A MULTI-SENSOR/MULTI-RAT SOLUTION FOR INTEGRATED EARTH & SPACE DISASTER MANAGEMENT SERVICES

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Abstract

The recent growth of emergencies caused by natural phenomena or human activities such as fires, flooding or landslides is providing a major pull demand of added value Disaster Management Services. To respond accordingly to the above strong needs, new coming Solutions shall be based on both Earth and Space integrating Communications, Navigation and Remote Sensing technologies. Moreover, the forthcoming 5G technology combined with satellite communications shall offer a better and more effective infrastructure to be used in emergency responses. With this purpose, a complete system architecture is proposed below, exploiting new interoperability layers among terrestrial / satellite technologies and stratospheric platforms to study, design and implement a new solution to support the Rescue Teams to prevent, monitor, detect and respond/mitigate the impact of disaster events. Bearing in mind the main objective of providing an efficient and resilient integrated service for the management of emergencies, in this paper the solution/system architecture shown in Fig. 1 will be described.

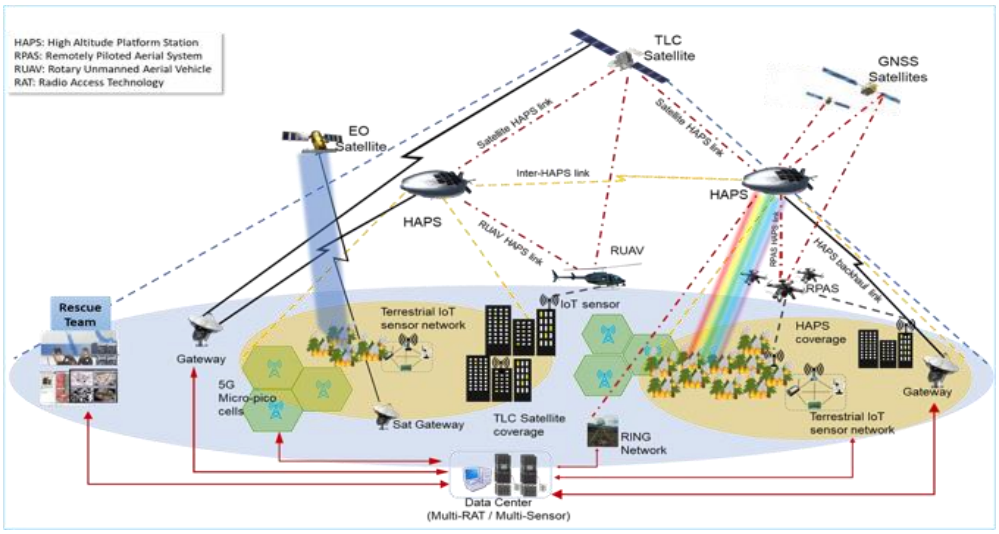

Fig. 1 Advanced Solution Architecture for integrated Earth & Space disaster management services

The disaster management service system, with the aim to reduce socioeconomic impacts in terms of loss of human lives of residents and first responders, health, infrastructures and economic activity, proposes an incremental solution, to enable new applications that can truly help Society in the real life, especially for the disaster prevention, monitoring, detection and response scenarios. This would require the harmonization of interoperable communication, navigation and remote sensing services based on the following main innovation elements:

- **Remote Sensing sensors**: both based on Spaceborne EO sensors (SAR, optical, etc.), High Altitude Platform Systems (**HAPS**) with on-board EO optical sensor payloads and earth IoT and RPAS sensors;
- New generation of **Smart Internet of Things (IoT) Sensor Networks** (infrared, temperature, geodetic, meteo, etc.), fast deployable on the territory and remotely configurable on a cloud based system via 5G, narrow band Satcom links (e.g. Iridium) or via IoT Satellites (e.g. LoRa satellite/terrestrial/ network);
- Remotely Piloted Aerial Systems (**RPAS**) for: a) **Low Air** prevention/monitoring and reconnaissance to identify the optimal paths and response area to minimize the risks of Rescue team lives; b) **High Altitude RPAS** preparedness for Local Weather forecasting useful for Prediction models and weather indexes for Fires, Flooding, Landslides, etc.
- Rotary wings Unmanned Aerial Vehicle (**RUAV**) or manned helicopter: foreseen to support the monitoring and detection operations (e.g. surveillance and reconnaissance of fire, landslides, earthquakes faults & shocks damage) in order to localize safely and in a more precise and detailed way the area of intervention.
- **Resilient Hybrid Networks** relying on different telecommunication Radio Access Technologies (RAT) including SatCom, 5G, stratospheric **HAPS** with on-board TLC payload, wireless ad-hoc networks and optimal algorithms based on a combination of Artificial Intelligence algorithms for network resource management and classic control / optimization methods;
- **5G/PNT solutions:** for *Positioning Navigation & Timing services* to support the Emergency Monitoring and Response;
- **Decision Support System**: to propose a set of mitigation actions and Logistic solutions for optimal land re-deployment of IoT sensors networks and resources based on the field state and the current deployed emergency measures (e.g. personnel in the field, emergency vehicles position, etc.). The system will utilize a prediction model to evaluate which measures are the best, allowing to offer an efficient service and to reduce service costs.
- **Data Center**: the system envisages the use of Satellites for earth observation (EO) in LEO orbit with SAR on-board sensors, which can provide the science data to be collected and processed in the Data Center with a Big Data repository of geo-referenced remote sensing data, where several different advanced data analytics services, based on **AI/ML technologies**, will be provided in a marketplace environment.

The prevention and monitoring processes will require planned and unplanned sensing procedures gathering real-time information and accurate dataflows, coming from raw data and processed aggregated data with high consistency, at the aim to provide a reliable repository of emergency data for all the emergency management phases.

As far as the disaster management is concerned, the proposed solution then affords a robust infrastructure to allow the access to use all the science data, coming from the already mentioned heterogeneous sensors, collected and analyzed in a Big-Data repository within the Data Center. This assures the ability of the Data Center to provide the required *Situation Awareness Services* to know in real time the location where the emergency is occurring and the entity of it, so the local Rescue Team can choose the most suitable countermeasures to be used in-situ, eventually aided by decision support systems with a set of mitigation actions based on the field state and the current deployed emergency measures (e.g. personnel in the field, emergency vehicles position, etc.).

Finally, the solution envisages an easy access of different Rescue Teams to a Data Center portal with a Rescue Team Emergency Dashboard supporting the decision makers for the emergency response phases.

In this paper a new integrated solution for disaster management services, relying on a complex Earth and Space multi-sensors/multi-RAT system architecture will be described in all the main components supporting the rescue teams in all the relevant critical phases of prevention, monitoring, detection and response.