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Wireless Public Safety Networks Techniques and Challenges

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LATINCOM 2010, Bogotá, Colombia

Outline

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  - Public Safety Networks
- **II - Alert Phase Support**
  - Vehicular Disruption Tolerant Networks
  - Virtual Access Points for Mobile Communication
- **III - Crisis Management Phase Support**
  - Challenges
- **IV - Ongoing projects on this field**
  - HNPS
  - RATCOM
- **V - Conclusions**

Introduction - Public Safety Networks

- **Unfortunately, disasters always occur**
- **Public Safety Networks (PSNs) are the networks set by the authorities to enable communication to either warn the population about an imminent catastrophe or coordinate teams during the crisis and normalization phases**

Public safety networks role

- **Goal: *Protection of Life and Property***
- **Public Safety communication is mission critical**
- **Communication during disasters**
  - 10-50x more network load as normal
  - Has to be set within 30 minutes
  - No time to bring in extra capacity
  - Erlang calculations based on normal use not applicable for Public Safety
- **It must be there !**

State of the art

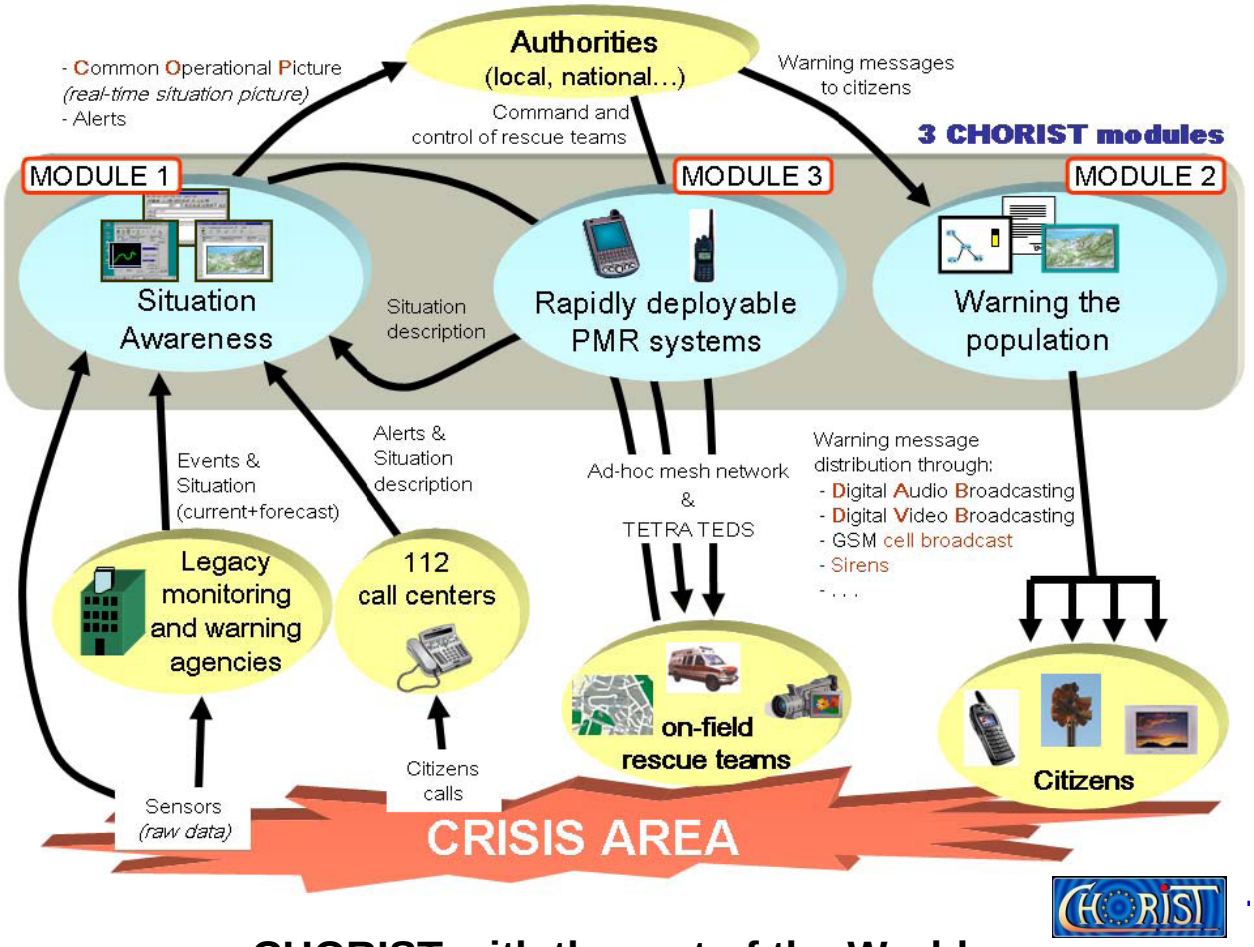
- **Limited interoperability, limited integration, limited awareness**
- **Lack of standardization and openness**
  - **European Security Research and Innovation Forum:**
    - ESRIF: " …the growing complexity of security, demands [...] modular generic capabilities and solutions at the system-of-systems level. …"
  - **European Organization for Security:**
    - ESO: "...EU Security Market is still fragmented and unstructured …"

Different sites, different requirements

- **One of the main issues for PSNs is that Different sites may have distinct requirements**
  - **But the equipment and people attending are frequently the same**

Reference architecture - CHORIST

- **CHORIST**
  - European Commission project, to address Environmental Risk Management in relation to natural hazards and industrial accidents
  - http://chorist.eu
- **Three main components**
  - **Detection of hazards**
  - **Support for field operations**
  - **Population warning**



- **CHORIST with the rest of the World**
  - Integrating communications for enhanced environmental risk management and citizens safety

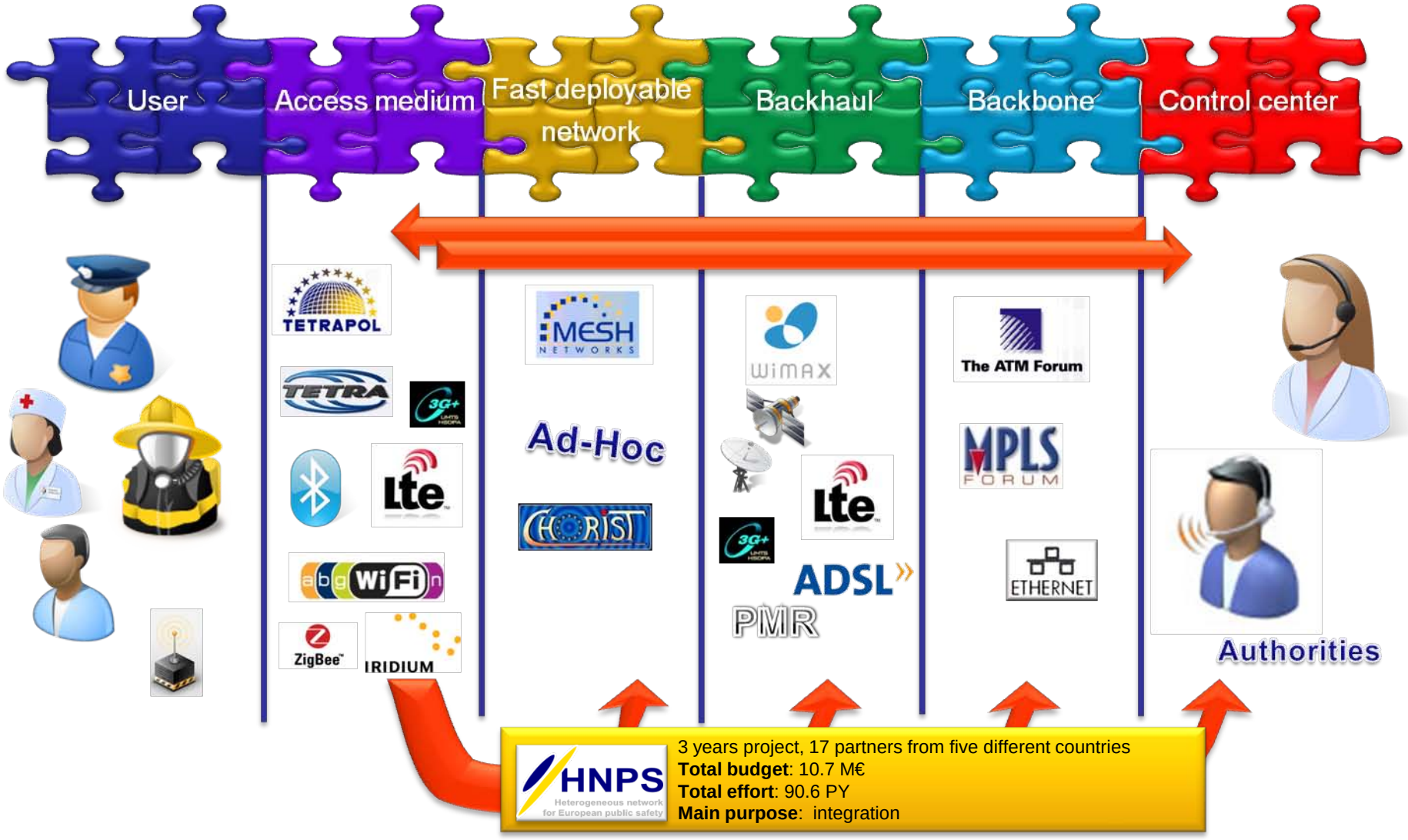
Disaster management phases

- **Preparedness consists of being prepared to the possible future disaster**
  - Personal training, equipment checking…
- **The Crisis Phase, goes from the moment the authorities decide to intervene to the exactly aftermath, when lives can still be saved**
  - Alert and Crisis handling sub-phases
- **Return to Normal Situation phase is when the infrastructure of the affected area is being rebuild**

Crisis phase

- **The Crisis Phase, goes from the moment the authorities decide to intervene to the exactly aftermath, when lives can still be saved**
- **In a disaster situation human lives are in danger**
  - September 11th reports point to communications failures as one of the direct causes to the loss of at least 300 firefighters and to many others lives indirectly
  - Telecommunication infrastructure may be seriously affected
  - Communication is required to:
    - provide information of the site to concerned people
    - Coordinate intervention teams

Possible interconnections



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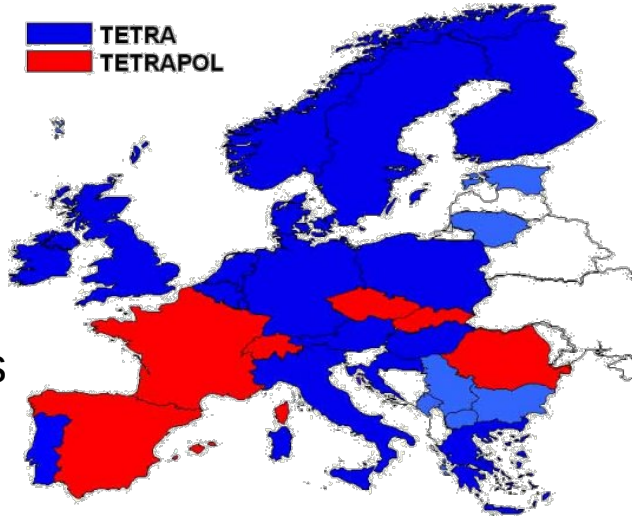
Public safety systems

- ***Terrestrial-based solutions***
  - **HF, VHF, UHF equipment**
    - ☞Amateur radio is often used as a means of emergency communication when conventional communications fail
  - **Professional Mobile Radio - PMR**
    - ☞System used by police centers and fire brigades
    - ☞Trans European Trunked Radio (TETRA)
      - provides excellent voice quality and ensure secure encrypted communications



Public safety systems

- ***Satellite-based solutions***
  - Even if the terrestrial network is completely out of order, it remains always possible to communicate using the satellite network
    - ☞ Ubiquitous Coverage: a group of satellites can cover virtually the entire Earth's surface
    - ☞ Instantaneous Infrastructure: satellite services can be offered in area where there is no terrestrial infrastructure and the costs of deploying a fiber or microwave network are prohibitive

Public safety systems

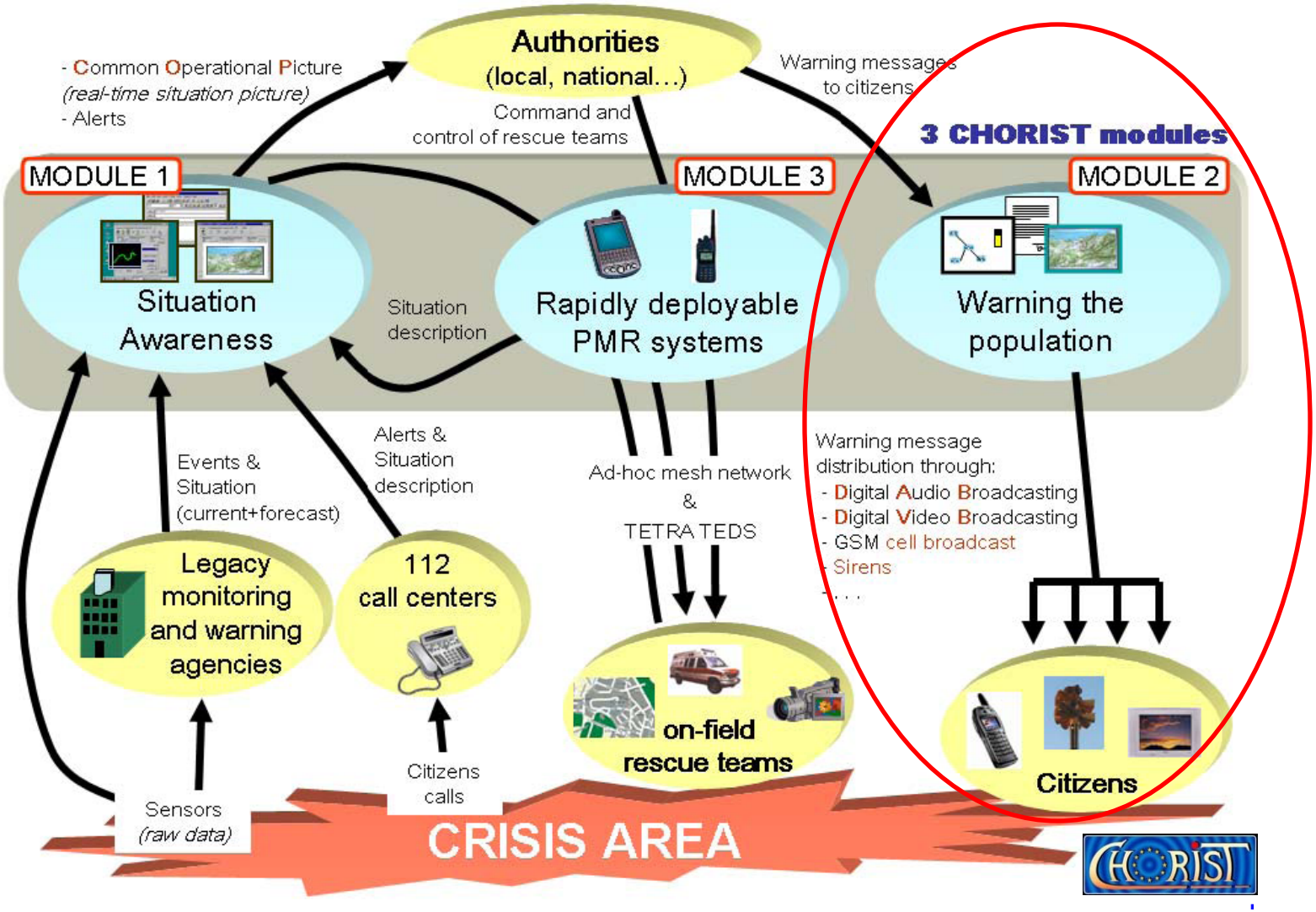
- ***Communications On The Move (COTM)***
  - It is one of the most promising solution for emergency communications for Fixed Satellite Service (FSS) and Mobile Satellite Service (MSS)
  - Can provide fully mobile IP data and voice services to vehicles on the move up to 100 km/h
    - Any vehicle can also serve as a mobile command post
    - A full 10 Mbps downlink channel is delivered via FSS with a 512 Kbps uplink channel

Public safety systems

- ***Hybrid satellite/terrestrial solutions***
  - TRACKS
    - A prototype van developed by *EADS Astrium*
    - Transportable communication station (VSAT terminal, GSM Micro Switch, BSC and BTS, internet access) dedicated to support pre-operational applications
  - EMERGESAT
    - Developed by Thales Alenia Space
    - Basically a container especially designed, for transportation in the luggage hold of any passenger line aircraft
    - Contains all the necessary equipment to provide communication in a public safety scenario

II - Alert Phase Support

Reference architecture - CHORIST



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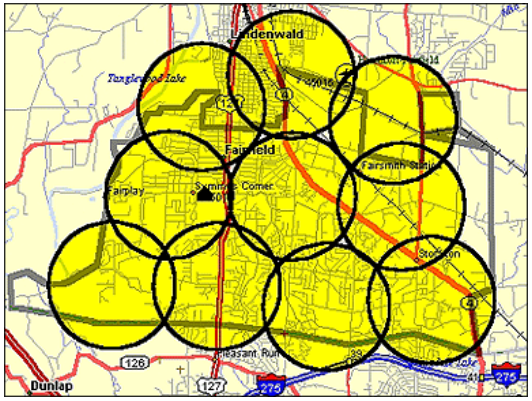
Alert Sub-phase

- **The alert phase consists of warning concerned people about an eminent dangerous situation**
- **Should reach as many concerned people as possible**

Alert phase: The main problem

- **People concerned by an eminent danger must be warned**
  - People may not watching TV or listening radio
  - Sirens
    - ☞Complete coverage is expensive
  - For all the mediums, in the advent of a catastrophe, equipments could be damaged



The City of Fairfield's network of 10 weather warning sirens

- **How to send warnings to uncovered areas?**

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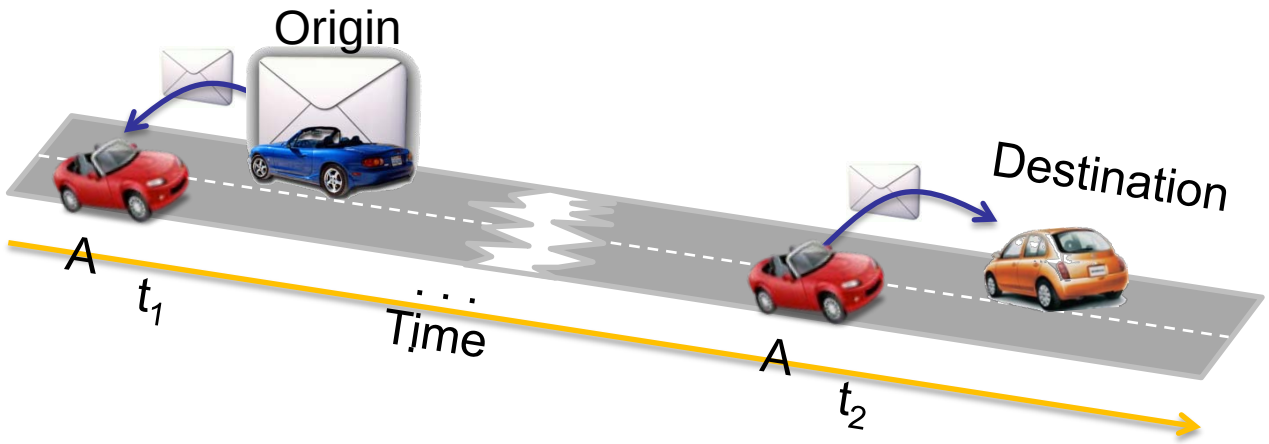
On demand warning communication

- **Delay/Disruption Tolerant Network (DTNs)**
  - In this environment an end-to-end path from source to destination may not exist.
  - However, nodes can still connect and exchange information in an opportunistic way.



On demand warning communication

- **RATCOM solution**
  - Virtual Road Side Unit approach
    - Areas without Road Side Unit (RSU) are covered by other cars
    - Each car stores in a queue the received data to rebroadcast it to other cars
    - Indeed, each car works as a small cache for the others
  - When a car reach an uncovered area it rebroadcasts the stored messages for the nodes around

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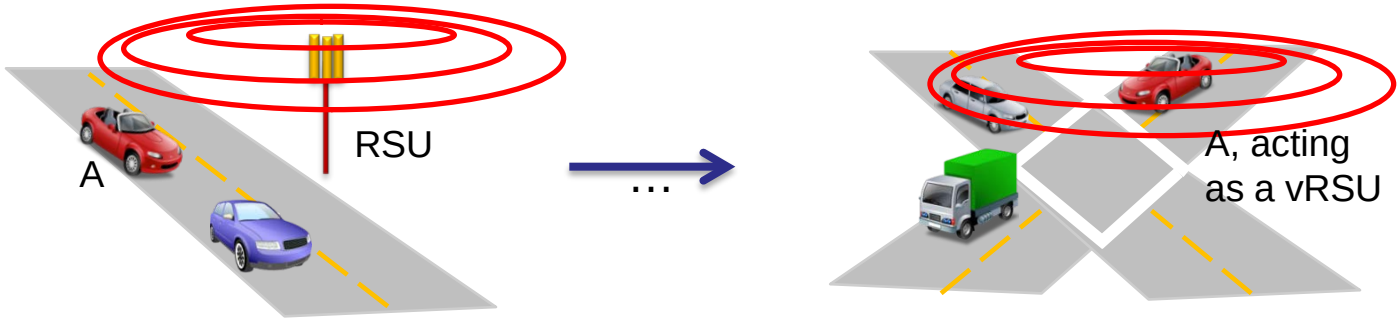
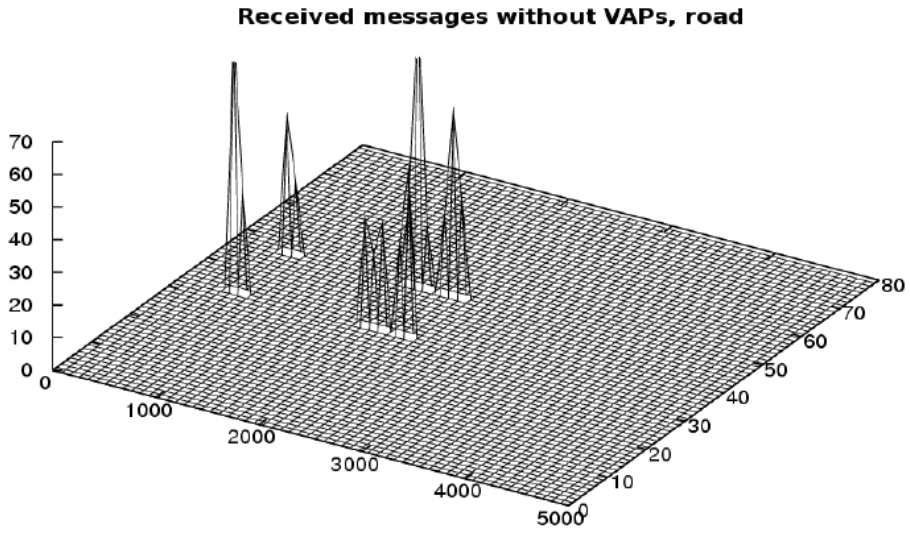
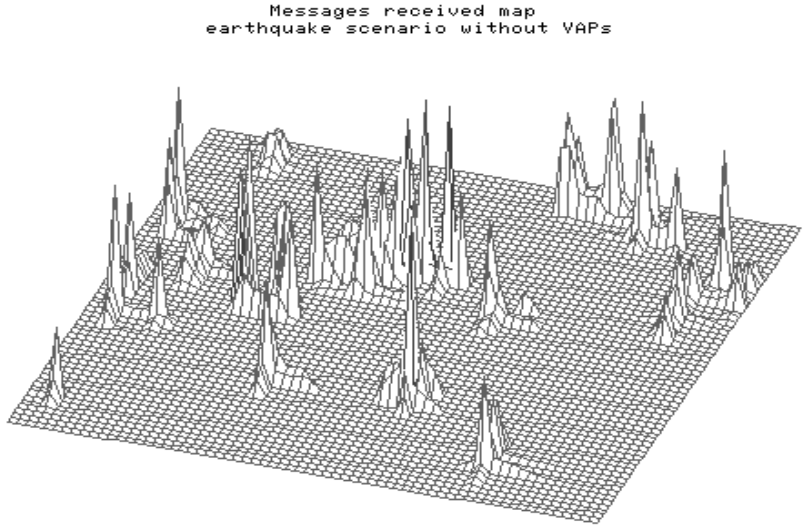
Virtual Road Side Units

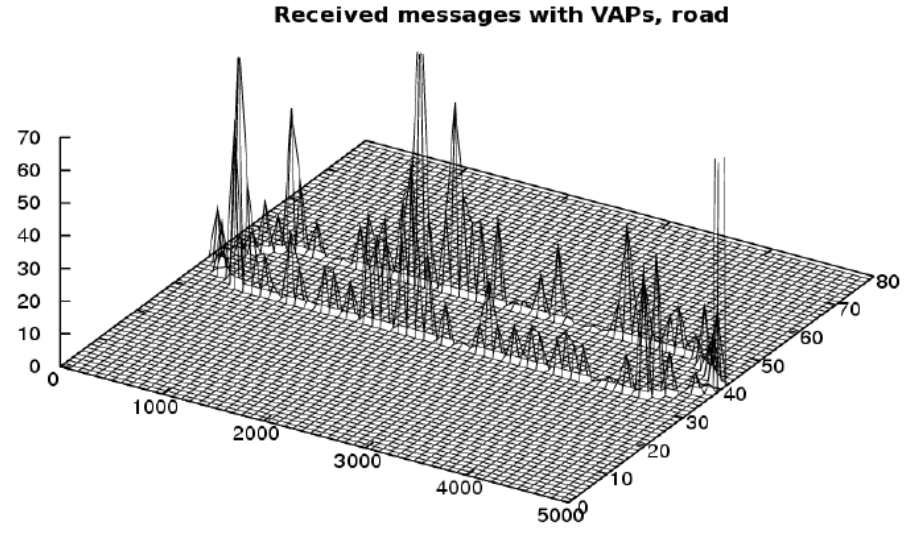
- **Virtual Road Side Units**
  - Increase the network coverage
  - Transparent for other nodes
  - Can be either dynamically or statically assigned
    - ☞Predefined areas or nodes detecting areas without coverage

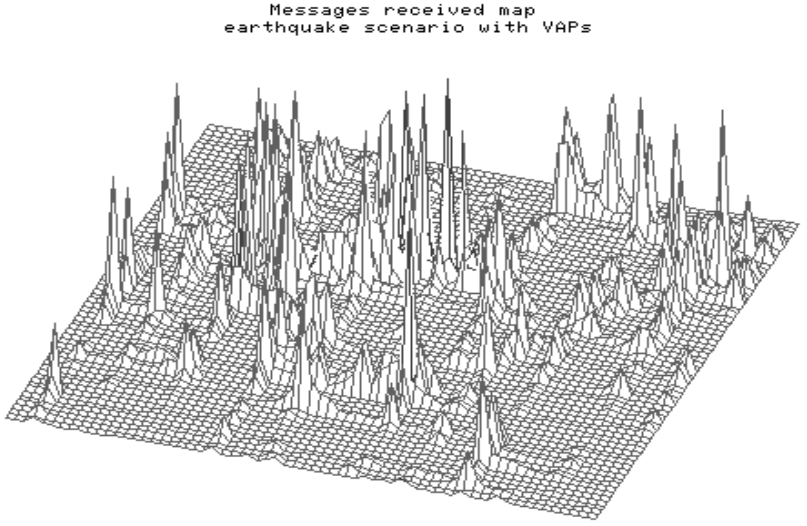


Messages distribution diagrams









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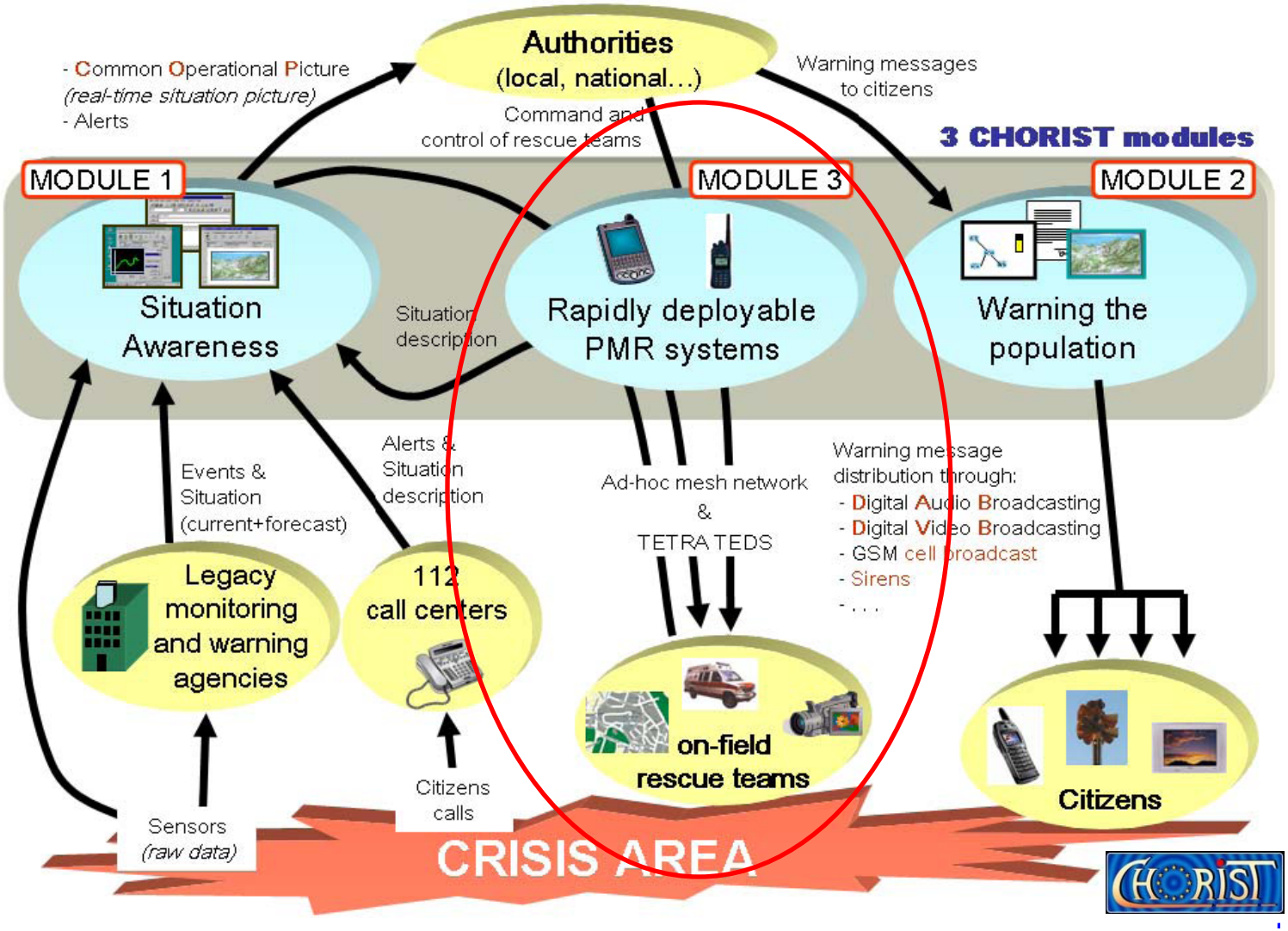
III - Crisis Management Phase Support

Reference architecture - CHORIST



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Crisis handling

- Coordination of Intervention Teams begins when the crisis breaks out
  - Local Authorities alerted just before the population
- Establishment of the Risk Management Centre
- Intervention Teams send back information to Local authorities, Risk Management Centre and Health Centers

Crisis handling network

- Specific technology requirements
  - Each kind of disaster site has its own nature and has specific communication needs
- Mobility, reliability and scalability
  - Devices must be capable of automatically organizing into a network and let the intervention teams focus on their job

- Interoperability and interdependency
  - Regardless of what technology each team might use, they should be able connected and exchange data
- Multimedia broadband services
  - Real-time video, medical data, digital maps, blueprints or intelligence data

Some challenges for this phase

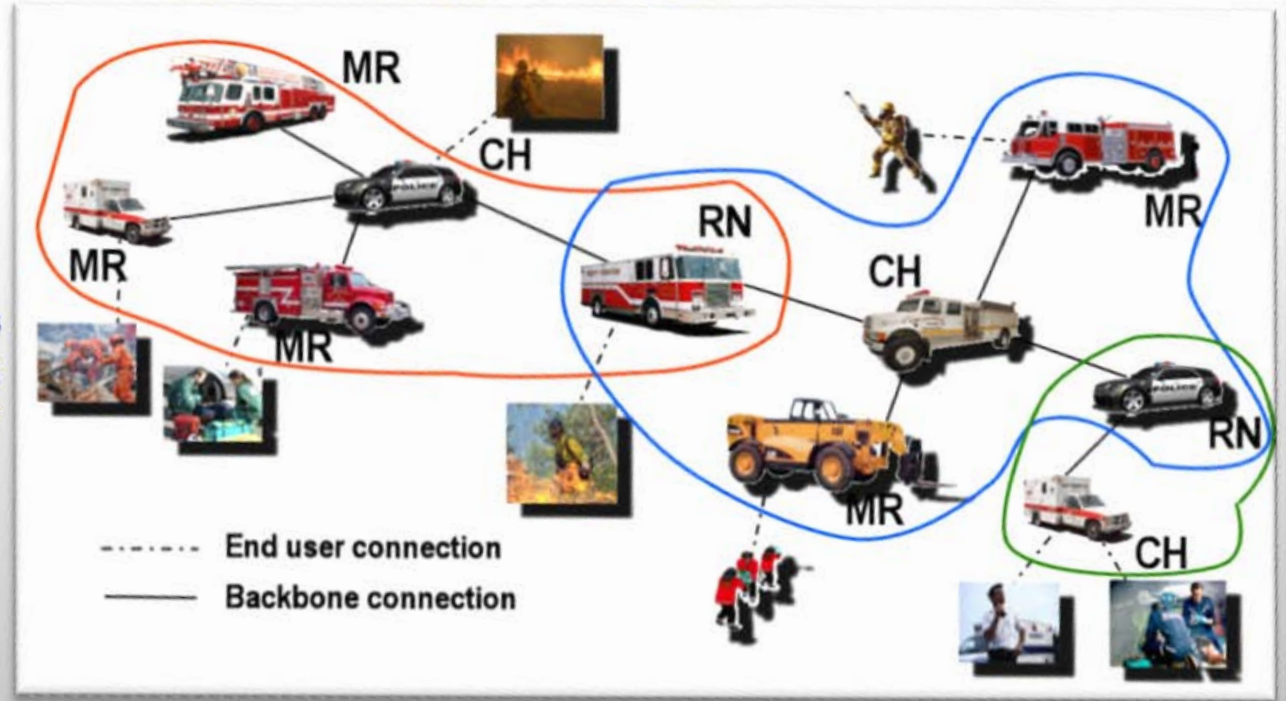
- ***Medium access control issues***
  - Reliability over highly unstable environments
  - Not adaptive solutions
  - Integration of different technologies
- ***Network layer issues***
  - Topology control
  - Mobility management
- ***Application layer issues***
  - Multihoming
  - Usability issues

Network Layer challenges: Topology management

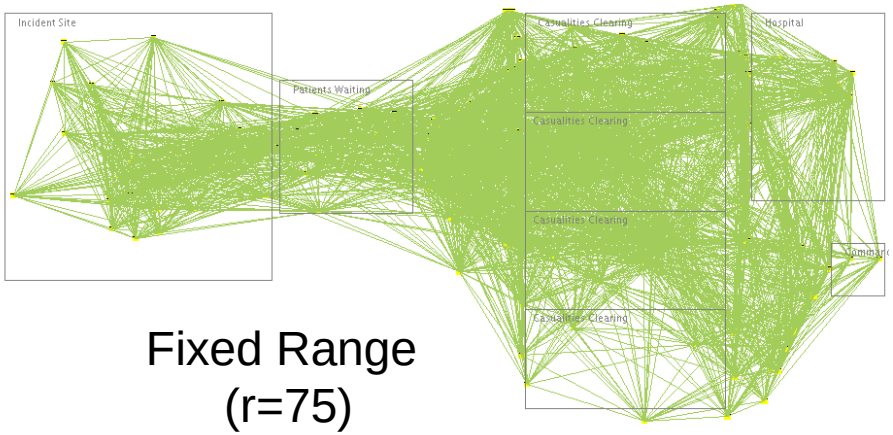
- **Dynamic environments, require flexible and self-adaptive mechanisms to control topology and medium access**
  - Topology control is a basic problem
  - Provides stability and a basis for other layers protocols
- **Wireless Public Safety Networks, represents an extreme case**
  - Lives depend on the network behavior
  - Main concerns are rapid deployment and survivability
  - Different sites may have distinct requirements

CHORIST Rapid Deployment Architecture

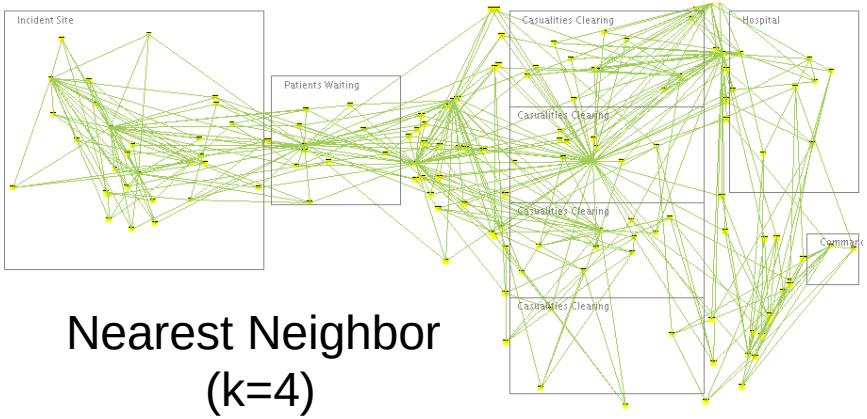
CH – Cluster Heads
MR – Mesh Routers
IN – Isolated Nodes
RN – Relay Node



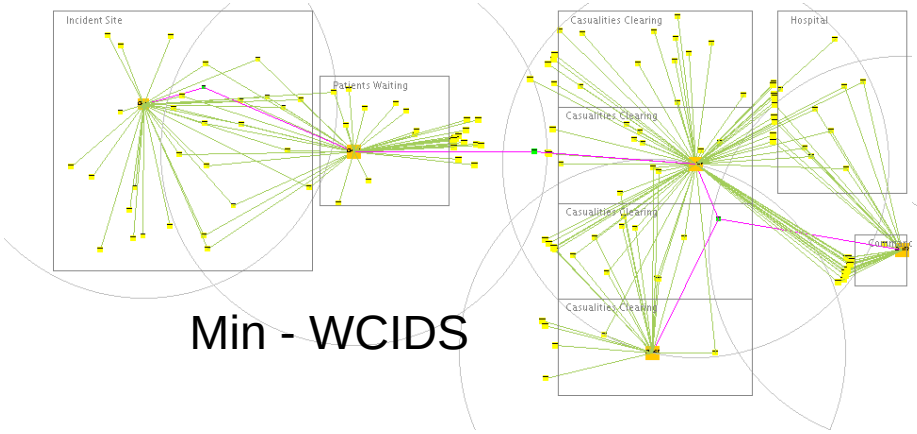
Connectivity Graphs



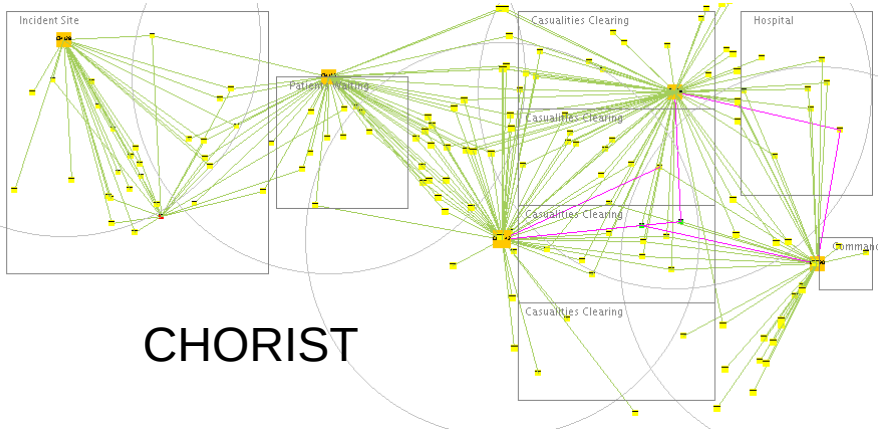
Fixed Range
(r=75)



Nearest Neighbor
(k=4)



Min - WCIDS



CHORIST

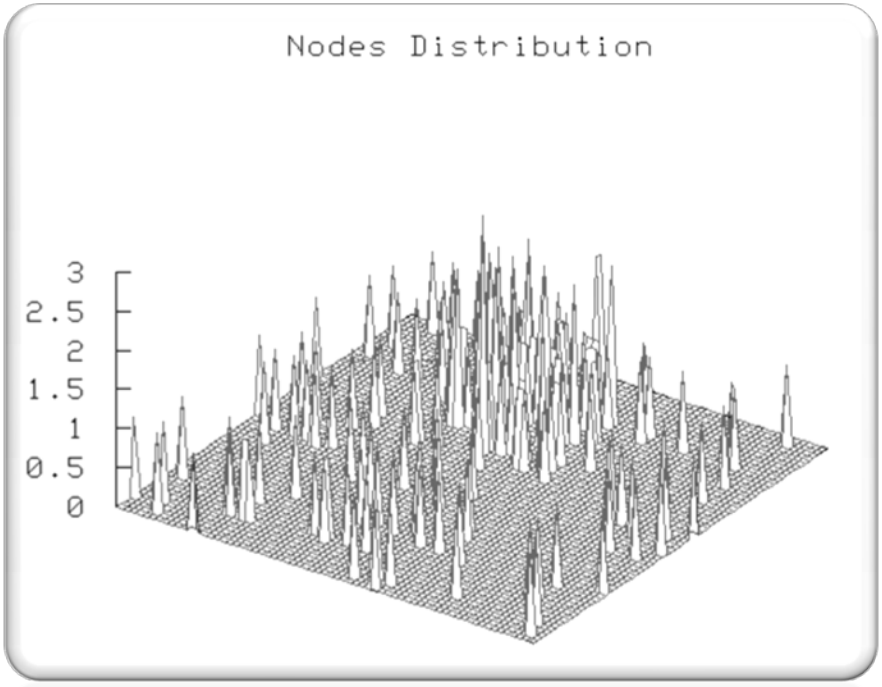
- Aschenbruck et al. realistic model for node distribution over disaster area scenarios, based on a real based on a real maneuver simulation

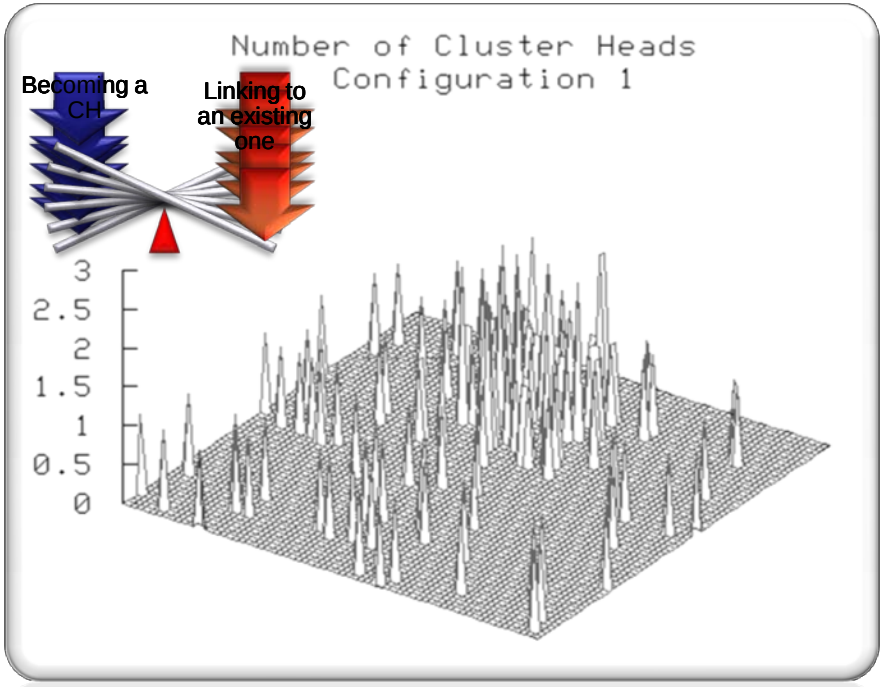
Research points to observe

- **The present solutions are not enough to fulfill the needs of PSNs**
  - One unique framework to shape fairly distinct networks
  - Shape a network topology in different ways just by changing parameters
  - Minimum interference from outside of the network
  - Change the topology of an already established network, if requirements change
  - Coexistence of different portions of the network with distinct requirements
- **Simple method**

Effects over the Cluster Heads distribution

- **We simulate a series of different scenarios and we defined a cost function, in terms of CHs, RNs, MRs**





Adaptive topology control

- **Supply and Demand Approach**
  - Based on the laws of supply and demand

- **High level description**
  i. Nodes continuously receive prices advertising and compare with the prices they are paying
  ii. When a node receives an offer from a better provider, it changes providers
  iii. Every node has a basic price, according to their role (CH, MR,…)
  iv. The provider increase its cost when receive a new connection and decreases it when a node leaves

IV – Some Projects and Systems in the PSNs Field

HNPS – Heterogeneous Network for European Public Safety

HNPS
Heterogeneous network for European public safety

- **Main objective**
  - Provide integration of different networks, including ad hoc deployable systems as a concept for future European Public Safety communications
  - *http://www.hnps.eu*

- **Part of the CELTIC initiative**
  - EUREKA–Celtic seal (CP5-010)

CELTIC Telecommunication Solutions

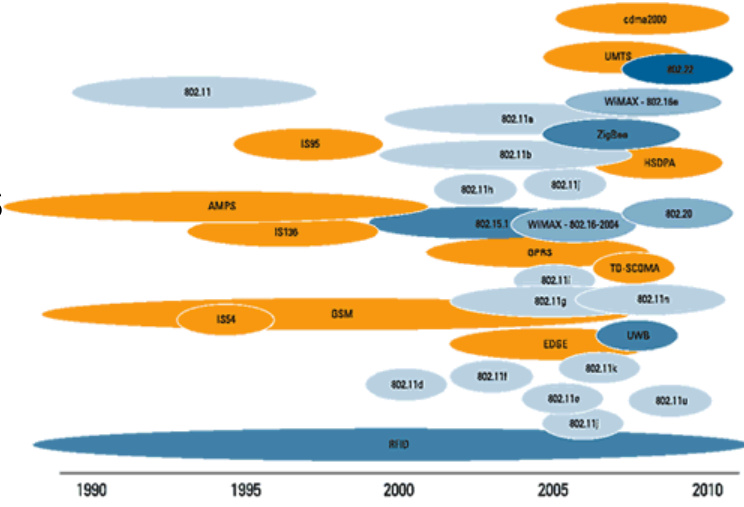
EUREKA Σ! 3187

HNPS – Heterogeneous Network for European Public Safety

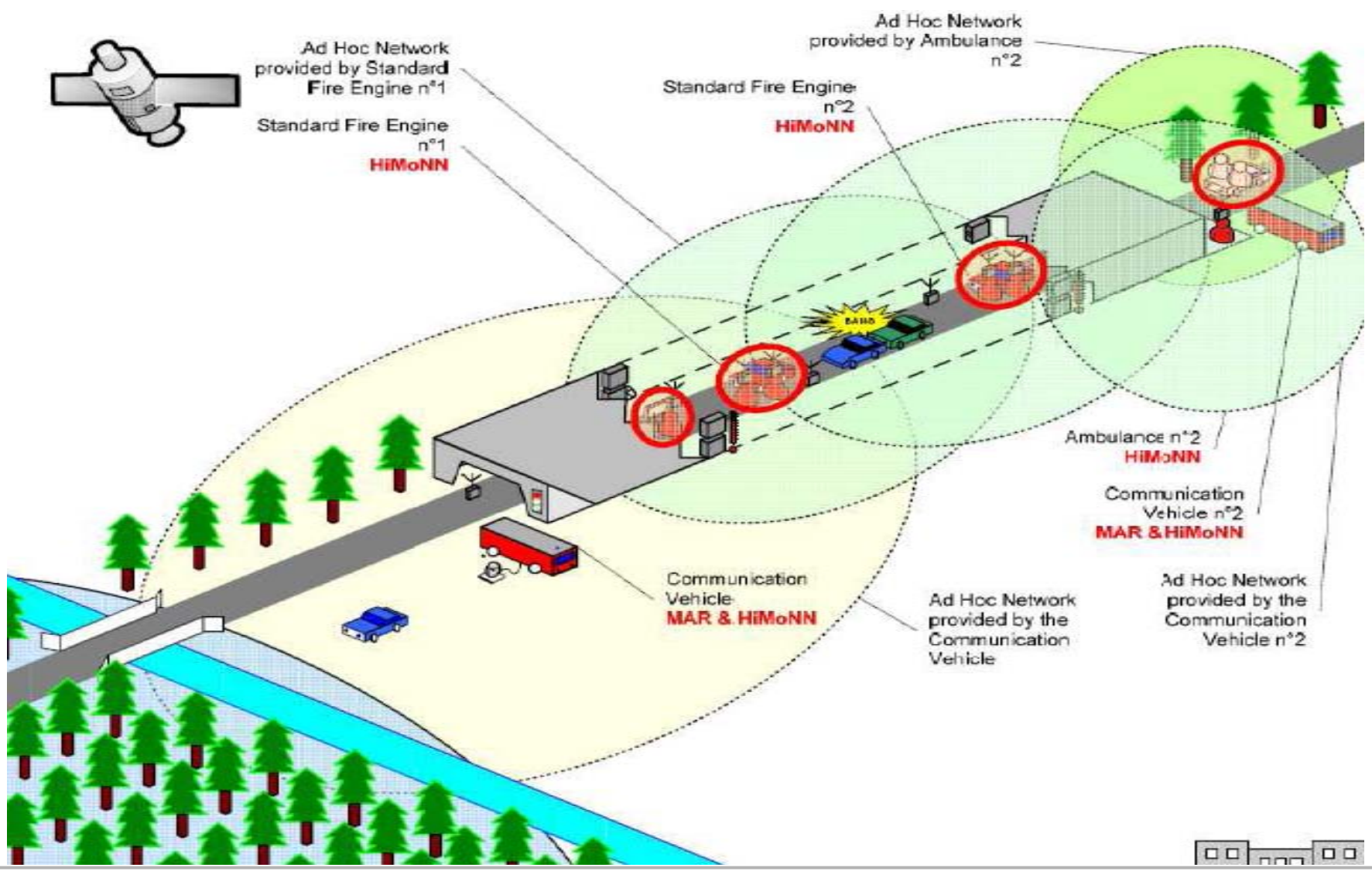
- **Integration of multi-standard systems**
  - Different countries follow distinct standards
  - Key aspect for multi-agencies and inter-country collaboration
- **Interconnection of different architectural approaches**
  - Distributed or centralised system
  - Deployable or fixed services

HNPS – Heterogeneous Network for European Public Safety

- **Consideration of heterogeneity of existing and future wireless access technologies:**
  - Network:
    - GSM/UMTS/HSDPA, PMR, WiMAX, WiFi, LTE
    - Fast deployable network solutions
    - Ad-hoc Wireless Sensor Networks
  - Applications:
    - ESB/Middleware distributed systems
    - Crisis Centre and tactical application
    - Intelligent Video Analytics



HNPS Scenario: Critical transport infrastructure



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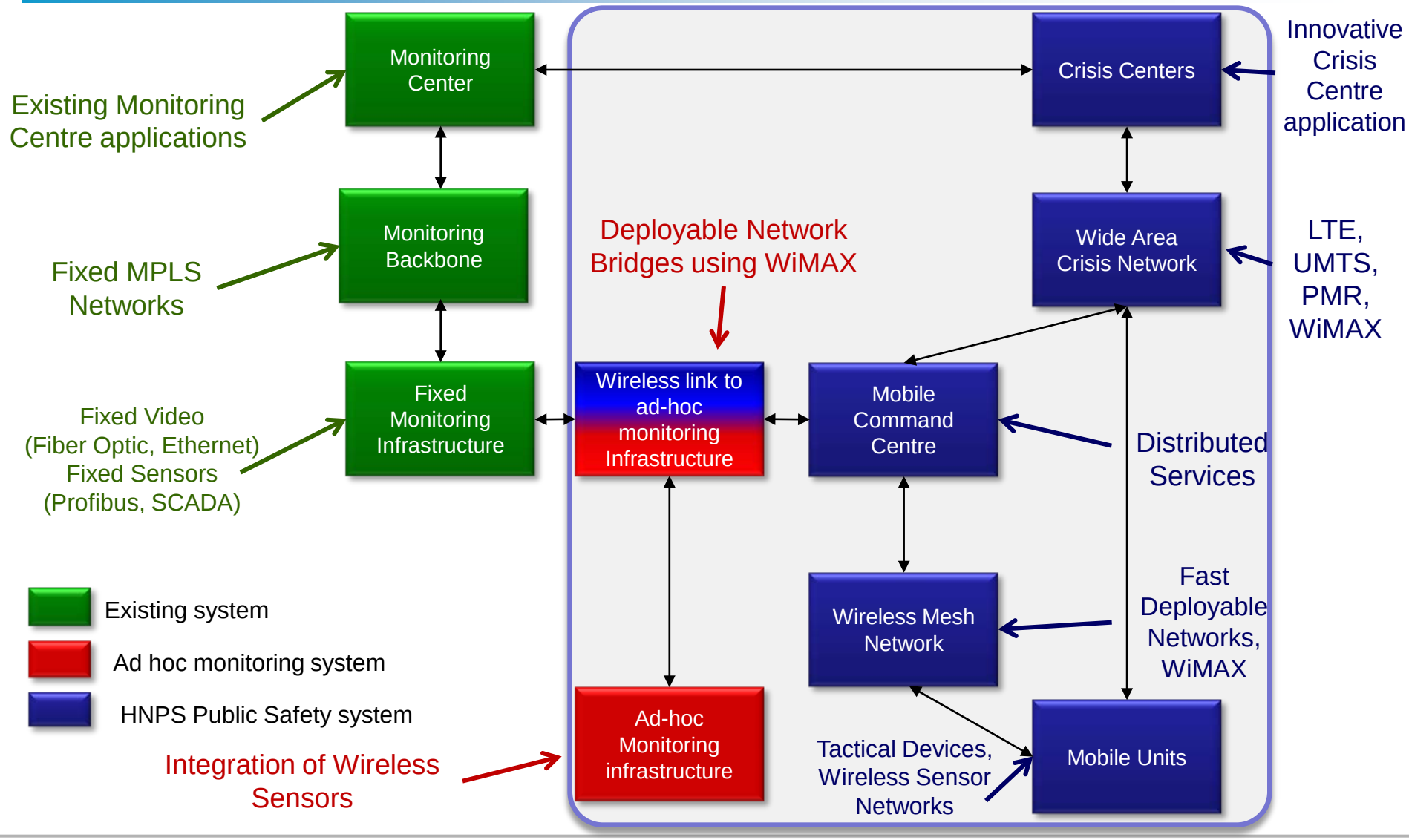
Heterogeneity in the core of the architecture



RATCOM: Detection and warning of tsunamis in the Mediterranean Sea

- RATCOM is one of the next generation Emergency Alert Systems (EAS) dedicated to detect and issue warnings for tsunamis in the Mediterranean Sea
  - *http://www.ratcom.org*
- When RATCOM will become operational, sensors will capture data and, if a real anomaly is detected, warning messages will be distributed automatically over the endangered region

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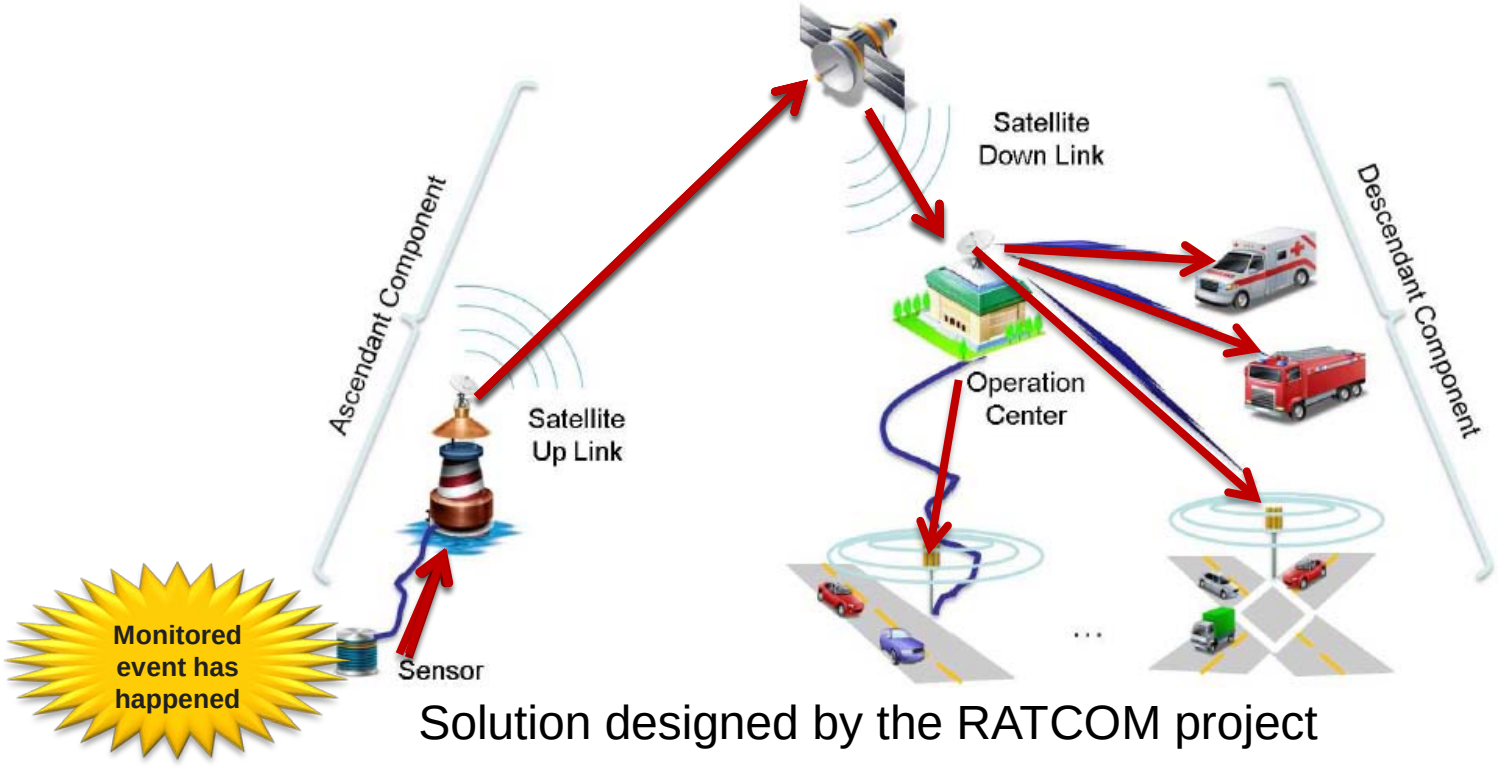
RATCOM architecture

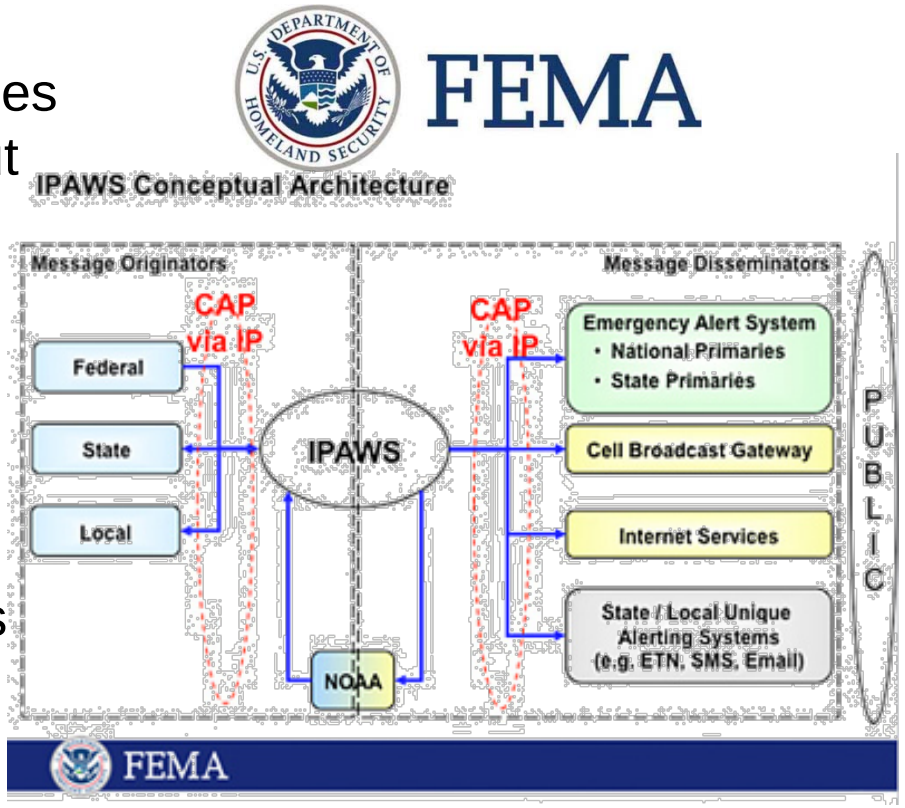
- Two main components
  - ***Ascendant***: senses the related data, filters false positives and retransmits the relevant information to the coordination center
  - ***Descendant***: spreads the information of the imminent dangerous situation among the authorities and population in general



Solution designed by the RATCOM project

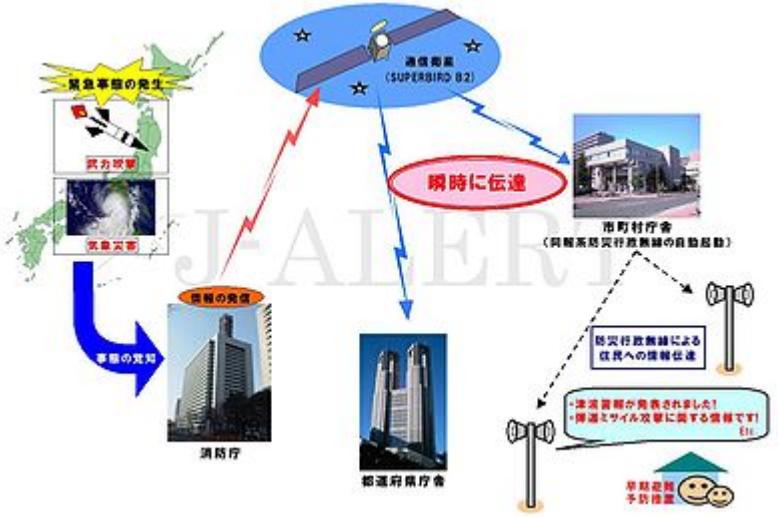
Emergency alert systems

- Integrated Public Alert and Warning System (IPAWS)
  - New American EAS of U.S. Federal Emergency Management Agency
  - When complete it will permit the broadcast of emergency messages not only through radio and TV but also by e-mail, cell phones and other different mediums
  - Test pilot conducted in 2007 in Alabama, Louisiana, and Mississippi the system was able to send alerts to 60,000 residential phones in ten minutes and also with Spanish and Vietnamese translations



Emergency alert systems

- J-Alert
  - The Japanese nationwide warning system, was launched in February 2007
  - It uses satellite wireless communication to issue a simultaneous warning to all municipal governments and interested agencies
  - It works with warning sirens and an emergency broadcast system
  - The system is automatically activated and, from the time an emergency is confirmed, it is able to warn the population in less than 7 seconds



V – Conclusions and Remarks

- **Public Safety Networks presents a series of challenging problems**
- **The field has attracted a great deal of interest, mainly after September 11**
  - Only in 2009 the budget requested to develop the new American EAS was 37 million dollars
- Great industrial players have interest on the field
  - EADS, THALES, Alcatel Lucent, Motorola, ….

EADS DEFENCE & SECURITY THALES Alcatel·Lucent MOTOROLA

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Thank you for your attention

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Simulations

If the time permits