implementation-specific functions would have to be defined which interface, one the one hand, the specific alerting device, and on the other hand the telecommunications network which transports the standardized MAMES alert message and - if applicable - the associated media, like speech or video. These functions would include:

i) decapsulation; and

ii) parsing of the alert message received;

iii) interpretation of its content; and

iv) if applicable based on the message's content or device location, activation of its attached alerting device according to that device's capabilities.

Most of the basic traditional alerting systems are activated through alerting mechanisms that can be encapsulated and transported within MAMES messages. For this purpose, alerting-system specific interfaces need to be defined between each proprietary alerting protocol/mechanism and MAMES on both the alerter and user side of the network. Owing to this interface, alerting devices (siren, loudspeaker, display, etc.) can be activated remotely through MAMES-based (satellite) communication links.

Table A.1 summarizes the above analysis of basic traditional alerting techniques.

Table A.1: Basic traditional alerting techniques

Alerting technique	Key characteristics	MAMES Applicability
Sirens	Specific alarm sounds alert the population in the local area.	MAMES-specific software or hardware-based functions are needed on both the alerter and user side of the network for the encapsulation/decapsulation, interpretation, and forwarding of alert information to the alerting devices.
Loudspeakers	Sounds or voice messages are played to alert, inform and instruct listeners in indoor or outdoor areas.	
Public displays	Large electronic displays located in highly frequented places are employed to display alarm information in multimedia form.	
Audible-visual signals	Combined audible-visual signals in mid-air are used to alert the population in the local area.	

A.1.3 Alerting Techniques Based on Broadcast Transmission

A.1.3.1 Overview

Paging

Paging denotes a technique whereby information is broadcast to user/subscriber devices (called pagers) by means of radio communications. The capabilities of pagers range from basic (beepers, tone-only) to advanced, allowing users to display text or play incoming voice messages. In terms of communications capabilities, pagers can be of type one-way (receive-only), response (allowing for simple responses), or fully two-way (supporting transmission of their own messages).

Paging systems can either be operated in small areas (on-site, e.g. in hospitals or restaurants), or in large regions, including over satellite. Wide-area paging systems exist today which support dedicated alert communication to both response crews and the general public. Although the use of pagers has been steadily declining with the rise of mobile communications, paging systems offer unique advantages over cellular networks, such as higher sensitivity and reliability (no overload).

Common paging technologies in use today are based on the POCSAG (Post Office Code Standardization Advisory Group) [i.24] and the FLEX (Flexible wide area paging protocol) [i.25] standards. Both are synchronous paging protocols supporting one-way communication (from the provider to the paging devices) at bitrates between 512 bps (baseline POCSAG) and 6 400 bps (FLEX). A variant of FLEX, called ReFLEX, supports two-way communications, allowing the user to reply to a received paging message.

Radio broadcast

The use of conventional radio broadcast for alerting the public to an emergency is a common practice world-wide. In this application, emergency authorities transmit the alert message to the radio station, e.g. using fax or e-mail, where the message is then read or a recording is played on-air. Additionally, existing Radio Data Systems (RDS), which are currently used to broadcast road traffic information in text form to in-car radio receivers, may also be used for alarm communication to inform drivers of emergency situations. RDS may also be used to signal to the radio receiver that an emergency broadcast is imminent, and to tune the receiver to the corresponding radio channel.

Furthermore, either in combination with RDS signalling or as a stand-alone facility, a public radio broadcast channel may be used by (road safety or emergency) authorities to override any radio program or CD playback for critical announcements (voice break-in, or VBI).

TV broadcast

Similarly to radio broadcast, television broadcast may be used to inform the public of an ongoing or impending emergency by pre-empting regular programming. In fact, other, less specific alerting techniques (e.g. a siren sound) will often cause the population to turn on TV or radio receivers where they expect detailed information and instructions. Additionally, it should be noted that technologies such as digital TV and especially Smart TV open up new opportunities to inform the general public of any emergencies. Smart TV sets, which are connected to the Internet, are capable of integrating TV-based content with Internet/Web-based content, thus enabling a range of novel applications.

As regards opportunities for alert communication, the interworking of TV and Web content within a single consumer device allows emergency authorities to reach the affected population with unprecedented granularity and level of detail. For example, an incoming alarm on a Web service may pre-empt an ongoing TV broadcast, or vice versa. Incoming information on one medium may contain pointers to more relevant or location-specific information on the other, etc. Also, the instantaneous availability of alarm information over two independent media is expected to increase its trustworthiness to the public, so that instructions would be followed more consistently.

A.1.3.2 Assessment & MAMES Applicability

The use of broadcast transmission for alert communications is an obvious, efficient and indeed widespread phenomenon. It relies on the wide availability and usage of appropriate consumer devices which can receive the alert message and inform the user accordingly. Indeed, radio/TV receivers and mobile phones are ubiquitous today in most countries. By using public broadcast channels, properly configured user devices are capable of receiving alert broadcasts independent of the devices' current setting or subscription.

As regards the applicability to MAMES, all broadcast technologies that reach a significant fraction of the population are important candidates. For all broadcast technologies that involve direct transmission (e.g. over satellite) to the end user device, that device (or a connected device or function) should be capable of MAMES decapsulation before the alert information can be presented to the user. This includes paging, radio broadcast and TV broadcast. Alternatively, to avoid integrating the MAMES capability directly in the receiver, an intermediate terrestrial entity may be employed which would decapsulate the MAMES message and re-broadcast its content in the standard broadcast format of the respective technology. Upon reception of a MAMES-based alert message, an intermediate entity (e.g. for a paging center) could determine if the alert pertains to the specific area it serves, and thus either distribute or discard the alert information.

In conclusion, all of the above broadcast technologies are important candidates for integration into MAMES. The following table summarizes the above analysis of alerting techniques based on broadcast transmission.

Table A.2: Alerting techniques based on broadcast transmission

Alerting technique	Key characteristics	MAMES Applicability
Paging	Pagers receive alert broadcasts and present the associated information according to their specific alerting capabilities (tone, vibration, text, etc.).	For direct reception of MAMES messages over satellite, pagers, radio receivers and TV sets should contain a MAMES decapsulation function. Alternatively, an intermediate (local) decapsulation and re-broadcast entity may be used to reach broadcast receivers within the local area. Smart TV sets can be enabled to receive MAMES-based alert information both through TV broadcast and/or via the Internet.
Radio broadcast	Alert-related information and instructions are read on-air over usual radio broadcast channels. Additionally, for enhanced or more specific information, existing techniques such as RDS and VBI may be used in a combined or stand-alone fashion.	
TV broadcast	Regular TV channels are used to broadcast emergency-related information and instructions. Additionally, emerging technologies such as Smart TV may be employed to combine standard TV broadcast with Internet-based content, thus significantly enhancing the user experience.	

A.1.4 Alerting Techniques Relying on (Interactive) Personal Communications Devices

A.1.4.1 Overview

Terrestrial networks

Given their intrinsic nature as point-to-point communications networks, PSTNs are not well suited and thus not typically used for alerting the public. An exception are so-called auto-diallers. These are automatic dialling systems that are capable of calling a set of pre-defined telephone numbers and playing a pre-recorded voice message to the called party. Once activated and properly set up by authorized personnel, these systems can thus alert a large number of key persons (e.g. local officials) in an affected area with rather specific information and instructions.

Mobile networks

Similarly, PLMNs - when used for point-to-point communication - are typically not well suited for alerting the public. Still, in some local applications, mobile telephony and SMS are used to warn a set of pre-defined (registered) subscribers of an imminent threat. To facilitate the registration process for smartphone users, mobile Apps have been published for selected applications. For example, Apps are available in common App stores that alert the user to an incoming tsunami wave at the user's current location, whereby both the alert message and the estimated time of arrival of the wave are communicated (e.g. via SMS).

Another PLMN-based solution is the Cell Broadcast Service (CBS). This is a standardized technique [i.26] that allows the transmission of (SMS-like) messages over the PLMN to a large number of subscribers concurrently. It is possible to target subscribers in a selected area on a cell-by-cell basis, independent of their roaming status. CBS messages may be repeated continuously according to a configurable cycle time. Since a dedicated cell broadcast channel is used, this service will continue to function even if the usual voice and data channels are congested.

In order to receive CBS messages, the corresponding feature in the mobile phone should have been activated prior to the transmission. According to the CBS specification, the transmission of messages is initiated either directly by network operator action, or from a dedicated, properly configured Cell Broadcast Center. The Cell Broadcast Center in turn receives the message from a network-external entity, called Cell Broadcast Entity. This entity is under the control of the authority in charge of composing the message and designing its broadcast details. The application of the Cell Broadcast Service for alarm communication is currently being investigated and trialled in a number of countries.

ETSI TS 102 900 [i.21] is available that defines the system requirements for a European Public Warning Service using the CBS Service as a means of message distribution and delivery to (mobile) user devices. The rationale for the TS was to enable 3GPP to develop a corresponding specification for 3GPP-compliant user equipment to support CBS-based alert communications.

Mobile satellite networks

Mobile satellite data services (e.g. Iridium SBD™ and Iridium Burst™) are used in some applications to deliver alerts to mobile devices in remote areas (e.g. activate sirens). Mobile satellite data services are discussed in annex B.

Internet

Owing to its architecture, the Internet is well suited for both point-to-point communications (e-mail) and for presenting rich information to a large number of users in different languages concurrently (websites). Especially the latter feature allows authorities to inform the public about emergency situations in a very specific and detailed form. A prominent example is the Global Disaster Alert and Coordination System (GDACS) [i.27]. This is a joint initiative of the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and the European Commission that serves to consolidate and improve the dissemination of disaster-related information. The GDACS maintains a website that serves as a multi-hazard disaster monitor and alert system for earthquakes, tsunamis, floods, volcanoes, and tropical cyclones.

Once alerted by other means (e.g. sirens or radio broadcast), Internet users can access these websites and obtain detailed instructions. Additionally, as discussed in the previous clause, using Smart TV technology, Internet-based content can be combined and integrated with TV broadcast to further enhance the public's understanding of the emergency.

Social media

Web-based social media have already been adopted by a significant fraction of the population. Public authorities can use their presence in these media to alert other users of the same medium or forum to a specific emergency situation. As a consequence of user-friendly communications features and the dense interlinking of user communities, such information and the relevant pointers will normally spread quickly throughout the medium.

This should ensure that a large number of users in an affected area are alerted to an emergency situation. Social media are typically accessed both from fixed locations (via a personal IT device) and via Web-enabled mobile phones. It should however be noted that the information presented and exchanged in this way is largely informal in character, and no guarantees exist as to their reliability.

A.1.4.2 Assessment and MAMES Applicability

Terrestrial communications networks, although primarily designed for point-to-point voice or data communications, are being used today to inform and instruct the population in emergency situations. Of particular interest is the Cell Broadcast Service (CBS) in PLMNs, which provides for the distribution of alert messages to mobile devices on a cell-by-cell basis. As regards the Internet, dedicated websites are used by emergency authorities to present relevant information and instructions, whereby the public should initially be alerted by other means to visit these sites.

Although these alerting mechanisms are embedded within well-established (terrestrial or satellite-based) communications services targeting common user devices, MAMES could play an important role by providing a standardized format and interface for encapsulating and delivering (arbitrary) alert messages. The MAMES Receiver at the user side would decapsulate the alert message and distribute it within the local area.

Additionally, in the case of CBS, it is conceivable to co-locate MAMES-capable receivers with base stations or their controllers (BTS, Node B, eNode B), so that the MAMES-decapsulated alert message could be broadcast within the relevant cell without having passed through the PLMN. The CBS-based alert messages would then still reach the mobile devices even if the PLMN is not fully functional anymore. Such specially equipped base stations could be installed only in certain sensitive areas.

Table A.3 summarizes the above analysis of alerting techniques relying on (interactive) personal communications devices.

Table A.3: Alerting techniques relying on (interactive) personal communications devices

Alerting technique	Key characteristics	MAMES Applicability
Terrestrial networks	Automatic dialling devices call pre-configured telephone numbers and play (pre-recorded or synthesized) voice messages.	Not applicable.
Mobile networks	The CBS is employed to distribute alert messages within the PLMN on a cell-by-cell basis. Much less widespread is the use of targeted SMS and mobile Apps.	MAMES could provide a standardized format and interface for encapsulating and delivering alert messages. Additionally, by co-locating MAMES-capable (satellite) receivers with base stations, the CBS would remain functional even in case of partial PLMN failure.
Mobile satellite networks	Mobile satellite data services (e.g. Iridium SBD™ or Iridium Burst™) are used to activate alerting devices (e.g. sirens) attached to a mobile satellite phone.	MAMES could provide a standardized format and interface for encapsulating and delivering alert messages.
Internet	Emails and websites are used to distribute resp. display alert information to (fixed or mobile) Internet users.	
Social media (Internet/web based)	Emergency authorities distribute alert information throughout their interlinked community, which in turn serves as a further multiplier.	

A.2 Dedicated Alerting Systems

A.2.1 EAS - Emergency Alert System

The Emergency Alert System (EAS) [i.28] is a US-based national public warning system that requires TV and radio broadcasters, cable television systems, wireless cable systems, and other public media to offer to the US President the communications capability to address the American public during a national emergency. The system may also be used by state and local authorities to deliver important emergency information to a specific area. The system superseded the earlier Emergency Broadcast System (EBS).

EAS is jointly coordinated by Federal Emergency Management Agency (FEMA), the Federal Communications Commission (FCC), and the National Weather Service (NOAA/NWS). The EAS regulations and standards are governed by the Public Safety and Homeland Security Bureau of the FCC. Each state and several territories have their own EAS plan. EAS has become part of IPAWS, the Integrated Public Alert and Warning System, a program of FEMA.

As to the technical design of the system, EAS uses the Specific Area Message Encoding (SAME) protocol. SAME messages encode, among other elements, information about the source of the alert, the type of threat, and the area affected. The body of the SAME message contains the actual audio message, respectively multimedia data.

A large number of radio stations (about 100) are designated as National Primary Stations in the Primary Entry Point (PEP) System to distribute presidential messages to other broadcast stations and cable systems. The PEP stations provide resilience for alerts and warnings to the public. The existing PEP stations are continuously being upgraded with next generation alert and warning equipment to include Common Alert Protocol (CAP) compliant equipment, as well as Internet connectivity.

EAS is designed to be useful for the general population, not just those with SAME-capable receivers. Several consumer-level radios exist, especially commercially available weather radio receivers. Special, locally configured receivers are available in areas where there is a potential hazard nearby, such as a chemical factory. These radios come pre-tuned to a station in each area that has agreed to provide this service to local emergency management officials and agencies.

A.2.2 CMAS - Commercial Mobile Alert System

The Commercial Mobile Alert System (CMAS) [i.29], also known as Wireless Emergency Alerts (WEA), or Personal Localized Alerting Network (PLAN), is a US-based public warning system for mobile phones. Customers who own certain wireless phone models and other enabled mobile devices are able to receive geographically targeted, SMS-like messages alerting them of imminent threats in their area.

CMAS allows federal agencies to accept and aggregate alerts from the President of the United States, the National Weather Service (NWS) and emergency operations centers, and send the alerts to participating wireless providers who will distribute the alerts to their customers.

Alerts are broadcast only from cell towers in the zone of an emergency. The alerts are geographically targeted to cell towers in the location of the emergency. All CMAS-capable mobile phones that are using a cell tower in the alert zone will receive the CMAS message, independent of their roaming status. There is no need to register for the service.

The technology employed by CMAS is the Cell Broadcast Service (CBS), a standardized technique [i.26] that allows the transmission of messages over the PLMN to a large number of subscribers concurrently. Participation by PLMN operators is voluntary but widespread in the US. Some carriers offer WEA over all or parts of their service areas or over all or only some of their wireless devices. Other carriers may not offer WEA at all.

CMAS messages, although displayed similarly to SMS text messages, are always free and are routed through a separate service which will give them priority over voice and regular text messages in congested areas.

The CMAS system is CAP-compliant, so that it can e.g. interface with any existing EAS system.

A.2.3 IPAWS - Integrated Public Alert and Warning System

IPAWS [i.30] is a public warning system in the USA designed to integrate and modernize the US alert and warning infrastructure. Following the shortcomings experienced during the government's response to the natural disaster caused by Hurricane Katrina, the Department of Homeland Security was ordered to establish a new program to integrate and modernize the nation's existing population warning systems. These systems include:

- Emergency Alert System (EAS);
- Commercial Mobile Alert System (CMAS;
- National Warning System (NAWAS) (an automated telephone system used to convey warnings to United States-based federal, state and local governments); and
- NOAA Weather Radio All Hazards (a network of radio stations broadcasting continuous weather information).

The new integrated alert network, termed IPAWS, is designed to integrate these various systems into one modern network, and also update them to take into account newer forms of communication such as cellular telephony and SMS, satellite and cable television, electronic billboards and the Internet.

The establishment of IPAWS was organized and funded by the Federal Emergency Management Agency (FEMA), an agency of the Department of Homeland Security. The system allows for alerts to be originated by Federal, State, local and tribal officials, and subsequently disseminated to the public using the above-mentioned existing alerting systems. IPAWS uses open standard digital formats such as the EDXL-based Common Alerting Protocol (CAP) v1.2 for its messages, allowing for interoperable dissemination to a wide range of third party receivers.

It is important to emphasize that IPAWS is not a new or separate alerting system, but instead provides a common framework for the operation of existing alerting systems. The common framework is provided by the IPAWS Open Platform for Emergency Networks (IPAWS-OPEN), which is an IP based network that is connected to the different emergency alert systems. Its purpose is to interconnect the alert originators (authorities) to a server which aggregates and forwards the alert messages to the alert systems for public dissemination. IPAWS-OPEN uses CAP.

A.2.4 SatWaS and MoWaS

SatWaS

SatWaS [i.31] is a satellite-based warning system in Germany. Developed by the *Bundesamt für Bevölkerungsschutz und Katastrophenhilfe* (BBK) (Federal Civil Protection Agency), it was designed to disseminate urgent alert information in case of major national security incidents or threats. The system is gradually replacing sirens in Germany.

SatWaS warnings are not disseminated directly to the population, but rather are sent to regional situation centres and regional media broadcasters. The system thus relies on the capabilities of the situation centres and media broadcasters to forward the alert messages to the general population. The originator of the alert message can be a national warning center, the Civil Defence Liaison Centre (CDLC) or federal/regional situation centres.

SatWaS messages are received by federal/regional situation centres, public and private media broadcasters, Internet providers, paging services, press agencies or the Deutsche Bahn AG (German national railway company). In the case of Internet providers, operators can subscribe to the SatWaS system and offer the alerts on their web portals. Similarly, paging service providers can subscribe to the service and include the SatWaS alerts in their service portfolio. Currently, T-Online is the only Internet provider subscribed to SatWaS, while e*Message (through the service e*Warn) is the only paging provider.

MoWaS

MoWaS (Modular Warning System) [i.32] is a modular upgrade of SatWaS. The main objective behind MoWaS is to allow local civil protection authorities to activate all alarm and warning systems in their area of responsibility in a decentralized manner and without discontinuity of media use.

Compared to the SatWaS system, MoWaS allows also local emergency response centres to be the originators of the alerting messages, thus providing a decentralized warning system. As regards the recipients of the alert, unlike in the SatWaS system (where citizens are able to receive the alert only via the connected media), in the MoWaS system citizens can be directly reached via any connected means. In terms of communication technologies used to disseminate the alerts, MoWaS adds the use of CBS and TETRA to distribute the alert messages.

A.2.5 NL-Alert

Civil protection authorities in the Netherlands are currently gradually replacing the siren system by the NL-Alert [i.33] system. NL-Alert uses the Cell Broadcast Service to deliver alert messages directly to (CBS-enabled) cell phones located in the affected area, independent of the phone's home network. All major PLMN operators in the Netherlands (KPN, Vodafone, T-Mobile) support the service.

NL-Alert was conceived to overcome the weaknesses to the siren system, in particular the unspecific nature of the siren alarm and the inherent difficulty of reaching certain sectors of the population (e.g. people with hearing problems). On the other hand, mobile phones are universally available and the high population density translates into (essentially) 100 % coverage of the land area.

Using NL-Alert, alert messages can reach all active and CBS-enabled cell phones located in either one, several, or all (over 20 000) PLMN cells in the country within seconds. The information can be very specific and may include instructions issued by the authorities.

A.2.6 UMS PAS - Population Alert System

The UMS PAS system is an alerting solution offered by the Oslo (Norway) based company UMS (Unified Messaging Systems) [i.34]. The system is designed to alert the population and communicate with residents, visitors and businesses in the affected area. The solution is an integrated system which allows authorities to respond flexibly to an emerging crisis or threat. For example, the system uses different media depending on the time of day according to the expected user reachability profile at the particular time. UMS PAS provides two types of alerts:

- Address based alerts: Fixed and mobile telephones linked to physical addresses in a given geographical area are identified and alerted via a voice message; only users in the targeted area receive the call. Several thousand citizens can be reached in this way within minutes.

- Location based alerts: Mobile phones, including those of visitors and foreigners in a given geographical area are identified and alerted via a voice message or an SMS.

PAS provides detailed information on the affected area, for example the number of people who are in the area and their nationality. Using these data, emergency response centers can estimate and manage their own personnel. PAS also monitors the response from recipients and presents the current status in real time. A number of features are provided that makes it possible to customize alerts for different types of situations.

In addition to UMS PAS, the company offers a suite of related solutions, such as UMS Group Alert (used by emergency services for internal purposes), UMS Service Alert (used by municipalities for notifications), UMS Traveller Alert (to alert citizens travelling abroad), among other solutions.

A.2.7 PTWS - Pacific Tsunami Warning System

The Tsunami Warning System (TWS) in the Pacific (PTWS) [i.35] is an initiative of 26 participating international member states. Its function is:

i) to monitor seismological and tidal stations throughout the pacific basin to evaluate potentially tsunamigenic earthquakes; and

ii) to disseminate tsunami warning information.

The operational center of the PTWS is the Pacific Tsunami Warning Center (PTWC) [i.36] located near Honolulu, Hawaii. The PTWC serves as both the regional tsunami warning center for Hawaii and as a national/international warning center for tsunamis that pose a Pacific-wide threat.

The PTWS does not alert the population directly, but rather provides tsunami warning information to national authorities in the Pacific basin. Real-time tsunami alerts, including PTWC alerts, are monitored by NOAA's National Weather Service.

Tsunami watch, warning, and information bulletins are disseminated to appropriate emergency officials and the general public by a variety of communications methods, such as:

- Tsunami watch, warning and information bulletins issued by PTWC and ATWC (Alaska TWC) are disseminated to local, state, national and international users as well as the media. These users, in turn, disseminate the tsunami information to the public, generally over commercial radio and television channels.
- The NOAA Weather Radio System, based on a large number of VHF transmitter sites, provides direct broadcast of tsunami information to the public.
- The US Coast Guard also broadcasts urgent marine warnings and related tsunami information to coastal users equipped with medium frequency (MF) and very high frequency (VHF) marine radios.
- Local authorities and emergency managers are responsible for formulating instructions and executing evacuation plans for areas under a tsunami warning.

A.2.8 EEW - Earthquake Early Warning System

The EEW [i.37] is a comprehensive system designed to issue urgent warnings in the event of an earthquake in Japan. Operated by the *Japan Meteorological Agency* (JMA), the system's over 4 000 seismometers monitor ground movements. Upon detection of p-waves (primary waves, travel faster than the more deadly s-, or secondary waves), the JMA automatically analyses the readings and predicts the approximate location of the epicentre, the strength of the earthquake, and the areas under threat by strong tremors or tsunamis. The time lag from the detection of p-waves to the arrival of s-waves in populated areas typically lies between several seconds and a few tens of seconds. Warnings to the general population are only issued if the earthquake exceeds a certain strength.

Once the decision has been made to issue a general alert, the JMA formulates and disseminates the warning message using a variety of distribution techniques, such as:

- **Television:** TV stations interrupt regular programming and alert viewers by presenting an alerting tone, a voice message and a text message window. TV sets can also be turned on by the alert signal when in sleep mode. Warnings are broadcast in the Japanese, English, Mandarin, Korean, and Portuguese languages.
- **Radio broadcast:** The specific and common chime tone from radio stations is automatically detected by the radio receiver and turns on the radio, if in sleep mode, and plays a chime tone and the EEW message. As soon as more details of the earthquake are available (after a few seconds), that information - e.g. earthquake strength and affected area(s) - is announced.
- **Mobile phone networks:** Japan's three major mobile phone carriers implemented the CBS service to support the dissemination of EEW messages throughout their networks. Measures are taken to ensure that a large number of mobile phones are CBS/EEW capable and that the service remains activated at all times. The predominant mobile phone carrier in Japan, NTT Docomo, provides this (free) service under the name "Area Mail."

- **Internet:** Internet-based applications are available which relay EEW alerts in real-time to dedicated EEW client applications installed on personal computers. Once an EEW alert is issued and the computer is on-line, the client application will present earthquake-related information to the user. In particular, the estimated seismic intensity is displayed and a count-down is provided indicating when major shaking is to be expected at the user's location.

- **Dedicated EEW receivers:** Due to the very short reaction times (possibly a few seconds only), individuals should be alerted without delay in various types of environments and daily situations. To achieve this, alarm devices such as sirens, light flashes, loudspeakers and public displays are installed in the private home and office, public buildings, elevators, buses and trains, and outdoors. These devices receive the EEW alert messages by various means, including EEW radio broadcast.

A.2.9 Summary

Table A.5 provides an overview of the dedicated alerting systems presented above.

Table A.5: Overview of dedicated alerting systems

Alert system	Dissemination Technology	Key characteristics	Country/Region
EAS	Radio and TV broadcast, cable TV, other public media	Designated, so-called National Primary Stations distribute the (SAME-encoded) alert messages to other radio stations and public media for general broadcast; upgrades to include CAP and Internet capabilities are on-going.	USA
CMAS	CBS	The CBS service is used to reach enabled mobile phones in the affected area(s); CMAS is CAP-compliant.	USA
IPAWS	(Integrating all available alerting systems)	The common alerting framework is provided by the IPAWS OPEN platform that aggregates and forwards the alert messages; CAP-compliant.	USA
SatWaS; MoWaS	Satellite broadcast	SatWaS: Alert messages are sent to public broadcasters and other media for distribution to the general population. MoWaS: Regional capabilities are introduced, and citizens can be addressed directly, e.g. via CBS.	Germany
NL-Alert	CBS	The CBS service is used to reach enabled mobile phones in the affected area(s).	The Netherlands
UMS PAS	Fixed and mobile networks	Fixed and mobile phones in the affected area are directly addressed.	mainly Scandinavia
PTWS	Radio/TV broadcast; MF and VHF marine radios	The warning center, located near Hawaii, issues warnings to local authorities and broadcasters, which in turn distribute these messages using their own means.	Pacific basin
EEW	TV, radio, CBS, Internet applications, dedicated receivers	The Japan Meteorological Agency (JMA) issues alerts and disseminates EEW messages using a wide variety of technologies.	Japan

A.3 Alert Message Standards

A.3.1 SAME - Specific Area Message Encoding

Specific Area Message Encoding (SAME) [i.38] is a protocol used to encode messages of the US-based Emergency Alert System (EAS), among other warning systems.

SAME messages consist of four parts:

1) Digital header: AFSK (Audio Frequency-shift keying) data burst.

2) Attention signal: A special audible tone.

3) Message: Audio, video, image or text.

4) Digital tail: AFSK data burst.

The digital parts (1 and 4), each repeated three times to allow for error correction, serve to (de-)activate the appropriate radio receivers. The header additionally contains various data, indicating the authority that originated the alert, an event code, the area(s) affected, the expected duration of the event, the date and time it was issued, and an identification of the originating station.

The first audio signal (part 2) is an attention tone, and the second one (part 3) is an actual audio message, video image or video text.

As regards event codes (encoded in the header), national authorities in the USA and Canada have defined and implemented approximately 80 such codes. Event codes are three-letter words, which serve to indicate the type of emergency or threat. The third letter in each code indicates the alert category (W=Warning, A=Watch, E=Emergency, and S=Statement). For example, the event code HUA means "Hurricane Watch", while HUW means "Hurricane Warning".

The affected location is signalled via a location code, which is also included in the header. There can be up to 31 location codes in any given SAME message. In terms of granularity, location codes in the US typically specify counties.

A.3.2 EDXL - Emergency Data Exchange Language

The Emergency Data Exchange Language (EDXL) [i.39] is a family of XML-based messaging standards developed by OASIS (Organization for the Advancement of Structured Information Standards). These standards specify message formats for exchanging emergency information between authorities and the full range of emergency-related organizations.

The EDXL suite comprises a number of individual standards:

- EDXL-DE (Distribution Element): XML-based header or wrapper that provides flexible message distribution for data sharing between emergency information systems.
- EDXL-RM (Resource Message): Describes a suite of messages for sharing data among information systems that coordinate requests for emergency equipment, supplies and people.
- EDXL-HAVE (Hospital Availability Exchange): Allows a hospital's status, services, and resources (including bed capacity, emergency department status, and available service coverage) to be communicated.
- CAP (Common Alerting Protocol): A format for exchanging emergency alerts and public warnings over networks (see clause A.3.3).
- EDXL-SitRep: Provides a format for sharing general information across the disparate systems of any public or private organization and Emergency Support Function about a situation, incident or event, including the operational picture and ongoing or desired responses.
- EDXL-TEP (Tracking of Emergency Patients): A format for exchanging emergency patient and tracking information from first contact with the patient up to hospital admission or release.

Out of this family of emergency-related standards, only CAP is relevant for disseminating alert information, as discussed in the following clauses.

A.3.3 CAP - Common Alerting Protocol

A.3.3.1 General

The Common Alerting Protocol (CAP, see [i.18] and [i.19]) specifies a message format used to distribute alert and emergency related information over all kinds of networks.

The first CAP specification (v1.0) was approved in April 2004 by the US-based Organization for the Advancement of Structured Information Standards (OASIS). Based on user feedback for CAP 1.0, OASIS updated the specification and released CAP 1.1 in 2005.

As part of the International Telecommunication Union adoption of CAP [i.18], a CAP 1.1 Errata was released in 2007 to support ASN.1 encoding. Specifically, the recommendation annex contains an authoritative ASN.1 module translation of the CAP XML schema that may be useful for some implementations.

The latest CAP specification is version 1.2 [i.19], available since July 2010.

The CAP data structure is backward-compatible with existing alert formats such as the Specific Area Message Encoding (SAME) (see clause A.3.1 above), which is used in particular by the EAS System and the Commercial Mobile Alert System (CMAS). CAP includes additional capabilities such as:

- flexible geographic targeting using different geospatial representations in three dimensions;
- multilingual and multi-audience messaging;
- phased and delayed effective times and expirations;
- enhanced message update and cancellation features;
- template support for framing warning messages;
- digital encryption and signature capability;
- facility for digital images, audio and video.

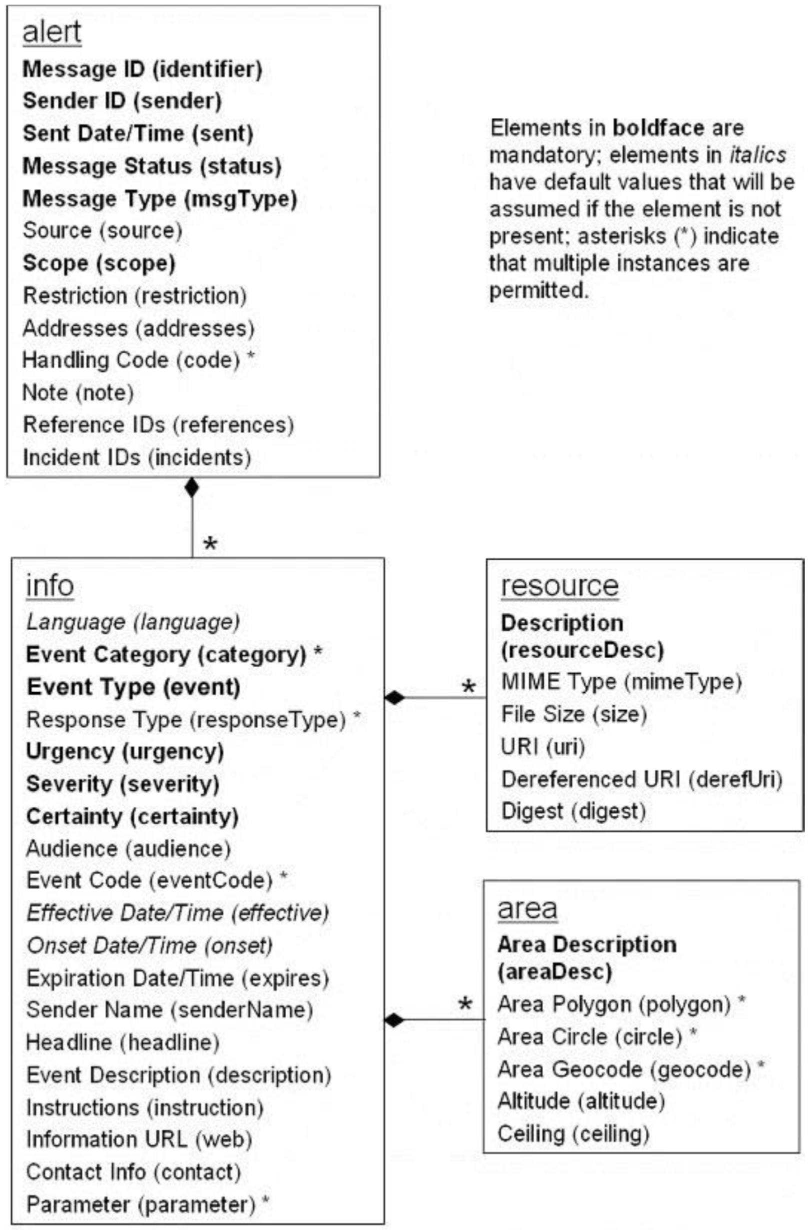
According to the CAP specification, the primary (anticipated) use of the CAP Alert Message is as an XML document. However, the format remains sufficiently abstract to be adaptable to other coding schemes.

Regarding message sizes, typical (human-readable) XML-based CAP Alert Messages have a size of about 1,5 kB. Straightforward *zip*-compression reduces the message size to about 1 kB. It should however be noted that the CAP specification does not support nor mention any compression schemes or options. An efficient compression scheme for XML-based CAP messages was devised and implemented by the Alert4All [i.17] project.

A.3.3.2 CAP Message Structure

As regards the message structure, a CAP alert message consists of an <alert> segment, which may contain one or more <info> segments, each of which may include one or more <area> and/or <resource> segments. Under most circumstances, CAP messages with a <msgType> value of "Alert" should include at least one <info> element.

The document object model diagram for CAP messages [i.19] is shown in figure A.1.



NOTE: The bold diamond ◆ indicates "composition," and the * symbol indicates "possibly more than one" (taken from [i.19].

Figure A.1: Document object model diagram for CAP messages

The <**alert**> segment provides basic information about the message: its purpose, its source and status, as well as a unique identifier for the current message and links to any other, related messages. An <alert> segment may be used alone for message acknowledgements, cancellations or other system functions, but most <alert> segments will include at least one. For example, a code value of "Alert" for the msgType element within the <alert> segment indicates that the CAP message requires the attention of the targeted recipients, whereby the details are specified in the <info> segment. If msgType="Ack", the CAP message signals correct reception of an earlier CAP message, which is referenced in the "references" element.

The <**info**> segment describes an anticipated or actual event in terms of its urgency (time available to prepare), severity (intensity of impact) and certainty (confidence in the observation or prediction), as well as providing both categorical and textual descriptions of the subject event. It may also provide instructions for an appropriate response by message recipients and various other details (hazard duration, technical parameters, contact information, links to additional information sources, etc.).

The <**resource**> segment provides an optional reference to additional information related to the <info> segment within which it appears (e.g. an image or audio file).

The <**area**> segment describes a geographic area to which the <info> segment in which it appears applies. Textual and coded descriptions (such as postal codes) are supported, but the preferred representations use geospatial shapes (polygons and circles) and an altitude or altitude range, expressed in standard latitude/longitude/altitude terms in accordance with a specified geospatial datum.

A.3.3.3 CAP Message Usage

The primary use of the CAP Alert Message is to provide a means for activating different alerting and public warning systems. This helps to ensure consistency in the information transmitted over multiple delivery systems, which is a key factor for warning reliability and effectiveness. As mentioned in the previous clause (see the description of the <alert> segment), a CAP message can also be used to acknowledge reception of an earlier CAP message.

Although primarily designed as an interoperability standard for use among warning systems and other emergency information systems, the CAP Alert Message can be delivered directly to alert recipients over various networks, including data broadcasts. Location-aware receiving devices could use the information in a CAP Alert Message to determine, based on their current location, whether or not that particular message is relevant to their users.

The CAP Alert Message can also be used by sensor systems as a format for reporting events to collection and analysis systems and centers.

A.3.3.4 CAP Security

Since CAP messages are (typically) presented in an XML format, existing XML security mechanisms can be used to secure and authenticate its content. In particular, the XML family includes a specification on XML Encryption, which defines syntax and processing rules for encrypting XML content. Furthermore, a specification on XML Signature exists, which defines syntax and processing rules for creating digital signatures on XML content.

As specified in subsection 3.3.4.1 of the CAP v1.2 specification [i.19], only the XML-Signature Syntax and Processing Rules defined in [i.40] (W3C Recommendation, February 2002) may be used as a signature mechanism. Furthermore, it is stated that *Processors must not reject a CAP Alert Message containing such a signature simply because they are not capable of verifying it; they must continue processing and should inform the user of their failure to validate the signature.*

An additional security mechanism for CAP was initially proposed in 2012 by the IETF's WG ATOCA (now closed). That mechanism - called ESCAPE (Encoding Secure Common Alert Protocol Entities) and described in Internet Draft draft-barnes-atoca-escape-02 (now expired) [i.60]- provides a security wrapper for CAP objects.

A.3.3.5 CAP Country Profiles

While the CAP specification defines the complete technical layout, a CAP Profile defines the policies and procedures for operationalizing such a system for a particular country. CAP-Country-Profile objectives are to define country-specific policies, procedures, authorities and message originators, as well as rules and conventions applicable to the country context.

For example, in Canada, a working group composed of public alerting practitioners and government agencies has developed a CAP Canadian Profile (CAP-CP) [i.41] based on CAP but specialized to address the needs of Canadian public alerting stakeholders, such as bilingualism, geocoding for Canada, managed lists of locations and events, etc. The Canadian government has adopted CAP-CP for its National Public Alerting System (NPAS) [i.42] project.

Annex B: Candidate SatCom and SatNav Systems for Alert Distribution

B.1 SatCom Systems

B.1.1 Classification of SatCom Systems

The selection of the satellite communications systems for the delivery of alert messages relies on the identification of the main factors that drive the warning effectiveness. Considering the main goal of an alerting system, which is to timely and reliably warn and inform a diverse population about a hazard, two criteria are considered for the classification of the existing satellite communication systems. These are:

- Availability/Non-availability of a return link.
- Fixed/Mobile reception mode.

Based on these classification criteria the main satellite systems candidates for carrying alert messages can be grouped into four classes:

- **Broadcast Fixed Satellite Systems:** which support alert messages broadcasting to fixed satellite receivers without providing a return channel.
- **Broadcast Mobile Satellite Systems:** which support alert messages broadcasting to mobile satellite receivers without providing a return channel.
- **Bidirectional Fixed Satellite Systems:** which support alert messages transmission to fixed satellite receivers while also providing a return channel.
- **Bidirectional Mobile Satellite Systems:** which support alert messages transmission to mobile satellite receivers while also providing a return channel.

Figure B.1 presents this classification in matrix form.

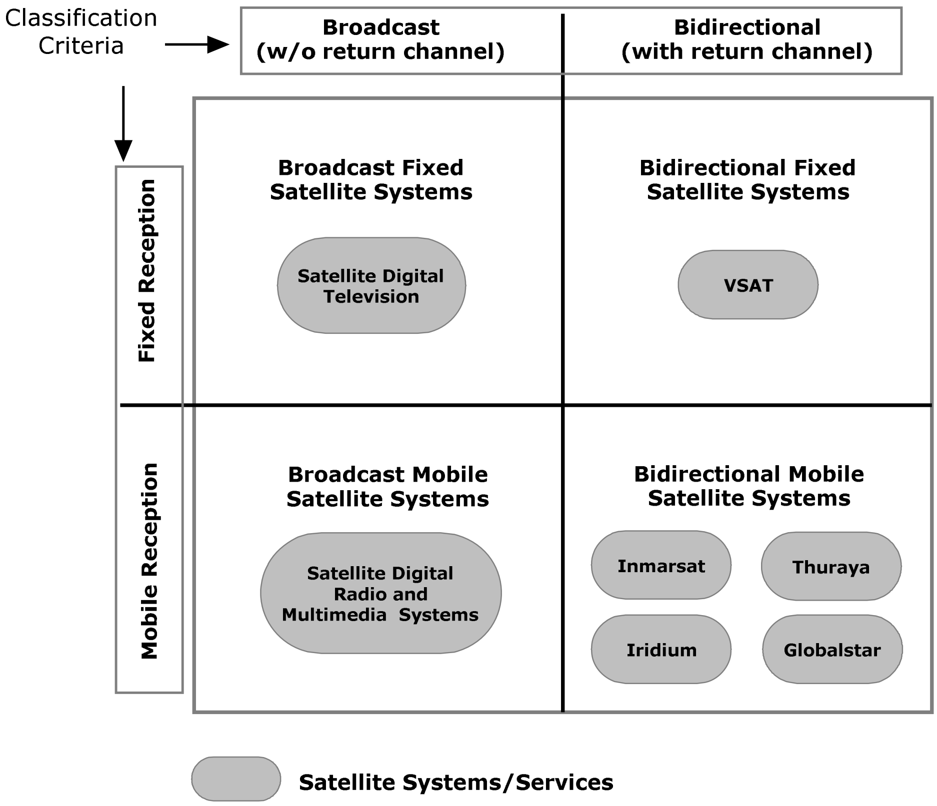


Figure B.1: Classification of SatCom Systems

In the following clauses each category is presented and analysed with the aim to highlight its suitability for supporting MAMES-based public alerting.

Finally, as regards the broader use of SatCom systems for public warning and disaster relief purposes, it is noted that the ITU-R has published several recommendations and reports as follows:

- Recommendation ITU-R BT.1774-1 [i.55] (04/2007): Use of satellite and terrestrial broadcast infrastructures for public warning, disaster mitigation and relief.
- Recommendation ITU-R M.1854-1 [i.56] (01/2012): Use of mobile-satellite service in disaster response and relief.
- Recommendation ITU-R S.1001-2 [i.57] (01/2010): Use of systems in the fixed-satellite service in the event of natural disasters and similar emergencies for warning and relief operations.
- Report Recommendation ITU-R M.2149-1 [i.58] (10/2011): Use and examples of mobile-satellite service systems for relief operation in the event of natural disasters and similar emergencies.
- Report Recommendation ITU-R S.2151-1 [i.59] (09/2012): Use and examples of systems in the fixed satellite service in the event of natural disasters and similar emergencies for warning and relief operations.

B.1.2 Broadcast Fixed Satellite Systems

B.1.2.1 General

The main requirements for a telecommunications system to support an efficient alert service are to provide reliability, fault recovery, resource management and extended geographical coverage. In this context, broadcast fixed satellite systems play an important role due to their resilient links and broadcast capabilities, which allow the distribution of information simultaneously over a large area. Such systems can be configured to provide either low-speed data transmissions or very high-bandwidth data and they rely on the presence of fixed satellite receiver antennas (at the end user side). Broadcast services are supplied by a large number of operators and systems and they include TV and radio broadcast, video services (video distribution, satellite news gathering) as well as telecommunications services (private networks, data broadcasting).

B.1.2.2 Relevant Aspects for MAMES

The adoption of broadcast fixed satellite systems for the distribution of different alert signals to the population (audio, images, data) represents a suitable solution to be pursued. In particular the one-to-many communications capabilities are crucial in an emergency context as far as the possibility to address already existing fixed receivers. The broadcast MAMES-based alert messages can directly reach a large number of receivers, thus enabling a rapid alert distribution over the affected areas.

It is important to note that these systems allow the transmission of MAMES messages to the already installed satellite terminal stations, which may include large earth stations as well as medium-size or small consumer satellite dishes. Therefore, a large number of home users, including people not equipped with other telecommunications devices, can be reached through these kinds of systems. Moreover, these systems could include also additional temporarily installed devices for emergency management purposes.

B.1.2.3 Summary

Table B.1 summarizes the key characteristics of broadcast fixed satellite systems in view of their applicability for MAMES.

Table B.1: Key characteristics of broadcast fixed satellite systems

Summary	
Reception Mode	Fixed satellite terminals
Availability of a Return Channel	Not available
Relevant features for MAMES	• One-to-many communications capabilities (rapid alert distribution to the interested areas). • Addressed to home users (traditional satellite TV receivers) or additional temporary communication terminals installed for emergency purposes. • Different bandwidth profiles (low/medium/high data rate).
Systems/Services examples	Satellite Digital TV
ETSI Standards/Specifications	DVB-S/S2/S2X

B.1.3 Broadcast Mobile Satellite Systems

B.1.3.1 General

The advantages of the broadcast capability described in the previous clause (fixed systems) are valid also for the broadcast mobile satellite systems. Regarding the mobile reception feature, these systems provide ubiquitous and resilient mobile data services. Both mobile satellite radio and multimedia satellite services allow the distribution of information directly to users equipped with satellite mobile handsets and radio receivers.

Examples of operators of broadcast satellite radio systems are Sirius XM™ Holdings [i.43], a US-based radio broadcaster, and the Europe-based company Solaris Mobile [i.44] (a subsidiary of EchoStar Corporation). Their systems offer mobile multimedia satellite services providing video, radio and data broadcasting to in-vehicle receivers and to mobile devices through geostationary satellites.

As regards data services, a service provided by Sirius XM™ Holdings called XM WX Satellite Weather™, is noted. This service allows users equipped with a XM WX-capable receiver to receive accurate weather updates.

Audio equipment manufacturers are developing a variety of satellite radio and multimedia receivers together with accessories, which allow the reception of these satellite-based services "on the move", using e.g. in-car radio equipment and portable receivers.

B.1.3.2 Relevant Aspects for MAMES

Broadcast mobile satellite systems can be used to broadcast MAMES messages over a large area directly to mobile users equipped with satellite mobile radio and multimedia receivers. Assuming the transmission of MAMES messages over these communication channels, on the receiver side a MAMES capability (MAMES Agent) is required. This agent is responsible for receiving and decapsulating the MAMES message. Moreover, functionalities are needed for the alert message interpretation and rendering based on the alerting device's capabilities.

B.1.3.3 Summary

Table B.2 summarizes the key characteristics of broadcast mobile satellite systems in view of their applicability for MAMES.

Table B.2: Key characteristics of broadcast mobile satellite systems

Summary	
Reception Mode	Mobile satellite terminals.
Availability of a Return Channel	Not available.
Relevant features for MAMES	• One-to-many communication capabilities (rapid alert distribution to the interested areas). • Direct alert to a large number of end-user mobile terminals. • Independent from the end-user location (outdoor) and the availability of a fixed terminal receiver.
Systems/Services examples	Sirius Satellite Radio, XM Satellite Radio, Solaris Mobile.
ETSI Standards/Specifications	DVB-SH, SDR.

B.1.4 Bidirectional Fixed Satellite Systems

B.1.4.1 General

In contrast to broadcast fixed satellite systems, the bidirectional fixed satellite systems include a return channel; the information is transmitted from the satellite to the user terminal (forward link) and a return link allows the transmission of data from the satellite terminal back to the ground segment. The interactivity can be provided through different return channels:

- return channel via satellite (two way satellite system);
- return channel via terrestrial links (one way satellite system).

In a satellite two-way interactive system both the forward and the return channel are provided through a satellite link. In particular, in a star topology (which includes a Hub station), the user terminal allows the end user to receive and transmit the desired information via the satellite, while the Hub station provides both traffic routing and satellite network management capabilities. The Hub is equipped with a larger antenna and a more powerful power amplifier with respect to the user terminals and its function is to receive user requests and to convey the desired information back to the user terminals. In this topology each user terminal has a dedicated point-to-point link only with the Hub station. Besides, point-to-multipoint connectivity in the forward channel (from the Hub station to the user terminals through the satellite) and multipoint-to-point connectivity in the reverse direction are supported.

On the other hand, in a satellite one way interactive system the forward channel is provided via satellite while the return channel is provided through a terrestrial technology.

The reception of signals transmitted by bidirectional fixed satellite systems requires a fixed satellite antenna receiver and the subscription to a service provider. Different data transmission rates are available depending on the specific service and user terminal capabilities.

A number of bidirectional fixed satellite systems are currently in operation. They are typically referred to as VSAT (Very Small Aperture Terminal) systems.

B.1.4.2 Relevant Aspects for MAMES

Bidirectional fixed satellite systems can be used to distribute MAMES Messages to private or commercial users equipped with fixed satellite receiver antennas. On the receiver side, a MAMES Agent, embedded in the already existing hardware or developed on a dedicated external hardware, is required for MAMES message decapsulation/encapsulation, and additional functionalities are needed for alert message interpretation and rendering, subject to the Alerting Devices' capabilities. The return link allows for MAMES-specific or alert-specific feedback/acknowledgements to be sent back to the originator of the MAMES/alert message.

B.1.4.3 Summary

Table B.3 summarizes the key characteristics of bidirectional fixed satellite systems in view of their applicability for MAMES.

Table B.3: Key characteristics of bidirectional fixed satellite systems

Summary	
Reception Mode	Fixed satellite terminals
Availability of a Return Channel	Available Return Channel via satellite (two-way satellite system) Return Channel via terrestrial link (one-way satellite system)
Relevant features for MAMES	• Bidirectional system (intrinsic robustness of satellite two-way systems). • Possibility of acknowledgment to report successful reception of the MAMES Message.
Systems/Services examples	VSAT
ETSI Standards/Specifications	DVB-RCS(2)

B.1.5 Bidirectional Mobile Satellite Systems

B.1.5.1 General

Bidirectional mobile satellite systems are fully interactive systems whose subscribers are mobile users equipped with handheld or portable satellite receivers. These systems are also referred to as MSS (Mobile Satellite Services) systems. Several commercial MSS systems are currently operational, offering mainly voice and data services with a regional or global scope. Depending on the system, satellites (or satellite constellations) of type GEO, MEO, or LEO are employed. As a result of the small form factors of the MSS terminals (mostly handheld) and the system architecture (optimized for conversational services), the available data rates are considerably smaller than for the bidirectional fixed satellite systems.

A number of commercial MSS systems are in operation today, which are briefly summarized below.

Inmarsat™

The Inmarsat MSS™ system [i.45] is a two-way satellite system that offers (mainly) voice and data services to users worldwide. A global coverage (excluding the polar regions) is achieved by GEO satellite constellations, while Land Earth Stations on the ground provide connectivity between the satellites and the terrestrial telecommunications network, guaranteeing users with portable or mobile terminals seamless services everywhere. In particular the broadband service (BGAN service) provides simultaneous voice and broadband data communications globally using small and lightweight satellite terminals.

Thuraya

The Thuraya™ GEO-based system [i.46] is a regional MSS system that provides mobile satellite communications (voice, fax, data and packet telecommunications services) to extended regions around the world, covering most of the planet. Among the large variety of products, it is worth mentioning the Thuraya SatSleeve™ product, which enables smartphones to transfer voice and data (phone calls, messages, emails and Internet access) via satellite through a GPRS-like connectivity.

Globalstar

The Globalstar MSS system [i.47] provides a large variety of services (such as voice, data, paging, etc.) by relying on a LEO satellite constellation. The Globalstar architecture is based on bent-pipe technology, where the satellites are transparent repeaters, while a network of ground gateway stations provides connectivity from the satellites to the public switched telephone network and the Internet.

Iridium

The Iridium MSS system [i.48] provides (mainly) voice and data services on a global scale, thanks to its satellite constellation of LEO satellites organized in a meshed configuration. The traffic is dynamically routed among the satellites, thus guaranteeing a full global coverage (including poles) and ensuring a continuous and ubiquitous connectivity and service provision.

Iridium comprises the satellite constellation, a ground infrastructure and user satellite phones and data units. Since the communication relies on data being relayed to and from ground stations (earth gateways) through satellite communications, Iridium is particularly suitable for emergency applications with a global scope. In fact, if a ground station is damaged due to (e.g.) a natural disaster, the traffic is routed through the satellite constellation to another ground station.

Among the Iridium satellite services, which include voice and broadband data services, the main potential candidates for carrying and distributing alert messages are: Iridium Burst™, Iridium SBD™ and Iridium SMS™.

The Iridium Burst Service

Iridium Burst™ is a one-to-many global data broadcast service with high signal penetration capabilities, which enables the transmission of data to a large number of remote devices, providing opportunities for the deployment of a global alert network. In order to transmit a message, the sender formats the transmission, specifying recipient group, targeted location and any optional information; the service then forwards the data to the Iridium gateway for subsequent transmission, via the appropriate satellites, to the correct satellite downlink beams. Only authorized devices (the ones belonging to the specified recipient group) are able to correctly receive and unscramble the message. The data bursts contain a user payload of 248 bits.

The Iridium Short Burst Data Service (SBD)

Iridium SBD is an end-to-end data service for transmitting short data messages between equipment and centralized host computing systems. It is used in different commercial applications contexts such as Oil and Gas, Rail, Maritime, Aeronautical and Utilities, as well as for Government/Military purposes. The maximum size of a Mobile Originated (MO-SBD) message is 1 960 bytes, while the maximum size of a Mobile Terminated (MT-SBD) message is 1 890 bytes. The payload size depends on the capabilities of the Iridium transceiver used. The smaller and lighter ones support shorter payloads. Global network transmit latency for message delivery ranges from 5 seconds for messages of 70 bytes to approximately 20 seconds for maximum-length messages.

The Iridium SMS (Short Message Service)

Iridium SMS is a two-way service, which allows the users to send, receive and reply to messages. SMS messages are 160 characters in length. They can be stored for up to 7 days within the Iridium network and are automatically delivered whenever possible, subject to system constraints.

B.1.5.2 Relevant Aspects for MAMES

MSS systems, although designed primarily for conversational services, can be used for distributing MAMES Messages. MAMES Messages may be carried by any suitable ptp or ptmp data service provided by a particular MSS system. This requires the subscribers to be explicitly addressed through the regular signalling scheme employed by the MSS system. An example of a well suited MSS-based ptmp data service is the Iridium Burst™ Service mentioned in the previous clause, where a group of recipients in a particular area can be addressed.

Furthermore, the (existing) SatNav functions within MSS user terminals could be complemented by a MAMES Receiver function, which would enable these terminals to receive MAMES Messages within the regular SatNav messages, to decapsulate them and to distribute the resulting Alert Messages to Alerting Devices throughout the affected area.

The return channel of MSS systems can be used for MAMES ACK Messages.

The limited capacity of the MSS channels (optimized for voice and low-speed data) is considered an intrinsic drawback of these systems with regard to an alert application. The transmission of large payloads over these systems would thus result in considerable end-to-end delays. For urgent alert distribution, small MAMES Payloads - or the use of the MAMES Ultra-Short ALERT Message - are recommended.

B.1.5.3 Summary

Table B.4 summarizes the key characteristics of MSS systems in view of their applicability for MAMES.

Table B.4: Key characteristics of bidirectional mobile satellite systems

Summary	
Reception Mode	Mobile satellite terminals
Availability of a Return Channel	Available Return Channel via satellite (two-way satellite system) Return Channel via terrestrial link (one-way satellite system)
Relevant features for MAMES	• Bi-directional system (intrinsic robustness of satellite two-way systems). • Possibility of acknowledgment report successful reception of the MAMES Message. • Independent of the end-user location (outdoor) and the availability of a fixed terminal receiver. • Typically used in areas with no terrestrial coverage and for professional/commercial applications.
Systems/Services examples	Inmarsat™, Thuraya™, Iridium™, Globalstar™
ETSI Standards/Specifications	GMR, S-UMTS, S-MIM

B.2 SatNav Systems

B.2.1 Classification of SatNav Systems

Satellite-based navigation (SatNav) systems can be classified into three categories as follows [i.49]:

- Global navigation satellite systems (GNSS), such as GPS (USA), GLONASS (Russia), BEIDOU (China), and GALILEO (Europe). These systems provide, among other services, autonomous geo-spatial positioning and timing services with a global coverage, which is generally achieved by means of a constellation of MEO satellites.

- Satellite-based augmentation systems (SBAS), such as WAAS (USA), MSAS (Japan), and EGNOS (Europe). These are systems that augment an underlying GNSS over a large region, thus improving the navigation service within the coverage area. This is done by implementing an SBAS-specific ground infrastructure and (at least one) GEO satellite.

- Regional navigation satellite systems, such as INRSS (India) and QZSS (Japan). These systems provide positioning services to a specific region by using dedicated (non-GEO) satellite constellations and an associated ground segment.

Since all these systems rely on data broadcast, the possibility exists to use certain data fields for other types of content, e.g. to carry alert-related messages.

In the present document, only the European SatNav systems GALILEO and EGNOS will be considered. The following two clauses in this annex provide a concise overview of these two systems, also highlighting aspects relevant for MAMES.

B.2.2 The GALILEO System

B.2.2.1 General

GALILEO [i.50], the European GNSS developed for civilian usage, is designed to guarantee highly accurate global positioning through a constellation of 30 MEO satellites. Although being an independent European system, it is compatible and interoperable with GPS and GLONASS. New positioning and broadcast data capabilities are the main features of GALILEO, which makes the system suitable for additional applications.

The GALILEO architecture is structured as follows:

- The *Space Segment*, which generates and transmits code and carrier phase signals and stores and retransmits the navigation message transmitted by the Ground Segment. It consists of 30 MEO (23 222 km) satellites (27 operational and 3 spares), which occupy 3 orbital planes (inclined 56° to the equator).
- The *Ground Segment*, which in turn is composed of two Ground Control Centers (GCC), five Telemetry, Tracking and Control (TT&C) stations, nine Mission Uplink Stations (ULS), and a network of GALILEO Sensor Stations (GSS). Additionally, it contains the European GNSS Service Centre (GSC), which offers a range of services to users, in particular it provides an interface between the GALILEO system and both the OS users and the CS providers and/or users.
- The *User Segment*, which is represented by the GALILEO receivers.

The Galileo services are:

- *Open Service (OS).* The OS provides accurate positioning and synchronization information, targeting the mass market. It is freely available and oriented to vehicle navigation and location-based mobile telephone services. It does not include encryption mechanisms and it does not require authorization.
- *Commercial Service (CS).* Thanks to its improved accuracy as compared to the OS and the adoption of authentication and encryption, this service enables the development of (payable) professional and commercial applications.
- *Safety-of-Life Service (SoL).* Also referred to as the *Integrity Monitoring Service*, this service provides vital integrity information by transmitting notifications of service performance problems to users. Like the OS it is free of charge.
- *Public Regulated Service (PRS).* This service is restricted to government-authorized users and oriented to sensitive applications relying on a high level of service continuity. It includes encryption and interference mitigation technologies (such as anti-jamming and anti-spoofing mechanisms), guaranteeing a reliable problem detection.
- *Search and Rescue Service (SAR).* This service detects emergency beacons and the location of incoming distresses signals, helping the forwarding of information to a search and rescue coordination center and thus allows rescuers to exactly know where the victim is located. Moreover a feedback can be sent back to a beacon indicating success reception of the distress signal. Ten minutes is the maximum period of time between the distress signal and the GALILEO SAR response.

As highlighted in table B.5, five types of GALILEO data (see the last five columns) are broadcast in four navigation messages (rows). These four messages are:

- Freely accessible Navigation Message (F/NAV).
- Integrity Navigation Message (I/NAV).
- Commercial Navigation Message (C/NAV.)
- Governmental Navigation Message (G/NAV).

Table B.5: GALILEO Navigation Messages [i.50]

Message Type	GALILEO Services	Channels	Data Rate (bps)	GALILEO Data				
				Navigation/ Positioning	Integrity	Supplementary	Public Regulated	Search & Rescue
F/NAV	OS	E5a-I	25	×				
I/NAV	OS/CS/SoL	E1B, E5b-I	125	× ×	× ×			×
C/NAV	CS	E6B	500			×		
G/NAV	PRS	E1A, E6A	50	×	×		×	

Focusing on the two GALILEO services CS and PRS, the corresponding GALILEO data are:

- *Supplementary data*, which are encrypted data accessible only by authorized users; these are used to support commercial services such as correction for high precision positioning services, weather alerts, traffic information, etc.
- *Public Regulated data*, which are encrypted data accessible only by government-authorized users and devoted to PRS. These data are under governmental control.

Some further characteristics of the CS and PRS services are summarized below.

GALILEO CS

Targeting the market of commercial applications, CS offers the possibility to provide improved (navigation-related) applications assuring the dissemination of data at a (gross) rate of 500 bps. Encryption and authentication mechanisms are included to guarantee a higher service quality and making the transmitted data accessible only for authorized users subscribed to the service.

As explained in [i.52], GALILEO-external data to be transmitted via the CS are sent to the GSC (located in Spain). After validating the data, the GSC forwards them to the operational GCC (Germany or Italy). The GCC incorporates the CS data into the appropriate (C/NAV) messages and forwards them to the ULSes for uplinking. The GALILEO satellites receiving this transmission incorporate the actual user payload data (448-bit data pages) into the E6B channel, as foreseen for CS data. Users subscribed to the CS service can thus receive and decrypt these payloads.

GALILEO PRS

The GALILEO PRS is designed for sensitive applications. Encryption and appropriate key distribution mechanisms managed by government authorities together with anti-jamming and anti-spoofing countermeasures guarantee service continuity for critical applications.

The PRS end-to-end system design ensures the protection and the availability of the signal and the data transmission. The main entities involved are: GALILEO Security Facility (GALILEO Security Monitoring Center and all Point of Contact Platform); GALILEO ground segment (GALILEO Mission System, GALILEO Control System, GALILEO Sensor Stations and Uplink Station); GALILEO satellites for the broadcast of PRS signal uplinked from the ground segment; the users with PRS receivers.

Detailed technical specifications on the PRS are confidential.

B.2.2.2 Relevant Aspects for MAMES

When considering the use of GALILEO for distributing MAMES Messages, the question arises as to which GALILEO service would be most suitable. As can be seen in table B.5, only the CS and the PRS employ GALILEO data types for use outside the GALILEO core mission, namely "Supplementary" data and "Public Regulated" data, respectively (see the second and third columns from the right in the figure). The C/NAV and G/NAV message types are thus the prime candidates for carrying MAMES Messages, provided that the regulatory and security issues, in particular for G/NAV, can be solved.

As also mentioned in the previous clause, external data that are to be distributed via the CS are brought into the GALILEO system through an interface to the GSC. This also applies to MAMES Messages, which implies that the MAMES Provider will need to connect to the GSC via a mutually agreed interface and associated procedures. Since MAMES Messages potentially carry urgent and safety-critical data, special arrangements should be foreseen to prioritize MAMES data over commercial data.

B.2.3 The EGNOS System

B.2.3.1 General

EGNOS [i.53], the European Geostationary Navigation Overlay Service, is based on a network of ground stations and GEO satellites, designed to augment the GPS/GLONASS satellite navigation system for safety-critical applications (e.g. flying aircraft, navigating ships, etc.).

EGNOS covers Europe, the Mediterranean Sea and parts of Africa and provides the following services:

- the *Open Service* (OS), which is freely available to the general public over Europe (started in 2009);
- the *Safety of Life Service* (SoL), supporting different applications in the transport domain for safety-critical operations (started in 2011); and
- the *Commercial Data Distribution Service* (CDDS) to allow professional users to access additional EGNOS data which are not broadcast by the EGNOS satellites (started in 2010).

The EGNOS architecture is composed of:

- The *Ground Segment*, which includes a network of Ranging & Integrity Monitoring Stations (RIMS) for monitoring GPS signals, four Mission Control Centers (MCC) for data processing and differential corrections computation, and six Navigation Land Earth Stations (NLES) for transmitting accuracy and integrity data towards the GEO satellites. These data messages are generated by the Central Processing Facility (CPF), which resides within the MCC.
- The *Space Segment*, which consists of three GEO satellites for ranging (using GPS-like signals) and for broadcasting EGNOS messages (enhancing the navigation performance) over the service area; and
- The *User Segment*, which is represented by EGNOS end-user devices for the SIS reception.

The EGNOS interaction with the users is achieved by messages encoded in the SIS, which are broadcast by EGNOS GEO satellites. At user level a burst of 250 bits of information is available for each message. An FEC code (convolutional code with rate ½) is used to encode the raw navigation message (250 bits), resulting in a 500 symbol/second EGNOS data stream. The 250-bit messages are structured as follows:

- *Preamble*, for frame synchronization (8 bits);
- *Message type identifier* (6 bits);
- *Data field*, containing various message-type specific signal correction and integrity data (212 bits); and
- *Parity information*, for redundancy and error checking (24 bits).

The 6-bit message type identifier allows the definition of 64 types of messages; currently only 20 types are defined. Table B.6 lists these messages together with the maximum update intervals for the respective message contents (not necessarily the message itself).

Table B.6: SBAS Message types and update rates [i.54]

Message Type	Contents	Maximum update intervals for the message contents [s]
0	Used for testing purposes	6
1	PRN (Pseudo-Random Noise) mask	120
2-5	Fast corrections	6
6	Integrity information	6
7	Fast correction degradation factor	120
9	Geo Navigation Data	120
10	Degradation parameters	120
12	SBAS Network time / UTC offset parameters	300
17	Geo satellite almanacs data	300
18	Ionospheric Grid Masks	300
24	Fast/Long-term corrections	6/120
25	Long-term corrections	120
26	Ionospheric delay corrections	300
27	SBAS Service message (optional)	300
28	Clock Ephemeris Covariance Matrix message (optional)	120
62	Internal test message (optional)	-
63	Null message (optional)	-

According to EGNOS specifications, one of these messages is transmitted every second, thus achieving a total throughput of 250 bps for data. The transmission sequence of the messages is under the responsibility of the EGNOS Service Provider.

B.2.3.2 Relevant Aspects for MAMES

When considering the use of EGNOS for distributing MAMES Messages, it is noted that the data field of EGNOS messages has a capacity of 212 bit (26,5 Byte), which is sufficient for the shortest MAMES Messages (not considering MAMES Message fragmentation).

Secondly, the question arises as to which EGNOS message type could be used. As can be seen in table B.6, all currently defined mandatory message types contain information related to aspects of the EGNOS core mission, which is to augment the GNSS signal. Any re-use of an EGNOS message for MAMES purposes thus potentially degrades the overall EGNOS service (with the possible exception of optional message types). Also, since only one EGNOS message can be transmitted every second, introducing a dedicated EGNOS message type for MAMES purposes would likely have the same effect. Still, the most promising route would be to define a new, dedicated message type for exclusive use by MAMES. Since favourable (e.g. atmospheric) conditions will frequently occur over extended periods of time, such extra EGNOS messages are not expected to significantly affect the overall EGNOS performance. It is up to the EGNOS service provider, in coordination with the MAMES Provider (and/or the Alert Issuer) to set a transmission schedule for these new MAMES-specific EGNOS messages.

As also mentioned in the previous clause, EGNOS messages are generated by the CPF and uplinked by the NLES. The natural point of interconnection with MAMES would thus be the CPF, where the MAMES Message would be inserted into the appropriate EGNOS message.

History

Document history		
V1.1.1	May 2015	Publication