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STELLAR PROJECT: THE GALILEO EMERGENCY WARNING SATELLITE SERVICE (EWSS) DEMONSTRATOR

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Abstract

In 2015, the United Nations adopted a new framework for Disaster risk reduction, the Sendai Framework. The 5th Target within this framework recommends nations to "*substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030*". The Galileo Emergency Warning Satellite Service (EWSS) is the EU contribution to this target.

EWSS is designed to deliver emergency warning information to users of Galileo compatible receivers through the Galileo satellites' Signal-in-Space. This service has been conceived as an early warning system complementary to the ones already established in EU Member States. While Member States and their administration will remain competent in deciding to trigger an advisory, a warning or an alert over their jurisdiction, the Galileo programme offers, thanks to its unique features, a possibility to reach a population on a large scale, including in the cases where the traditional terrestrial alerting systems cannot operate at full capacity or have even collapsed. The main capabilities offered by the Galileo infrastructure to be exploited in the frame of EWSS are:

- Single point of access to Galileo infrastructure for national alert services,
- Worldwide access via the Galileo Signal in Space, independent of terrestrial mobile or internet access,
- Dissemination of an advisory/warning/alert message, including associated instructions to react,
- Authentication of the message by using the Galileo OS-NMA capability (message authentication),
- Geo-location information encoded in the message used to target only the relevant population.

In this context, the objective of the Horizon Europe project "STELLAR" is to demonstrate an end-to-end service delivery with the real Galileo infrastructure, therefore paving the way for an early introduction to Galileo First Generation.

The techncial components of the demonstrations include: : a prototype interface to the Galileo system, a suitable service provision concept, a dedicated operational concept, the Galileo infrastructure, and adequate user equipment. The demonstration's results will be used to consolidate the end-to-end service concept before its entry in operation. EWSS Initial Services are planned to be available in 2024.

Keywords: (maximum 6 keywords)

Nomenclature

BCS-UMF	=	Beacon Command Service User management Function	RLM	=	Return Link Message
CAP	=	Common Alerting Protocol	RLS	=	Return Link Service
C/S, CS	=	Cospas/Sarsat	RLSP	=	Return Link Service Provider
CNES	=	French National Space Agency	S/W, SW	=	Software

CPA	=	Civil Protection Agency	SAR	=	Search and Rescue
DPS	=	Distress Position Sharing	SGSC Centre	=	SAR/Galileo Service
EC	=	European Commission	SGDSP Provider	=	SAR/Galileo Data Service
EENA Association	=	European Emergency Number			
EWM	=	Emergency Warning Message			
EWSS Service	=	Emergency Warning Satellite			
EWOKS Uptake in widespread PWS **S**olutions	=	**E**nabling E**W**S/Galile**O** Mar**K**et			
GMS	=	Ground Mission Segment			
GNSS	=	Global Navigation Satellite System			
GPS	=	Global Positionning System			
KPI	=	Key Performance Indicator			
MCC	=	Mission Control Centre			
MEO	=	Medium-altitude Earth Orbit			
MEOLUT	=	MEO Local User Terminal			
MEOSAR	=	MEO Search And Rescue			
OSNMA Message Authentication	=	Galileo Open Service Navigation			

1 High level concept of the Emergency Warning Service

The principle of EWSS is simple: Member States' civil protection authorities contact Galileo through a dedicated platform and issue a service request for warning its citizens about a planned occurrence of a hazard. The content of the service request is analysed, verified, and converted into an Emergency Warning Message (EWM). The format of EWM allows for encoding the type of hazard, its characteristics (such as severity, time of onset, expected duration), the targeted area, and instructions to react, and more. The EWM is then transmitted in the Galileo system, uplinked by the mission segment to the relevant satellites, and broadcasted over the region targeted by the civil protection authority.

The EWM is embedded in the Galileo Open Signal (E1), as part of the navigation data, and can therefore be received by everyone equipped with a Galileo receiver in view of the broadcasting satellites. Using the principle of geofencing, the user receiver reads and displays the EWM only if it is located within the area of interest encoded in the EWM. In other words, a user is alerted only if he/she is in the geographical target of this alert.

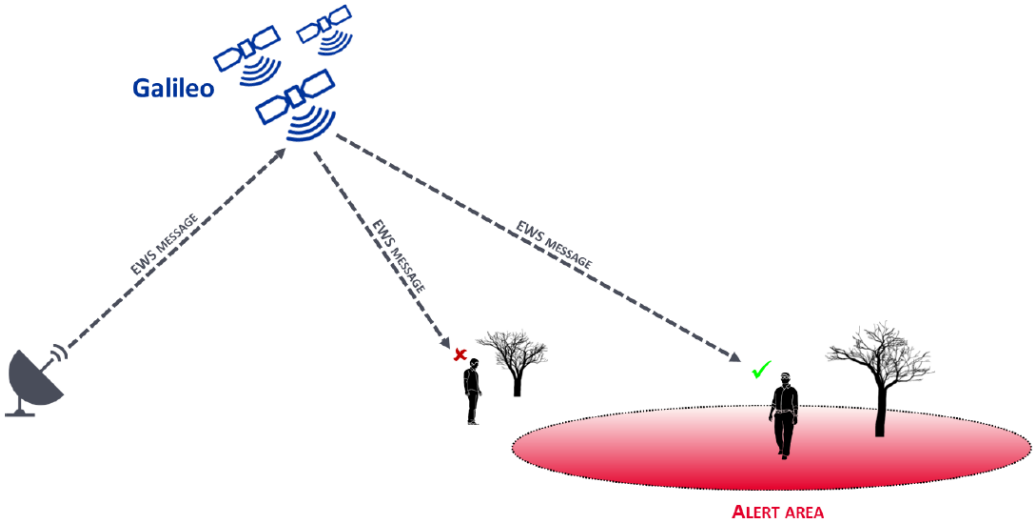

Fig. 1. EWM notification example

2 The STELLAR project ambitions

EWSS will be a key differentiator to further support the Galileo User and Market uptake. In this perspective, the STELLAR project has the ambition to pursue the following three high-level objectives: :

- Deliver impactful and representative demonstrations to create a strong momentum just when the EU member states are deploying their Public Warning Systems;;
- Show case a mature service concept with no blind spots or obstacles- thus ensuring they are perfectly ready for the end-to-end implementation and prepared for a smooth entry into operation;
- Develop an active and sustainable Galileo EWSS community including all stakeholders (EU and international institutions, Technology providers, Civil protection authorities …) to support the adoption in the long term.

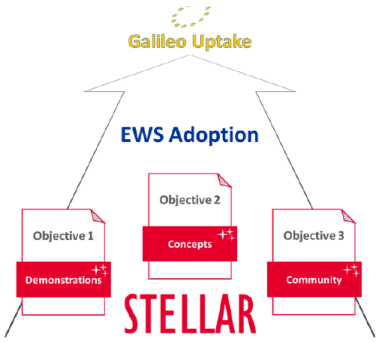

Fig. 2. Stellar Objectives

The STELLAR project will deliver end-to-end service demonstrations using the real Galileo infrastructure. Such demonstrations aim at showcasing to civil protection community the chaaracteristics and benefots of the service.

With the demonstrations, the STELLAR consortium will showcase a representative end-to-end process of delivering an EWM covering the full transmission chain, from Civil Protection Authority to the citizens through the Galileo infrastructure and mass-market user equipment (such as a smartphone).

The close cooperation with the Civil Protection Authorities involved in the demonstrations and their feedback allows for consolidating the service concepts ahead of entry in operation..

An active community of EWSS stakeholders is part of the project to give reality to the future service and keep it alive to share and agree on a common understanding and a common vision. Communication and dissemination

activities will be of great help to support the service adoption by raising awareness and interest to a growing audience.

3 The STELLAR project organization

The STELLAR project is primed by Telespazio France, with F24 France (F24), the European Emergency Number Association (EENA) as partners, and with the Centre National d'Etudes Spatiales (CNES) and Thales Alenia Space France (TASF) as subcontractors.

Fig. 3. Stellar project organization

4 STELLAR demonstration overall architecture

The messages are broadcasted through the Galileo constellation via the Return Link Service Provider (RLSP) interface. The RLSP provides the capability to embed additional data within a long RLM message described below:

- Long RLM

Part (1/8)			Part (2/8)			Part (3/8)			Part (4/8)			
		SAR RLM data			SAR RLM data			SAR RLM data			SAR RLM data	
Start bit = 1	Long RLM	Beacon ID (1/3)	Start bit = 0	Long RLM	Beacon ID (2/3)	Start bit = 0	Long RLM	Beacon ID (3/3)	Start bit = 0	Long RLM	Message code	Parameters (1/5)
1	1	20	1	1	20	1	1	20	1	1	4	16
22			22			22			22			

Part (5/8)			Part (6/8)			Part (7/8)			Part (8/8)		
		SAR RLM data			SAR RLM data			SAR RLM data			SAR RLM data
Start bit = 0	Long RLM	Parameters (2/5)	Start bit = 0	Long RLM	Parameters (3/5)	Start bit = 0	Long RLM	Parameters (4/5)	Start bit = 0	Long RLM	Parameters (5/5)
1	1	20	1	1	20	1	1	20	1	1	20
22			22			22			22		

Table 1. SAR Long RLM data

The following figure provides a simplified view with the main elements of the architecture involved in the broadcasting of Emergency Warning Messages (EWM) data.

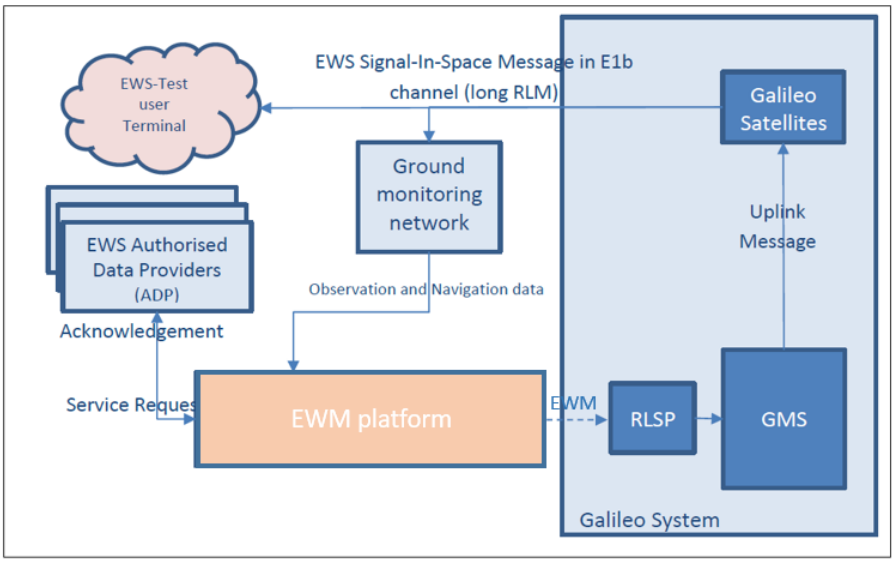

Fig. 4. EWSS Demonstrator architecture

After reception of a service request from an EWSS Authorized Data Provider (EWS-ADP), the EWM Platform will build the related EWM and will format it for transmission to RLSP for encapsulation in a long RLM. The EWM is then provided, via the EWM recipient, to RLSP and then to the GMS and uplinked to the satellites, and is eventually received and processed by the EWSS Test User Terminal (EWS-TUT). The EWM Platform, through an adequate Ground Monitoring network, will verify the compliance of the broadcasted message versus the original service request from the EWS-ADP.

The EWM Platform will interface through Internet with the EWS-ADP as well as with the Ground Monitoring Network. For security reasons, the EWM built at EWM Platform and received at the EWM recipient will be provided manually to the RLSP operator through a portable device via air gap, as shown in figure above.

In addition to EWSS data management, the EWM Platform server has both monitoring and showcasing missions.

First, the EWM Platform server aims at monitoring the proper functioning of the demonstrator For this matter, the status of the Service Requests (received, under processing, EWM generated, EWM provided to EWM Platform, EWM included into Galileo SiS), the status of connection with EWM Platform clients and the compliance of the EWM (EWM sent to RLSP versus EWM received by reference stations) will be monitored and displayed in the EWM Platform HMI. The service KPIs will be monitored for reporting the service demonstration performances.

In parallel, the health and status of the Galileo constellationwill be monitored, as well as the following key figures displayed in the HMI: satellite coverage, satellite ID, DOP, C/N0, sky view and satellites footprints.

The data necessary for this monitoring will come from:

- The demonstrator itself (e.g. a database managed by EWM Platform Server will maintain up-to-date status of all received Service Requests)
- A Ground Stations network, collecting in real time Galileo observation and navigation data.

5 STELLAR demonstration building blocks

The demonstration concept is based on existing building blocks and on components to be developed as part of the project.

The EWSS demonstrator detailed architecture is described in the figure below:

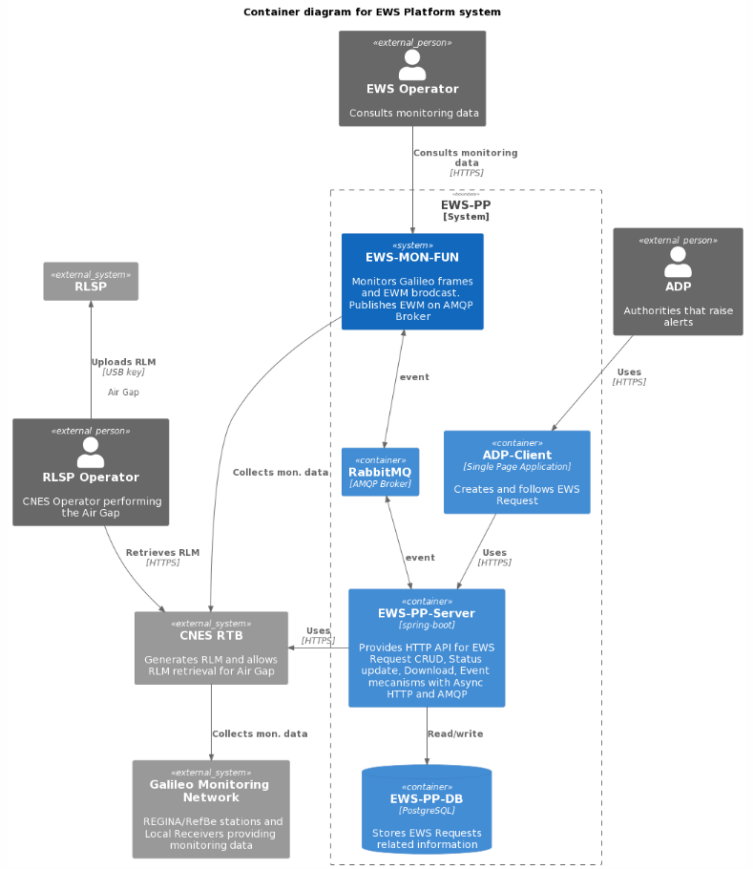

Fig. 5. EWSS Demonstrator detailed architecture

5.1 *The EWS-PP-ADP Client*

The EWS-PP-ADP Client represents the national civil protection entities in charge of issuing alerts on their jurisdiction. Alert messages are generated in the CAP format for further processing and interpretation. The demonstration archirtecture allows for the reception of such a CAP message generated by the participating national entities.

The Client is the entry point of the system for the ADP user.

It is a thin client with which the ADP user can send the alerts. The user loads the request as an already prepared CAP or from a blank form, edits the request and submits it to server. It also allows to follow the process of the EWSS Request..

The EWS-PP-ADP-Client will generate a message formatted as per Common Alerting Protocal (CAP), directly convertible into a EWM by the EWS-PP Server.

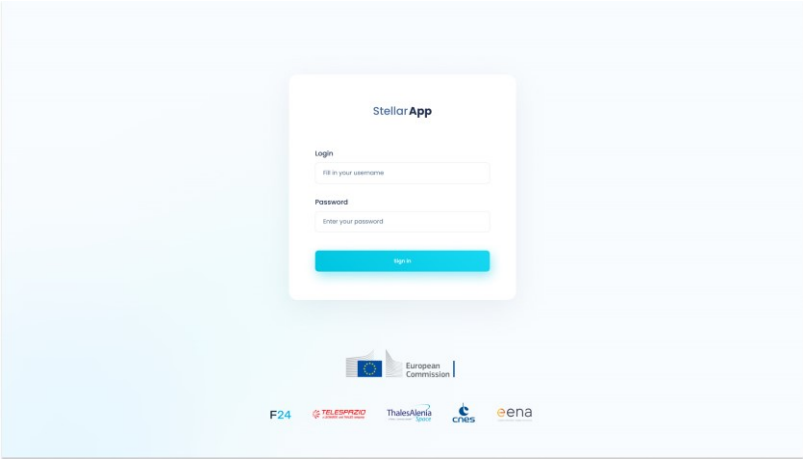

Fig. 6. EWS-PP-ADP-Client first page

5.2 *The EWS-PP-Server*

The EWS-PP is the platform that receives the service request from the EWS-ADP.
The EWS-PP-Server has the responsibility to:

- Provide HTTP API to manage EWSS Requests
- Verify CAP file validity
- Compute an ellipse corresponding to the alert area
- Compute the EWM bit chain from the EWSS Request parameters
- Encode the EWM into a RLM xml file (not to be done in case of deployment in CNES RTB – solution 1).
- Provide event mechanisms for request state monitoring needs.

The server is hosted by the CNES Return Link Test Bed (CNES RTB, see figure 3) that provides standard services (user authentication, database management, generic export features) to allow the sending of the EWM message within an RLM request from the operational RLSP. The test bed also provides the capability to retrieve information for the SGDSP (SAR Galileo ground segment, see section 2.3.2) that are:

- from the MEOLUT ground segment: calibrated detections and raw locations,
- from the REGINA network (https://regina.cnes.fr/en/general-presentation): semi-real time monitoring of the return link messages dissemination through the Galileo constellation

5.3 *The EWS-MON-Services*

The objective of STELLAR monitoring service is to provide the capability to collect, understand, and detail what happens in the delivery of the Emergency Warning Service messages. The implementation of STELLAR monitoring service is then divided into 2 main functions:

- Collect reception information from a receiver or from a group of receivers
- Provide means to analyze dissemination performances

5.4 *The Galileo System*

The Galileo system will be used to disseminate the EWM, without impacting the operational service provision. The interface has been chosen as the RLSP for the purpose of the demonstration.

5.5 *The EWSS test-user terminal*

The EWSS test-user terminal is the final recipient of the EWM broadcast by Galileo. It shall take the form of a standard smartphone equipped with Galileo positioning technology and standard mobile connection features. It shall be able to decode and interpret the EWM and notify its users with the information therein.

5.6 *The ground monitoring network*

The ground-monitoring network consists of GNSS-capable stations distributed in the area of interest for the demonstration and is capable of retrieving and decoding the raw data coming from the Galileo satellites.

The STELLAR project will rely on the REGINA network to ensure the monitoring of EWM broadcasting. The REGINA infrastructure is based on a global network of more than 30 GNSS stations, equipped with receivers capable of acquiring signals from current and future navigation systems (in particular GPS, GLONASS, GALILEO, BEIDOU and various SBAS) and provide real-time (RT) and non-real time (DT) data streams. Network deployment is done in collaboration with many organizations with the aim of having the best worldwide coverage. It also includes the upgrade of French GNSS partner stations operated by CNES and the integration of IGN stations. For site selection, it is sought to colocalize several spatial geodesy measurement techniques such as DORIS, in order to participate in international terrestrial reference system (ITRS).

REGINA provides state-of-the-art navigation data to the scientific community with a very good availability. A modern mission center is operational since June 2016 and allows network monitoring, data processing, and data dissemination to users.

Fig. 7. REGINA network

6 The outcomes of the STELLAR project

In addition to the demonstration platform that will be developed for the project, the following main outcomes are worth mentioning.

6.1 *The computation of the area to alert*

The objective of the demonstration project is to show that users over an area that is defined by the national civil protection entities can be alerted timely on their personal equipment. The picture below depicts the look and feel of the Stellar application:

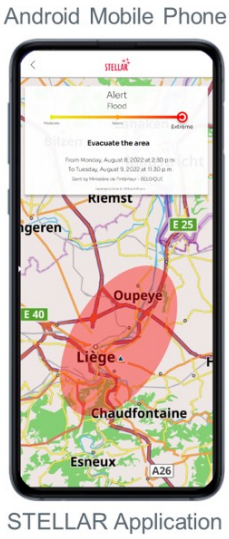

Fig. 8. STELLAR application

In the CAP, alert areas are defined as polygons. For conversion into EWM alert area, the optimal ellipse shall be computed, meaning that the two following criteria are covered:

- All the people inside the ellipse target area must be alerted;
- Outside the target area, as few people as possible must be alerted.

The first point implies that the ellipse must encompass all the target area. The second one implies that the ellipse must have the smallest surface as possible.

In addition, the ellipse of the EWM is defined by sampled parameters: the centre of the ellipse is a point belonging to a grid, the axes have discrete possible values, as well as the rotation angle.

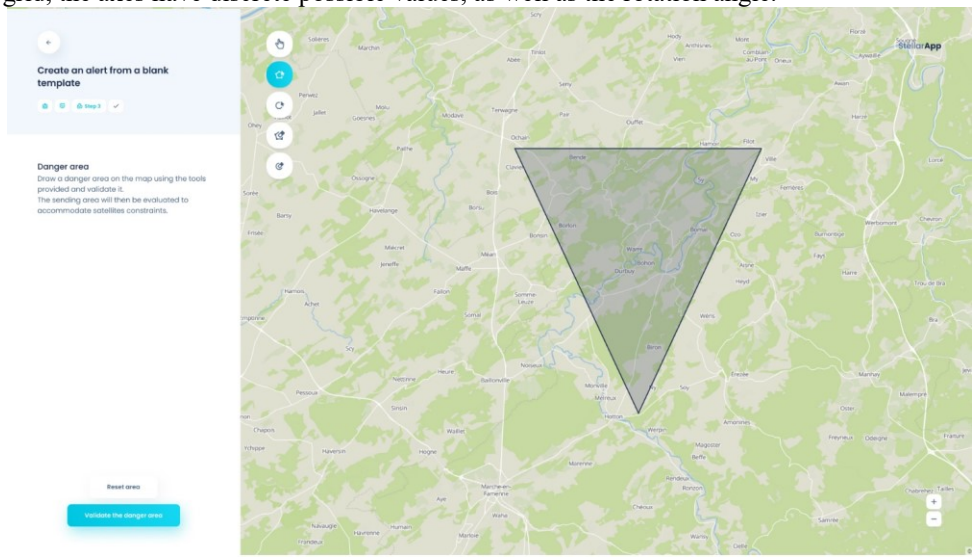

Fig. 9. Example of alert zone provided in CAP message

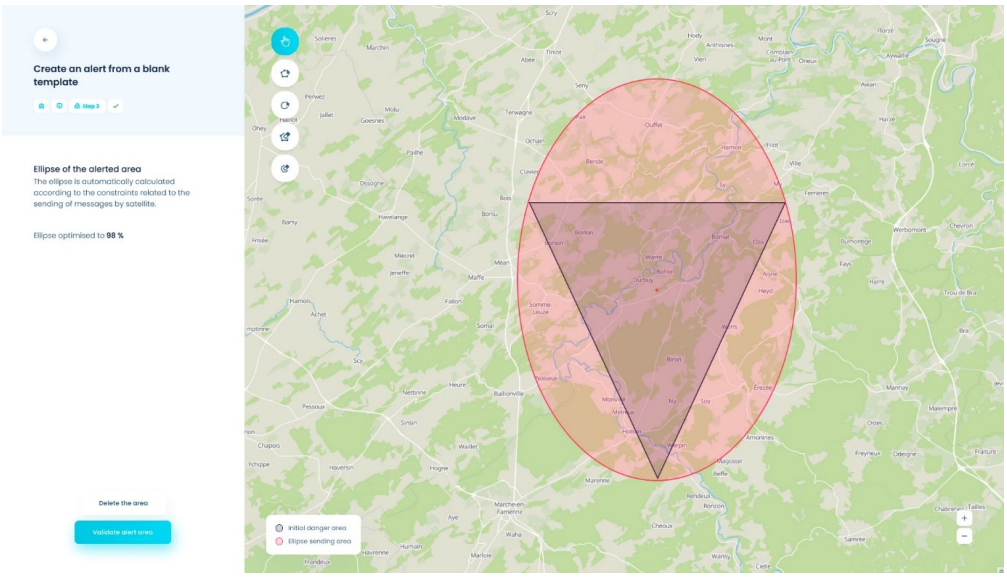

Fig. 10. Optimal alert area to be broadcasted in the EWM

The ellipse calculation function will be developed as a Python script, with the following parameters:

- Input parameter: the CAP polygon, provided as a list of latitude/longitude couples.
- Output parameter: an EWM compatible ellipse, provided as a center (latitude/longitude couple), semi major and minor axes and azimuth rotation angle.

The EWM compatible ellipse shall:

- Contain the whole CAP polygon.
- Be defined by constrained parameters allowed by the EWSS Message format
- Offer the ratio surface of CAP polygon / surface of EWM ellipse the closest to 1.

6.2 *The demonstration campaigns*

Following the development of the demonstrator bricks, the project will run several demonstration campaigns. There are currently three batches of simulations foreseen:

- Batch 1: Industrial chemical site explosion event in France and in Germany
- Batch 2: Intense wildfire in Greece / Tsunami in Cyprus
- Batch 3: Cross-border floods in Belgium and Luxembourg

All components developed (EWS-PP Client, EWS-PP Server, EWS-TUTs) and existing operational system (RLSP, Galileo infrastructures and satellites) will be used for the demonstration campaigns.

For each batch of simulations, the organization will be identical: preparation campaign, briefing, dry-run, demonstration execution, and debriefing.

6.3 *The EWSS OPS Concept definition*

The idea is to consolidate the Service Concepts (operational and technical) required by all the actors of the EWSS value chain to understand, implement and use the service: The Concept of Operation (CONOPS), the Service Definition Document (SDD), The EWSS Message format (EWSS format), and The EWSS instructions (EWS-INST).

All opportunities to interact with the authorities and other EWSS stakeholders will be leveraged to obtain feedback on the Service Concepts, in particular with each demonstration feedback session. The protocol of operation will be reviewed with civil protection authorities, relying on EENA's network and stakeholders involved in the demonstrations. All the feedback and recommendations will be presented at the final workshop (see following section) for a last feedback session to issue the final version of the service concepts.

The communication activities will also be leveraged to widen the source of information and increase the variety of feedback to be used in the Service Concepts refinement process. An internal report will be prepared after each event to list the involved stakeholders and record their feedback to be used as input for the Service concepts.

7 Schedule

The overall schedule of the STELLAR project is presented herebelow.

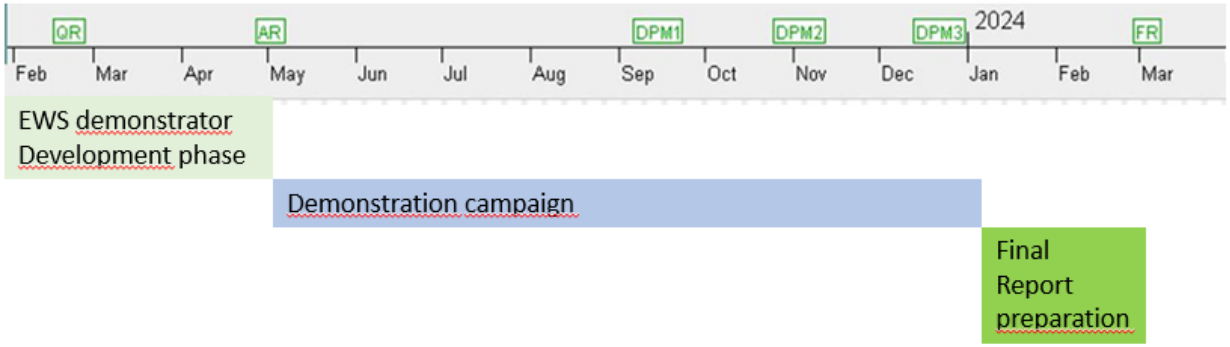

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Fig. 11. STELLAR project schedule

8 Conclusion

The in-field demonstation campaign will be useful to test for the first time the end-to-end service concept using the Galileo infrastructure. Involvement of civil protection authorities will ensure the service concept is well understood, supporting efficiently the integration steps of this satellite capacity in the established national alert systems. The integration of the necessary decoding function in user equipment is carried out in parallel, and international attention is arising notably with other GNSS Providers worldwide. Overall, key factors for the success of EWSS are: coordination with the Civil protection authorities, constructive discussions with the smartphone manufacturers to implement the adequate libraries directly in the firmware, promote service introduction and interoperability with other GNSS Providers.

Acknowledgements

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References

In the text

[1] : http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html

[2] : GRALLE – Galileo Reliable Automatic Low Latent Emergency Warning Service (europa.eu)

Reference to a journal publication:

[1] Emergency Warning Service in Galileo State of play – EC presentation at ICG 16, October 2022https://www.unoosa.org/documents/pdf/icg/2022/ICG16/WG-B/ICG16_WG-B_10.pdf [2] Tender Specifications of European Commission Call for tenders DEFIS/2021/OP/0006 Emergency Warning Service Demonstrator