Final Report

Which type of Public Warning System should France adopt by 2021?

July 2020

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Report follow-up & updates

Final report title:
WHICH TYPE OF PUBLIC WARNING SYSTEM SHOULD FRANCE ADOPT BY 2021?
Author: Project Scientific Team (ESPACE, CHROME, ATRISC)
Nature of contract: Fonds d'Investissement en Etudes Stratégiques et Prospectives (FIESP)
Contracting authority: CHEMI (Centre de Hautes Etudes du Ministère de l'Intérieur)

General information

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Last modification	Johnny DOUVINET	Project Manager
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Evolution of the report since its creation

Stages	**Date**	**Objective**
Creation of report	September 21, 2019	Layout
Drafting of context	October 15, 2019	Presentation of project
Methods and objectives	November 22, 2019	Validation of questionnaire
Characteristics of existing solutions	December 2019 – February 2020	Knowledge summary
Correction	January 22 to 25, 2020	Proofreading and amendments
Interim report	February 25, 2020	Drafting of first collected results
Sending of interim report	March 9, 2020	Digital version of report sent
Presentation to Monitoring Committee at CHEMI / DGSCGC	Cancelled due to the COVID-19 pandemic	Presentation of first collected results
Checking consistency of observations in the 4 countries studied	April 30, 2020	Consistency check of Part I
Processing of questions	May 4, 7 and 8, 2020	Cross analysis of questions
Checking consistency of interviews collected in spreadsheet	May 20, 2020	Preparation of summary for Part II
Creation of graphics	June 4, 2020	Interaction between sub-systems
Proofreading of subsections by different team members	June 12 to 18, 2020	Proofreading of Parts 4, 5 and 6
Project Team meeting	June 18, 2020	Discussions on summary
Sending of report (provisional version)	June 25, 2020	Report sent to Monitoring Committees
Presentation	July 10, 2020	Presentation of final report
Integration of stakeholders' feedback and finalization	July 20, 2020	Final delivery of the project

Approval by decision makers

Reference	**Date**	**Objective**
Sending of interim report	June 25, 2020	Proofreading by stakeholders
Sending of final report	July 20, 2020	Official delivery of report

Contents

Glossary and list of abbreviations

ACMA: Australian Communications Media Authority / Australia
AFAC: Australasian Fire and Emergency Services Authorities Council / Australia
AIIMS: Australasian Inter-Service Incident Management System / Australia
BMKG: Badan Meteorologi, Klimatologi, dan Geofisika, (Meteorological, climatological, and geophysical agency) / Indonesia
BNPB: Badan Nasional Penanggulangan Bencana (National Disaster Management Authority) / Indonesia
BOM: Bureau of Meteorology / Australia
BPBD: Badan Penanggulangan Bencana Daerah, (Provincial Disaster Management Agency) / Indonesia
CAP: Common Alerting Protocol / USA-Australia
CBC: Cell Broadcast
CFA: Country Fire Authority / Australia
EAS: Emergency Alert System / USA
FEMA: Federal Emergency Management Agency / USA
IPAWS: Integrated Public Alert and Warning System / USA
JATWC: Joint Australian Tsunami Warning Center / Australia
NOAA: National Oceanic and Atmospheric Administration / USA
NRF: National Response Framework / USA
PVMBG: Pusat Vulkanologi dan Mitigasi Bencana Geologi (Center for Volcanology and Mitigation of Geophysical Hazards) / Indonesia
PWS: Public Warning System
GDPR: General Data Protection Regulation
SNS: Social Networking Services
SAIP: Système d'Alerte et d'Information aux Populations (Population Alert and Information System)
SDGSN: Secrétariat Général de la Défense et de la Sécurité Nationale (General Secretariat for National Defense and Security)
SES: State Emergency Service / Australia
SEWM: Standard Emergency Warning Message / Australia
SPF (Interior): Service Public Fédéral (Federal Public Service) / Belgium
WEA: Wireless Emergency Alert / USA
3GPP: 3rd Generation Partnership Project

Summary of observations and recommendations

This study allowed us to **identify issues and recommendations** to be implemented by 2021, or even 2030, in order to improve the Public Warning System in France. Please note that the recommendations below are not listed in any order of priority or relevance.

OBSERVATIONS	RECOMMENDATIONS
In certain countries, disasters have led to a complete transformation of local warning systems. In France, they are often managed in an emergency, and even if feedback is collected, we have not learned from past experiences and harnessed the knowledge acquired through the years.	**We must not wait for a disaster to occur to improve the French Public Warning System.** Prevention and crisis management must be tackled differently, the top-down approach must be abandoned while feedback becomes the basis on which organizations plan their continuous improvement. We must **take the time** to build a consistent system. Recommendations must also regularly be followed up.
A wide variety of alert tools are available at an international level, but no national strategy is in place in France. The diverse local environments, communities and potential scenarios make it difficult to adapt alert tools to the local context. The absence of a “culture of alert” (in the broad sense) leads to a diverse range of reactions from inhabitants.	The tools used must be adapted to several factors: 1) needs of targeted communities, 2) local specificities, 3) kinetics of hazards, 4) risk levels, 5) risk culture… **It is mainly the approach to warning that must change.** Instead of asking people to adapt to one single system, **we must develop shapeshifting systems** that can adapt to the needs of local communities. Local authorities may have a major role to play in the choice of warning tools.
CBC is the most efficient tool technically for early warnings and in case of extremely dangerous events (flash floods, landslides, tsunamis, earthquakes). Location-based SMS are however more adapted to communicate preventive measures if the time before the event occurs is sufficient (> 1 hour). However, these tools have inconsistent effects and limited impact in rural areas or overseas territories.	It is necessary to identify the local areas where the impact of CBC or SMS is low (“gray areas”) and find alternative solutions. **At a national level, we must promote a hybrid, multichannel solution and identify several levels of warning deployment capacities while ensuring their consistency.**
The available channels are not used enough or at all in an emergency (governmental / non-governmental, public / private, places of worship, etc.) to reach a maximum amount of people, who have **very diverse frames of reference**.	“Informal” approaches must be put forward not to be limited to existing regulatory processes and give decision-makers free rein to use all the means they deem relevant to broadcast the warning message.

Warnings are perceived as negative; they are still considered as a nuisance or a threat.	Alerts should be **an opportunity to practice safety procedures**, as a way to support the community, and avoid disrupting people's daily lives. We must allow ourselves to make mistakes and the untimely triggering of an alert must be decriminalized.
Warning systems are **not something society asks for** as they are not debated as a social issue.	**Discussion and sharing sessions must be organized with the general public**, which must play a central role in the process. Individual requirements regarding warnings must be escalated. A communication channel dedicated to the detection of weak signals must also be created to involve each individual, who then **participates in the warning process**.
Education (training) and culture (maintaining, within the community, the knowledge of the procedures or actions to undertake) **are two key pillars of risk prevention; culture being the result of education.**	The **durability of both projects** (crisis management and communication) **and the role of stakeholders must be guaranteed over time** to help build sustainable local knowledge. **Crisis management roles must also be professionalized** to make it a specific area of expertise within the administration.
If the community does not engage with the training exercises offered by and for local inhabitants, resources must be found to better organize them and ensure their appropriation. Training for "stressful situations" should also be implemented.	While privacy must be respected, as well as French regulations and ethics, **the organization and implementation of this training must be improved** to find the perfect balance between acceptability (by the participating community), realistic exercises (stress level, scenarios) and context (reference to distant events?). The main players, i.e. local inhabitants, must always be involved in training exercises.
There are many stakeholders involved in public warning procedures and they are poorly coordinated. Projects are underway to improve coordination (notably the recent consolidation of several departments within the National Agency for Territorial Cohesion – ANCT in French)	**A single Public Warning System must be developed, free from political contingencies but in permanent contact with prefects** (who could act as delegates) **and local authorities**. Support from different ministries is key: the services of the Prime Minister, notably SGDSN, would be the ideal players to support this initiative.

Table 1. Main insights gained from the "Cap'Alert" project (2020)

1. Context of the study

1.1. Current knowledge overview

This project is based on a double observation: 1) **diversity of warning and information tools** (SAIP sirens, alert call machines, future implementation of location-based SMS alerts or Cell Broadcast) **to alert the French population of an imminent danger or threat that puts the physical integrity of property and people at risk**; 2) **lack of responsiveness by local inhabitants** who choose to continue their activities (Lutoff *et al*., 2016) or do not perceive the risks (Weiss *et al*., 2011), while the warning should instead trigger a response (Lagadec, 2016) and the implementation of emergency safety measures (Creton-Cazanave, 2010; Douvinet, 2018). While the authorities will be equipped with efficient and powerful tools, improvements are still necessary: 1) the duration of the governmental approval process is more and more difficult to understand by the population (Douvinet *et al*., 2017), which leads to the emergence of informal initiatives; 2) the diversity of communication tools, not always consistent with official standards, diminish the impact of messages; over the years, the direction of communication has become multilateral and transverse; 3) issuing warnings is a social process, which involves the credibility and legitimacy of the source but the recipients are rarely considered, even though it is necessary to define instructions that are suitable and understandable by everyone, and to avoid providing instructions that are too generalized.

In an **evolving, uncertain and unknown context, it is necessary to support changes in security professions and organizations**, **and to consider the needs of the population from the tool design phase**, all the more so in a period of social, ecological and technological transition, which should not impact on the situation that vulnerable communities are already facing (the elderly, areas with no Wi-Fi or 4G coverage, etc.).

1.2. Objectives

This project aims at meeting three operational objectives:

1. **Identify good practices** in the warning systems used outside France in terms of upward alerts (detection) and downward alerts (reaction).
2. Carry out **a prospective study of requirements** and technological developments in the medium term (to anticipate the requirements for major international events taking place in France, such as the Rugby World Cup in 2023 and the Olympic Games in 2024).
3. Define **recommendations** to identify the system most suited to the French context.

These three operational objectives have been broken down into **three areas**:

1. <u>Technology</u>: What are the developments in call management systems to the 112 platform? Which technology (location-based SMS; Cell-BroadCast) should be chosen in accordance with the decree of December 14, 2018, adopted throughout Europe?

2. <u>Societal and psycho-social aspect</u>: Are local communities aware of the security measures taken? What are their expectations? How to make the warning message credible?

3. <u>Organization</u>: How are operational practices evolving and what are the managerial issues in terms of recruitment and training?

1.3. Suggested hypotheses

H1. All relevant players in the security warning sector do not use the same standards or do not have the same approach. **These practices, which vary from country to country**, are the results of a social, political, cultural, and economic legacy that cannot be ignored, which makes it impossible to replicate in France the warning tools or systems used elsewhere. However, such diversity will allow us to address issues regarding the implementation of a **suitable PWS**.

H2. The progress of technology has gradually updated existing devices and tools. But beyond purely technical aspects**, disasters have led to changes in approaches and practices.**

H3. Actors are keen to use the tools they know, mainly based on what is available, without considering the needs of the targeted community. However, current developments suggest that the verticality of downward alerts is being gradually replaced by new communication devices (individuals / authorities / operational players). If this were the case, one would have to use a wide variety of tools and be the first to capture the population's attention in the event of an alert, at the risk of leading to uncontrolled (or "spontaneous") community initiatives.

H4. Tools do not take sufficient account of **the socio-spatial specificities of alert reception**. By focusing on technical aspects, players tend to minimize the **issues of perception and appropriation** by the targeted communities, making it more difficult for them to understand the instructions associated with an emergency situation and more reluctant to follow them.

These hypotheses were used as guidelines when collecting data that led to the identification of other needs or hypotheses, in accordance with the experience-based nature of this project, which draws on the in-depth analysis of a limited number of approaches (March *et al.*, 1991).

1.4. Methods used and countries studied

Our analysis is based on qualitative data, which offers a wide range of points of view, and allow us to better address the complexity of the elements considered by existing systems (interviews with players in public safety, feedback from recent events, focus on the impact of digital technology). A qualitative approach was favoured as, in line with the **experience-based focus** chosen for this project, case studies or the identification of practices are more efficient in gathering knowledge, which cannot lead to more quantitative analyses.

It is also important to note that there were existing partnerships with research institutions and security players in each of the countries studied, which **allowed the study to become quickly operational and made the time schedule more attainable.**

At the instigation of the SAFE cluster, a collaboration agreement between Australia, France and the United States was signed at the French Embassy in Canberra in 2011 and ATRISC was behind this initiative. Belgium was already the subject of a study within the ANR MACIV project (in which ATRISC is involved), in particular regarding how to help communities engage with the warning message and the operational response during crises through SNS. ATRISC contributed (via Civipol) to the implementation of crisis operational centers in Indonesia. And in March 2019, UMR ESPACE organized a symposium on warning systems in Avignon (more than 110 people attended, and 42 papers were given in 3 days).

We focused on four countries, for different reasons:

1. **Belgium**, where sirens, abandoned in 2016 and dismantled in 2018, are now replaced by a single system, *BeAlert©*, established by royal decree.
2. the **United States**, where a multichannel platform has been in place since 2006.
3. **Australia**, where the governors of each state define multimodal strategies specifically designed to adapt to the specificities of each region.
4. **Indonesia**, where social networks are increasingly used face to natural disasters.

1.5. Expected outcome

This report produced for CHEMI will enable **a real prospective and strategic study to be carried out by widening our perspective beyond French expectations and areas of competence**. This study seeks to anticipate medium-term developments in digital warning systems and integrate the influence of the psychosocial behavior associated with alerting processes to highlight the guiding principles of the approach and the potential developments in the current process (**Figure 1**). The outcome will allow us to go beyond a vision too often based on **available technology**: the warning systems currently used by authorities are based on the technology offered by security providers. Discussions are underway regarding Cell Broadcast (CBC) and location-based SMS messages in France (complying with Article 110 of the European decree of December 11, 2018), but the authorities have not verified if these solutions are adapted or not to the needs of the targeted communities.

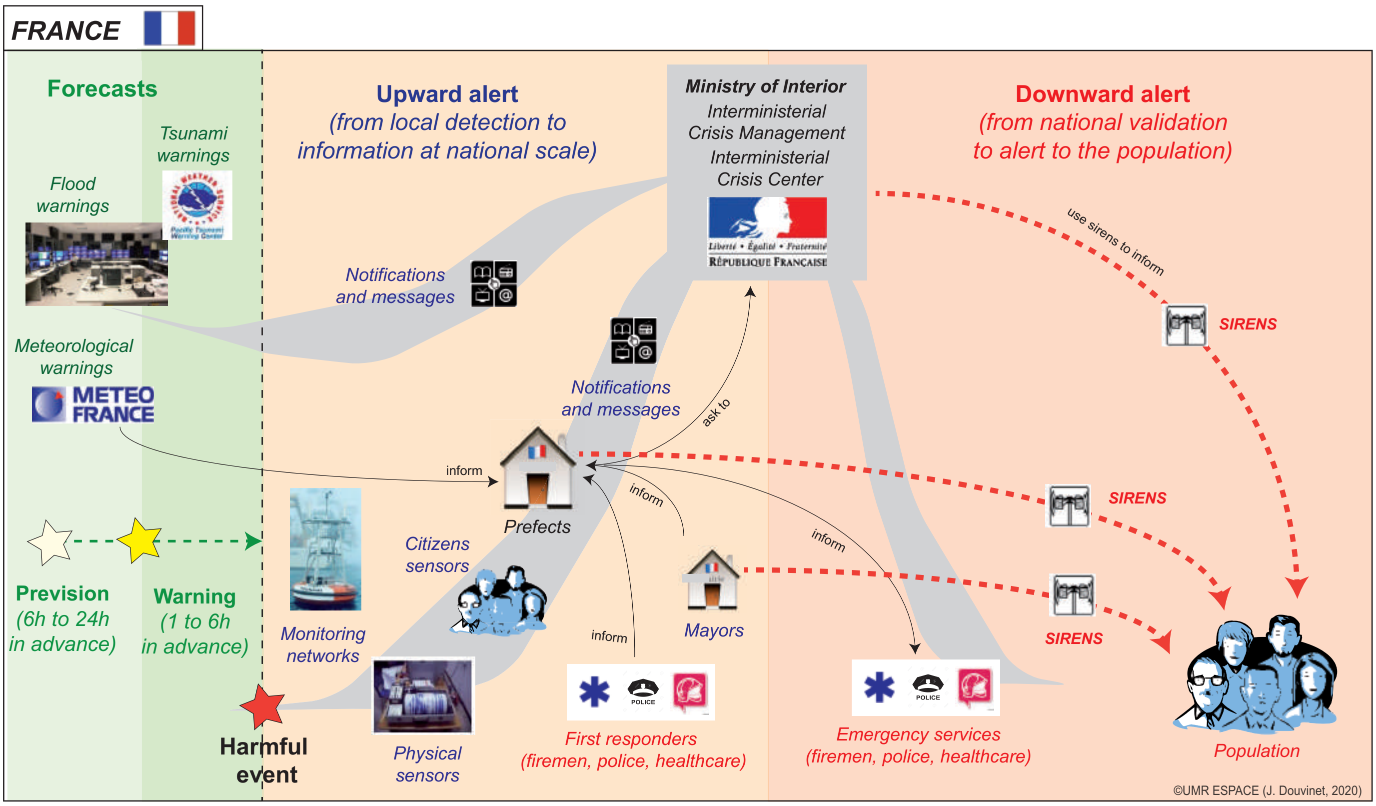


Figure 1. Overview of the alerting process and tools used in France

This project is also the "academic insight" of ANR's ***Cap-4-Multi-Can'Alert*** project, which was selected on the theme of *"Security of the Olympic and Paralympic Games in Paris 2024,"* which started on January 1, 2020 (involving most of the team in charge of this project) and will last 18 months, and is co-financed by SGDSN.

Two theses (one in Environmental psychology on decision-making in the event of an alert, and the other in Geography on optimizing the tsunami warning system in the Mediterranean), funded since September 2019, complement the assessment undertaken.

2. Project Team & Partners

The Scientific Team (COPIL) consists of the following members:

Partner	Surname	First name	Current position	Role & Responsibilities in the project
Avignon Université / UMR ESPACE 7300 CNRS (Study of the Structures & Processes designed to Adapt to Spatial Changes)	DOUVINET	Johnny	Associate Professor in Geography (University Professor, Sept. 2020)	- **Project Manager** - Local and spatial impact of warning systems / time frame of hazards / triggering of procedure / relevance of warning systems to requirements
	BOPP	Estéban	PhD student in Geography (Supervisor: J. Douvinet)	- Warning tool assessment, i.e. location-based tools and the Internet of Things used for warning - Spatial and local approach of risks
	BOUFFEL	Alexia	Financial Manager at UMR ESPACE 7300 CNRS	- Protect monitoring - Budget monitoring
ATRISC (Crisis Management Experts)	MARTIN	Gilles	Crisis management consultant	- Expert in public safety warning procedures - Implementation of training exercises (Prefecture, local councils)
	VIDAL	Renaud	Director of Innovation at ATRISC, Research Associate CCRM, UC Berkeley	- Expert in High Reliability Organizations (public safety, key facilities, and high-risk operators)
EA CHROME 7352 CNRS (Ongoing Emerging Risks)	WEISS	Karine	University Professor in Environmental Psychology	- Warning decision-making - Psychological and social factors
	AHOSSI	Franck	PhD student (Supervisors: K. Weiss / J. Douvinet)	- Impact of psychological and social factors on decision-making process during warning procedures (authorities and individuals)
	GISCLARD	Béatrice	Associate Professor in Design, University of Nîmes, EA PROJEKT	- Perception of signals by local communities - Understanding behavior

The Monitoring Committee (CS) consists of the following members:

Partner	Surname	First name	Current position	Role & Responsibilities in the project
DGSCGC (Direction Générale de la Sécurité Civile et Gestion des Crises)	CONDEMINE*	Jean-Pierre	Former Prefect (Loir-et-Cher)	- Operational feasibility of recommendations - Interface with prefecture - Support in project implementation
IGA (Inspection générale de l'administration)	CANNARD	Philippe		- Interface with administration
	ESCANDE-VILBOIS	Sylvie	Assistant to the Head of IGA department	- Project implementation - Interface with administration
	SAUZEY	Philippe		- Interface with administration
DGPN (Direction Générale de la Police Nationale	JACQUINET	Ludovic	Strategic advisor	- Interface with law enforcement (police)
	ROSSELIN	Didier	ENSP	- Interface with law enforcement (police)
DGGN (Direction Générale de la Gendarmerie Nationale)	LABRUNYE	Frédéric	Project manager at DGGN, Former Commanding Officer	- Interface with law enforcement (gendarmerie)
	SCHOENHER	Dominique	Colonel	- Interface with law enforcement (gendarmerie)

* Honorary Prefect Jean-Pierre CONDEMINE participated in most of the internal meetings with the Project Team and has put us in touch with several prefects and associations of elected officials. Many thanks to him.

Monthly meetings were organized to coordinate the project (19/09, 18/10, 15/11, 20/12, 15/01, 12/03, 20/05, 12/06, 18/06). Meeting summaries are available in the Appendixes.

3. Description of studied systems & relevant players

During January and February 2020, a two-person team bringing together two partners visited one of the 4 targeted countries (the COVID19 crisis did not disrupt these meetings). The table below lists all the transcribed interviews and shows the dates of the various meetings. Several prefects in France were also interviewed.

SURNAME Name	Function	Date	Name of participants	
RAMACKER Benoît	Head of Crisis Management Task Force, Belgium	28/11/2019	J. Douvinet	G. Martin
DE BUDT Koen	BE-ALERT Project Manager	28/11/2019	J. Douvinet	G. Martin
HALLOWES Michael	Managing Director, Zefonar Advisory, specialist in the design of requirement-led multi-purpose Public Warning Systems	03/12/2019	B. Gisclard	/
LISTON ABEL Erin	Chief of Staff, Director, Operations Support AFAC	18/02/2020	B. Gisclard	K. Weiss
MILLER Amy	Manager, Emergency Management Community Information	21/02/2020	B. Gisclard	K. Weiss
RILEY Jacob	Public Information and Warnings State Emergency Service	20/02/2020	B. Gisclard	K. Weiss
SLIJEPCEVIC Alen	Deputy Chief Officer, Bushfire for Country Fire	18/02/2020	B. Gisclard	K. Weiss
MOONEY Carla	Project Manager of disaster mitigation, Bureau of Meteorology	20/02/2020	B. Gisclard	K. Weiss
HERMANS Michael	Acting assistant commissioner Victoria Police	19/02/2020	B. Gisclard	K. Weiss
HAMBLETON Roland	Manager Consultant in Solution / Everbridge	19/02/2020	B. Gisclard	K. Weiss
COMFORT Louise	Professor, University of California, Berkeley	04/02/2020	J. Douvinet	R. Vidal
LINDBERG Sarah	PhD (former experience in risk forecasting in Brazil)	04/02/2020	J. Douvinet	R. Vidal
SKALETON Randy	US Forest Service	03/02/2020	J. Douvinet	R. Vidal
PARKER Derek	Fire Department, Sacramento	28/01/2020	J. Douvinet	R. Vidal
WESTROPE Scott	Santa Rosa Fire Department	03/02/2020	R. Vidal	/
MEYER David	California EOS	03/02/2020	J. Douvinet	R. Vidal
HUSSEIN Salahuddin	Professor of Geology, UGM	08/02/2020	K. Weiss	/
NOVANTI Lucia-Peppy	Psychologist	08/02/2020	K. Weiss	/
MUTAQIN Bachtiar	Merapi Forecast, PVMBG	08/02/2020	K. Weiss	/
HADI Suprayoga	Primary Planner on Regional Development	12/02/2020	E. Bopp	K. Weiss
JATI Rahna	Junion Planner at BMKG	13/02/2020	E. Bopp	/
DARYONO Hli	Vice-President of HADI, BMKG	13/02/2020	E. Bopp	K. Weiss
OMEGA Petrayuna	Researcher, Christian University of Jakarta	13/02/2020	K. Weiss	/
ARUMININGSIH Sudjamata	Director for disadvantaged areas BAPPENAS	14/02/2020	E. Bopp	K. Weiss
DOMENEGHETTI Bertrand	Interministerial Chief of Staff for the South-West	07/02/2020	B. Gisclard	/
MERINO Jacques	Association of French departments	16/01/2020	J. Douvinet	/
OSTRE Didier	Deputy Director of the Association of French Mayors	20/01/2020	J. Douvinet	D. Faure
GALICHET Olivier	Agence Numérique Sécurité Civile (Digital Department for Public Safety)	17/01/2020	J. Douvinet	/
MAHLER Luc	DGSCGC Liaison Officer for the Tour de France	17/02/2020	J. Douvinet	D. Faure
ANDREZJEWSKI Florence	Security & Safety department manager at Avignon University	17/02/2020	J. Douvinet	R. Vidal
JOUGLA Eric	Security Manager at Orange Vélodrome Stadium	18/02/2020	J. Douvinet	R. Vidal
WITKOVSKI Jacques	Prefect of the Hérault department, former director of DGSGCG	28/05/2020	J. Douvinet	/
ALLIONE Grégory	Directeur of SDIS-13, President of FNSPF	30/06/2020	J. Douvinet	/
DURAND Pierre-Henri	Prefect of the Seine-Maritime department	01/07/2020	J. Douvinet	E. Bopp

4. Methods used and data collected

Following the information presented at the **launch meeting** on September 12, 2019, certain choices were made to convert this 8-month project in success. The risk of a terror attack, a common threat in all regions, was discussed with our partners in different countries, while good practices in terms of monitoring risks selected in the 4 countries studied addressed different potential disasters (tsunami, fire, landslide).

4.1. Descriptive approach

The alerting tools and signals sent to local communities differ according to cultural, political, and military legacies and to the nature of the risks faced by each country. For example, the number of sirens, the main traditional alert system, varies dramatically from one country to another: 1,250 in Norway (2016), 1,496 in Slovenia (2015), 3,100 in Israel (2017) and 8,500 in Switzerland (2016). Differences can be observed in testing days (Denmark tests its sirens silently every night, and an audio test is carried out in the local community on the first Wednesday in May, while Switzerland tests its sirens on the first Wednesday in February), and alarm tones, with sounds varying according to risk levels (Austria, China, Norway, Sweden) or the nature of the alert (United Kingdom). Some cities are particularly well-equipped: Mumbai (India) has 450 sirens distributed throughout the city while 2,000 electronic sirens are deployed in Singapore. Other countries have, on the contrary, decided to abandon sirens altogether (the Netherlands since 2015, Belgium since 2016) to use a single solution integrating more modern alert tools such as social networks, Cell Broadcast or smartphone applications.

We chose not to list all the tools used at an international level as it would result in overlooking the political reasons for using them. The authorities in charge do not operate on the same scale either. That is why we focused on the systems used in only 4 countries, chosen for their exemplary character. **The objective of this first task was to identify how other countries operate and better understand the specificities of the French system in order to make recommendations for change in the near future.**

4.2. Analytical approach: the contingency theory

The **contingency theory** is based on hypotheses: 1) organizations whose internal structures best meet environmental requirements adapt better and are therefore more efficient. This is what makes this theory so innovative; renowned sociologists (notably Burns and Stalker, from 1961) who studied it, have all sought to understand **the relationship between performance and context.** *"A system can simply be defined as "a complex of interacting elements" (not random). The whole cannot be reduced to the sum of its parts, and it has its own properties that cannot be reduced to those of the elements it is composed of and that the interactions of the latter are essential"* (Rojot, 1997). 2) The theory is in line with the science of complexity, which is based on the principle according to which "the whole is not only the sum of its internal parts" and which was further studied by Edgar Morin (1982). In other words, the efficiency of an organization is due more to the consistency between its subsystems than to the quality of each of them, taken separately. The modification of one of the subsystems most often requires a change in the other three (which is in line with another principle, the "butterfly effect").

3) An organization also depends on its environment in two different ways: it is inspired by it but also enriches it with its input. The contingency theory is based on the idea that best practices depend on **current contingencies**. While it may seem simplistic, assessing risks on which decisions depend can be complex. Contingency theorists therefore try to identify **the conditions under which events are likely to occur.** Organizations are therefore influenced by the socioeconomic context, and this observation is the starting point for a great deal of research relating to managerial theories. The key idea here is contingency, which refers to the influence of external variables on the evolution of organizational structures. Other aspects characterize these managerial theories: specialization of the organization, standardization of work, formalization of operation (flexibility), centralization of the decision-making process, and even the very structure of the organization.

Within this project, and after several discussions, we chose to define warning systems in 4 areas in order to characterize subsystems from a multidisciplinary point of view. Environmental requirements must be identified, then potential interactions, in order to assess the consistency of the different subsystems. To put this concept into practice, we have defined several benchmarks within each area.

1. Organizational objectives

Public Warning Systems send a warning signal to inform the population of an imminent danger. But such a broad definition raises several issues: the time frame is not considered; the tools being used are not differentiated according to hazards; the impact on behavior is not addressed. The time required to assess the situation (to understand it and make a decision) is not included either.

2. Organization (division into sub-elements and coordination)

In France, the triggering of the alert has to be authorized by the Prefect, the mayors, and the Interior Ministry, but what happens in other countries? Do they face the same issues regarding approval? And who is in charge of detecting potential risks? Who passes on the information? Who approves the decision and who implements it?

3. Techniques

In this section, we will consider the aspects related to production (How is it carried out? What tools are used?) and management (cost, investment). Production techniques aim at transforming resources to create goods or services (for example, sirens cover only 38% of the French population, so not everyone is covered and others methods have to be identified); management techniques participate in steering the organization (budgeting methods, accounting controls, project management, job evaluation, etc.). All these aspects help one better assess if the system in place is actually suited to initial expectations.

4. Organizational culture

In this section, we will address issues such as values, beliefs and behavioral patterns. A culture consists of patterns, codes of conduct, lifestyles, and solutions to problems. It is usually inherent as it is shared by all or part of a group. A culture results from history and is passed on over time. It leads to symbolic manifestations (rites, myths, taboos, etc.) and integrates environmental variables (for Var department firefighters, information from social networks is deemed unreliable so it is not considered during the decision-making process).

The table below summarizes all the factors studied (the list is non-exhaustive) (**Table 2**). Depending on interviewees, we focused on threats (terror attack), (industrial) accidents or natural disasters (tsunami).

Themes	Questions to ask	Prompts or additional information
Organizational objectives	What are the objectives of a Public Warning System? What are the expected results? Which time frame does it follow? Which steps must be taken upstream? Which steps must be taken downstream?	What behaviour is expected from the population? From whom? Are these expectations clear (understandable) during the alert?
Structure	Which organizations and players are involved? How does the approval process work? Who receives and analyses upward information? Who triggers the downward warning process? Who approves the broadcasting of the alert to the population?	Which players are indispensable in the process? Which ones can be done without (and in which cases)? Which ones can hinder the process (in terms of speed for example)?
Technology	Which tools are usually used? For which hazards are they most relevant? Did you use them? If yes, why and in which time frame? What tools would you need? Who is in charge of tool implementation (cost, investment)?	How are tools chosen? Is it possible (or advisable) to use the same tools whatever the type of hazard?
Operational culture	How efficient are the available tools? What are the conditions for the appropriation of these tools by users and recipients? What factors lead to the decision of broadcasting a warning? When do you know it is the “right decision”? And the “right time”?	Do these tools take into account the diversity of users and communities? How? Is it enough?
The optimal warning system?	How could technical shortcomings be addressed? How could organizational shortcomings be addressed? What are the main threats / risks in the future?	Does the current system seem optimal to you? If not, according to your experience, how could it be improved? Are there any obstacles? What are they?

Table 2. Criteria used to describe each element of a Public Warning System

5. Study of existing systems

The tools in place in each of the countries studied depend on several factors: politics, budget, economics, strategy and/or context. A common framework has been created to better present the systems implemented in each country.

5.1. Belgium: sirens replaced by a single warning system

Structure and context of the alert

In Belgium, the alerting process is the responsibility of the authorities (mayors, governors, minister), under their administrative policing power. It became law through Discipline 5, as stated in Paragraph 1 of Article 14 in the law of February 16, 2006, relating to emergency plans and emergency response. Since the law on public safety and crisis planning (1963), several sirens had been deployed in high risk areas, notably around high risk industrial plants (Seveso high threshold) or associated with nuclear activities (Doel, Mol-Dessel, Tihange, Fleurus, Chooz in France and Borssele in the Netherlands). The focus on NBC risks was the main driver in implementing 560 sirens across the country (**Figure 2**), which were managed by the SPF Interior Alert Service. Until 2016, the sirens were tested every first Thursday of each quarter between 11.45 am and 1.15 pm. At the time of the test, the siren emitted a modulated sound, repeated after a 5-second interruption, followed by a spoken message ("Test Signal") played through the sirens' loudspeakers.

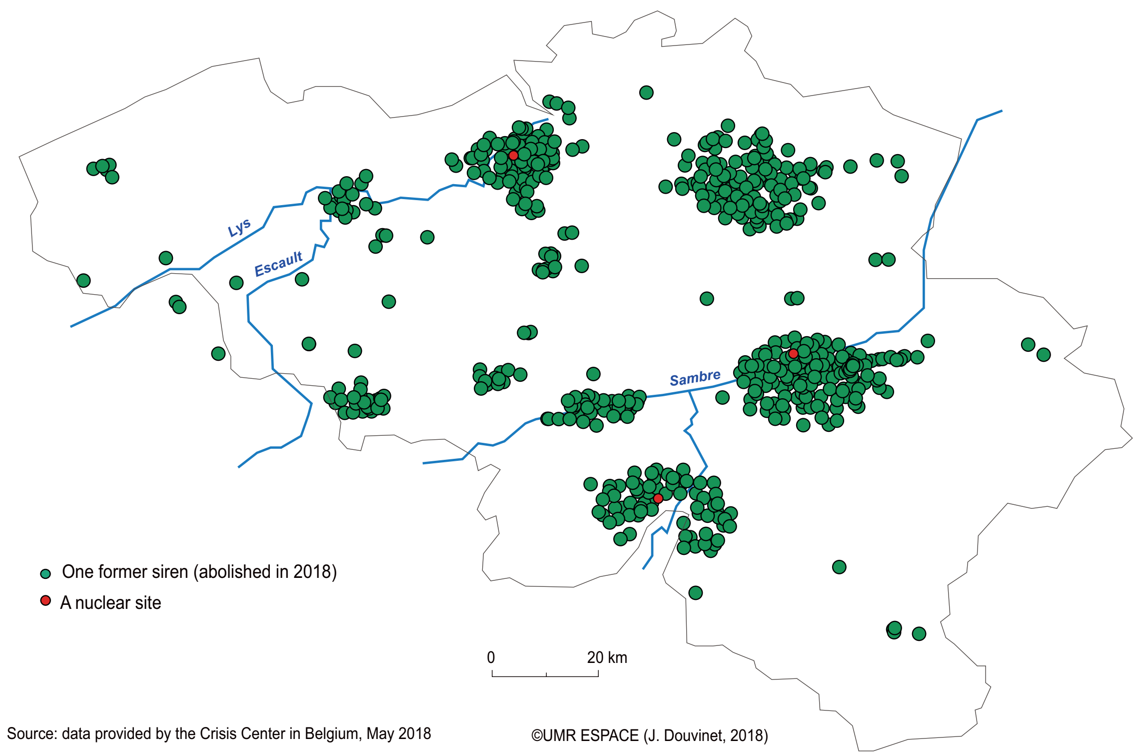


Figure 2. Location of former sirens in Belgium, removed in 2018

Strategy and organizational culture

Following the terror attacks in Brussels on March 22, 2016, the federal authorities became aware of the limited relevance of sirens: they were ineffective (as local inhabitants did not understand their meaning), barely audible (the sound could not be heard beyond a 1.5km radius) and expensive to maintain, both technically and in manpower. Tests created more stress and panic within the community than a desired reaction, and the signal was no longer adapted to changes in building materials (insulation making the sound hardly audible indoors) or to the increasing ambient outdoor noise in the most populated urban areas. There was no multi-risk warning system either and domino effects were never considered (IBZ, 2017).

However, the operationalization of warning systems is now addressed **in a global way**, with a set of tasks that can be carried out by other players (such as the media or motorway services for example), as recalled in Appendix D5 of the NPU-4 Ministerial Circular. Several warning methods can also be used simultaneously: sirens, police cars with loudspeakers, motorway signs (managed by the *PEREX Center* and *Vlaams Verkeerscentrum*), or the media (IBZ, 2017). The example of Belgium shows how warning tools can be redesigned in their entirety, provided, however, that the **decision comes from political authorities**.

As a result, sirens were finally abandoned at the end of 2016, their removal is ongoing and scheduled to be completed at the end of 2019. Instead of sirens, the federal government has decided to deploy a single warning system called *Be-Alert*©. The Crisis Management Center has indeed been studying this system since 2011 (**Example 1**). Between 2013 and 2015, a pilot project has been tested and assessed in 33 communities, notably through a secure multi-channel online warning platform. Several improvements were made during the two years of experimentation, leading to the creation of a robust tool intended for all services and authorities (from local to federal level) involved in public safety.

EXAMPLE 1. The *Be-Alert*© system (which is short for "Belgique-Alerte" and refers to its main meaning, "being alerted") was designed following the tornado that occurred on August 18, 2011, during the *Pukkelpop* festival that was attended by nearly 60,000 people. Two marquees collapsed and five people died (3 seriously injured), but no evacuation was ordered, and, on the day of the event, King Albert II joined the crisis operation center located in Hasselt, the neighboring city.

On December 24, 2016, a decree concluded the emergency communication agreement between the Institut National des Télécommunications (INT) and the government; the three main telephone operators (*Proxima®, Télémet® and Orange®*) being directly integrated into the *Be-Alert*© platform, which has been operational since June 13, 2017. The facilities are owned by the three operators, but, when required by the Crisis Management Center, they must broadcast a warning message to the 200 local councils that have subscribed to this service (for an annual fee of €1,100). The Crisis Management Center pays operators according to the number of messages sent (€9,500 for 100,000 calls) and the number of alerts. Thanks to the detection of SIM cards located near the antennas, *Be-Alert*© claimed to be able to cover 67% of the population by the end of 2017.

Technical overview

When an alert is triggered, SMS (100/s), phone calls (600/s) and e-mails (up to 10,000/s) can be sent simultaneously by the Crisis Management Center, and the process can be triggered at the request of local councils, mayors or federal authorities within a limited time frame (**Example 2**). The procedure is complemented by a GIS platform managed by *Gedicom®*, which monitors where and when the message is broadcast and its reception by recipients. In 2018, the Crisis Management Center employed 28 people, whose function was to coordinate emergency situations and inform the authorities as soon as possible. An agreement was also signed with several SNS (*WhatsApp©*, *Twitter©* and *Instagram©*) to increase the number of information channels. Training exercises involving the community were also carried out to check the conformity of the procedure and raise awareness of the system, as it was the case on June 30, 2017 during the *Rock Werchter* festival (40,000 calls were received out of 44,000 festival-goers) in Rotselaar, or July 8, 2018 in Huy Waremme.

EXAMPLE 2. The *Be-Alert©* system has been used for several events, at the request of certain mayors and the federal government, while respecting their powers in terms of public warning. On November 11, 2017, *BeAlert©* sent an SMS to all those located within a 20km radius of Drogenbos to inform them that a container with lithium batteries was on fire at the Electrabel ENGIE plant. Following the release of slightly toxic smoke, the inhabitants of Brussels were asked to close their doors and windows. On March 15, 2018, *Be-Alert©* was also used to inform the inhabitants of Andoy, Wierde, Erpent, Naninne, Dave and Jambes that the drinking water had been cut off and a few hours were needed to solve the problem. The warning was sent at 9.30 p.m. and several messages were sent afterwards to keep people informed of the current situation, which returned to normal at 5 p.m. the next day.

Critical analysis

The choice made by Belgium is not so far from that of the Netherlands, where 3,800 sirens have been removed to create one single system, *NL-Alert©*, which allows the sending of SMS messages without depending on the cell phone network (CBC). SMS has several advantages:

1. The alert is no longer only triggered by the authorities, and the collaboration between the different players (who have legal backup and 24/7 assistance) makes broadcasting the warning faster and more efficient (**Figure 3**).
2. Informed through different channels, the community can better identify the danger.
3. Ongoing collaboration between the Crisis Management Center and actors in the field makes information and awareness initiatives aimed at the community more consistent.
4. *Be-Alert©* warnings are triggered depending on the **location** (alerting people located closest to the event, using concentric circles), the **context** (warning everyone as a precaution, thanks to the optimal distribution of the channels used) and the **time** of the event (using different channels according to time and day), for better flexibility.
5. No smartphone application is used, for two reasons: having to install it beforehand was deemed too complex (IBZ, 2017), and the penetration rate in 2015 (66%) was one of the lowest across the 28 European countries (according to a 2015 iVOX survey).

Potential solutions and requirements

The next step would be to customize the alert and, more specifically, the information that a person receives, to avoid the standardization of alert messages. In this regard, using artificial intelligence based on individual data (people with family or not, managers of businesses open to the public, persons living alone or within a group, etc.) would make it possible to create personalized messages, even if cognitive and perceptual factors are still difficult to consider when developing such tools. Work is underway to combine hydride-related hazards (often the target of disinformation) and the impact of climate change (increasing weather variability and its consequences), in order to better consider the domino effects (notably during a blackout). And the LB-SMS finally appear as a good solution in this country.

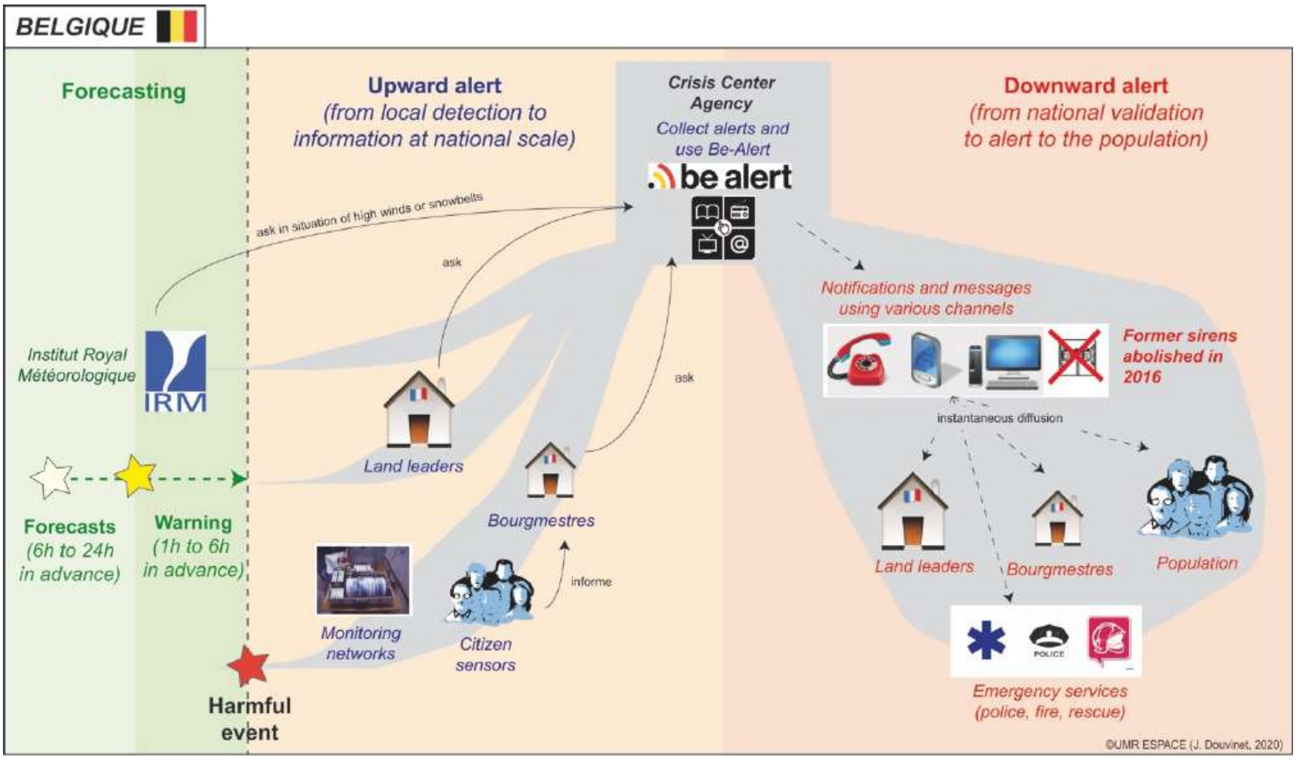


Figure 3. Overview of the alerting process and tools used in Belgium.

5.2. United States: a single, multichannel digital platform

Structure and context of the alert

Responsibility for the Public Warning System was established under the *Disaster Relief Act*, created in 1970 by President Richard Nixon (Zunkel, 2015) and which was amended on November 23, 1988 by the *Stafford Disaster Relief and Emergency Assistance Act*. The *National Response Framework* (NRF) provides an overview of the *Stafford Act*, which requires federal agencies to aid local authorities in case of emergency or in the event of major disasters. The EAS (*Emergency Alert System*), which covers 90% of the population, stems from a long federal tradition (**Example 3**); WEA (*Wireless Emergency Alerts*), which allow a 90-character SMS to be sent to mobile phones and pagers using relay antennas; NOAA (*National Oceanic and Atmospheric Administration*) *Weather Radio*, the organization in charge of broadcasting vigilance and alert bulletins in the event of potentially damaging hydro-climatic hazards. These systems have been gathered together within a platform called IPAWS (*Integrated Public Alert and Warning System*).

EXAMPLE 3. The *Emergency Alert System* is a national Public Warning System allowing the President of the United States to address the entire population in less than 10 minutes, via radio and television, as well as warning local communities in the event of severe climatic risks (tornadoes, flash floods or severe thunderstorms). It has been operational since January 1, 1997, after being given the green light by the *Federal Communications Commission* (FCC) in November 1994 and was integrated into IPAWS in 2006. 77 stations are set as priority and must then broadcast the signal to other stations. During a test on November 9, 2011, an FCC report showed that 18% of the stations did not receive the signal due to network and reception issues. After some improvements were made, the test carried out on September 28, 2016 provided better results, with a success rate of nearly 90%. But the system still has its flaws, the EAS was notably used by hackers in 2013 to warn people of a zombie attack in Montana and Michigan counties. The EAS replaced the *Emergency Broadcast System* (EBS), which had been used since A ugust 5, 1963 and led to the creation of a single communication network by bringing together different independent television channels (ABC, CBS, NBC). The EBS broadcasts messages on specific frequencies (between 853 and 960 Hz) and was used more than 20,000 times between 1976 and 1996, mainly to warn local inhabitants of major hazards. The EBS is part of the CONELRAD (*Control of Electromagnetic Radiation*) project, initiated at the request of President Harry Truman in 1951, which alerted the population in the event of an air attack (during the Cold War). This project enabled the continuous transmission of passive defense information on radio and television stations by quickly switching transmitters, while preventing outsiders from connecting to it.

Sirens were among the alerting tools put in place across the United States in the early 1900s, their number then increased once the country entered World War II (Sorensen, 2000). Most sirens at the time were almost an octave higher than their European counterparts, with a unique modulated sound (Zunkel, 2015). From the 1950s, they were gradually replaced by "double sound" sirens and standard signals were created and used during the Cold War as passive defense. In parallel, emergency services in charge notably of monitoring forest fires, deployed their own models, with a different signal (defined by the *National Fire Alarm Code*, NFPA 72). Many cities, especially in California and New England, kept their old sirens, which are complemented by megaphones, or fog horns calling for reservists to come forward.

Strategy and organizational culture

The example of the United States is particularly interesting, for two reasons: **1)** In the USA, public warning is shared between different authorities (ranging from local, tribal and territorial administrations to state governors and federal administrations, except in Hawaii, where only the federal administration can trigger an alert). **2)** Since June 1, 2006, following the shortcomings during Hurricane Katrina (2005) in New Orleans (Louisiana), and the decision by President George W Bush, a single platform called IPAWS was created to consolidate several existing solutions (EAS, WEA, NOAA). This system makes it possible to aggregate the various messages into a single server and broadcast them through various channels. It is supervised by the *Federal Emergency Management Agency* (FEMA) but can only be triggered by the President or the Department of Homeland Security.

Sirens are tested once a month, emitting a first warning signal ("*steady tone*") for one minute, followed by a minute of silence, then emitting another signal ("*fast wail*") for one minute. This makes it possible to check the power supply and the proper functioning of the sirens without the signal being interpreted by local inhabitants as a warning for an actual danger or threat. In some cities, sirens are tested every weekend, every year or at specific times, which are set by local authorities. In order to raise awareness of the importance of this tool, especially in the event of a tsunami, Honolulu created a website called "*Adopt a siren*," drawing inspiration from an initiative carried out in Boston in 2008 to make it easier for volunteer firefighters to locate fire hydrants ("Adopt a hydrant"), and to access them more quickly if necessary.

Technical overview

Even if areas are covered by sirens, the channels are defined by local authorities and by each State. They can therefore vary from one state to another. The two most well-known tones usually refer to a danger ("*steady tone*") or an air threat ("*fast wail*") (**Table 3**), but other sounds can also be emitted, such as Westminster chimes (used for testing sirens). Each state can use them differently depending on hazards: in the Midwest for example, sirens sound when there is a risk of tornadoes, and they are located within a 5km radius of nuclear facilities. On the East Coast, they are most often used for hurricanes, as in August 2017, during hurricane

Harvey. In Washington State and Pierce County, sirens along the Puyallup and Carbon River valleys can sound when there is a risk of volcanic eruptions or lahars from Mount Rainier (Sorensen, 2000). Some universities also have sirens, especially since the Virginia attack in 2007. They broadcast a “fast wail” signal, designed to ask students to take cover.

Type of signal	Type of sound	Nature of danger	Type of use
Attack warning / fast wail (threat)	Modulated sound of 3 to 5 minutes, or repeated series of fog horns, emitted as many times as necessary	An actual attack or the launch of a ballistic missile has been detected	Sound restricted to this type of threat (although it may be used in some states to raise the alarm for tornadoes or fires). It is more often heard in war movies
Attention or alert warning / steady tone (danger)	Regular, constant sound for 3 to 5 minutes, emitted by sirens, loudspeakers or fog horns, and repeated as many times as necessary	Detection, in peacetime, of hydro-climatic hazards (tornadoes, hurricanes, flash floods and tsunamis for example)	Sound asking the population to use appropriate behavior and inviting them to turn on their radio and television for additional information
Local fire signal (forest fires)	Series of 3 pulsing sounds repeated according to a predefined cycle (5 seconds of alarm then 5 seconds of silence, then 5 seconds of alarm…). However, this signal may vary from one state to another.	Warning local population of a fire. In some communities, this sound can be emitted when there is a fire within 3 miles of a town.	Sound restricted to this type of danger. Local inhabitants are asked to evacuate as quickly as possible, and in arid regions, they must first shut off their water supply to ensure there is sufficient water pressure for firefighters.

Table 3. Characteristics and uses of sound alarms in the United States

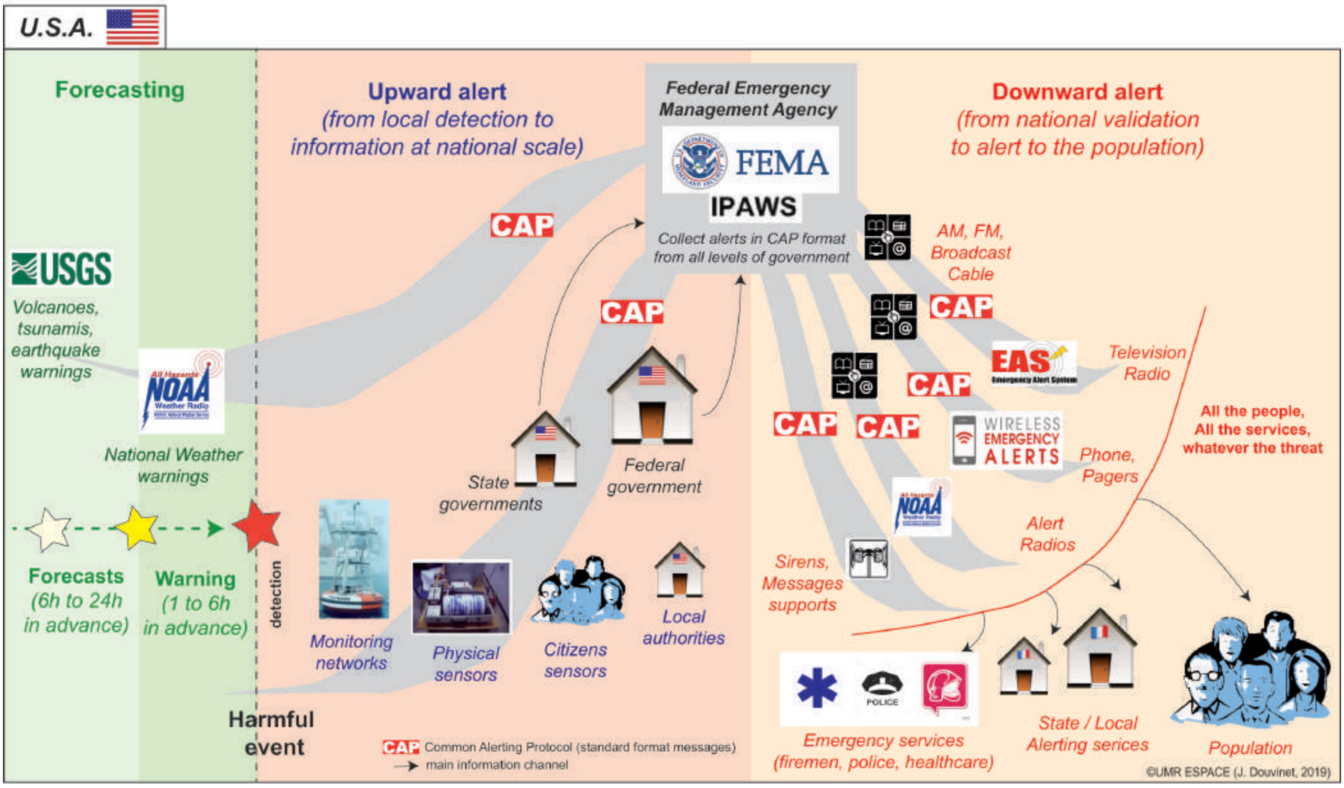
Critical analysis

Although Public Warning Systems vary from one state to another and if their use can differ according to the risks or threats (**Example 4**), the digital strategy implemented by the United States is nonetheless remarkable. Since the early 2000s, the authorities operating at various levels (federal institutions, states, counties, and cities) have developed a major communication device (Hecker, 2014). They are now aware of the need to devise a digital strategy so that the information broadcast to the public is as clear as possible (Rubin, 2012). IPAWS uses the *Common Alerting Protocol* (CAP), an international standard that improves consolidation and interaction between tools and can be used in different countries.

EXAMPLE 4. Before Hurricane Sandy in 2012, New York City already had several accounts on SNS (*Twitter©*, *Facebook©*, *Google+©*, *Flickr©*, *YouTube©*), followed by almost 3 million Internet users before the hurricane. The firefighters and the police were also very active online, and, during the event, this prevention effort allowed them to easily communicate and ensure that the inhabitants adopted the best possible behavior (Hecker, 2014). In 7 days, from the end of October to the beginning of November, almost 2,000 tweets were sent to advise local communities, warn them of power cuts and/or road closures, and tell them where to find places where food was distributed and other relevant information.

Potential solutions and requirements

The FEMA (*Federal Emergency Management Agency*) has created smartphone applications (Steff, 2012) as well as other emergency services (the Red Cross or the Fire Services). Other digital innovations are also underway, notably real-time emergency maps that were soon to be integrated into the messages broadcast by WEA (Liu *et al.*, 2017). But one of the recurring issues is the **lack of visibility on the effectiveness of the tools**: 1) for example, once people have been evacuated, it is not possible to inform them that they can return to their homes; 2) apart from the number of messages received or sent, no feedback is sent or provided to operators or emergency services, who therefore do not know the scope or relevance of the tools used to warn the population; 3) the risk of a power cut is one of the most dreaded scenarios, as sending SMS would no longer be possible if relays were not functioning.



CAP stands for Common Alerting Protocol, a standard international protocol used in the USA since 2006

Figure 4. Overview of the alerting process and tools used in United States

5.3. Australia: multi-modal and multi-scale solutions

Structure and context of the alert

In Australia (and in all the countries that are part of the Commonwealth), the alerting process comes under federal jurisdiction, which enforces the laws and defines how they are applied, but also involves governmental authorities, which are responsible, in each State, for organizing emergency services, choose the type of warning system used and trigger it when they see fit and in total independence. Each state implements its own legislation but must follow national protocols, notably the *Emergency Alert* (EA) (**Example 5**), as well as international standards such as the *Common Alerting Protocol* (CAP), applied since 2012.

EXAMPLE 5. The *Emergency Alert* is a national phone-based multi-hazard warning system. It has been operational since December 1, 2009 and was implemented following the fires that occurred in the state of Victoria during the 2009 heat wave, particularly in the Kinglake region, with extensive damage (231 dead, 650,000 ha. burnt and more than 1,000 houses destroyed) mainly during "Black Saturday" on February 7, 2009. In case of a serious event, a voice message is broadcast on all landlines, and an SMS message is sent to the mobile phones detected in the radius defined by the relevant authorities. In 2013, the Australian government improved the range of the *EA* by using people's home addresses and the last known location of their mobile phone when the alert was triggered. While this system has been highly successful on several occasions (especially during the Brisbane floods in 2011), its dependence on the telecommunications network raises concerns (Handmer and Ratajzak-Juszko, 2011; Choy *et al*, 2016). The *EA* is ineffective in areas where the network is weak or non-existent, in particular in rural areas, and this hinders the efficiency of rescue services, as seen during the Dareel fires (16 houses and 18 buildings destroyed) on October 7, 2013.

The authorities can install sirens locally (**Example 6**), according to local policies or the means allocated to them. Following the overflow floods in the Brisbane region, which occurred from December 2010 to January 2011, SNS were used to alert local communities. This practice then became widespread, notably with the agreement signed on June 22, 2017 with Facebook® and AMBER® to broadcast abduction alerts even more quickly.

EXAMPLE 6. In Australia, sirens are very inconsistently distributed. Many cities and some states do not have any, due to a lack of resources and political will, while other cities are very well-equipped. Sydney's financial and economic center (CBD) for example, has its own Public Warning System, with 98 sirens (installed in January 2007 for the APEC summit aiming at fostering economic cooperation in Asia-Pacific), which can emit a modulated sound associated with 13 predefined messages. Rescue centers can also use sirens to trigger an alert in the event of a severe fire ("bushfire" or "grassfire"), and they can broadcast a specific sound signal calling on the population to implement safety instructions, while calling upon volunteer firefighters. Industrial facilities may also have their own sirens (like the ICPE in France), such as the Kwinana plant (south of Perth), which tests its siren every Monday, and can use it to evacuate the factory and inform the entire surrounding population of tornadoes or storms.

The field survey focused on the Public Warning System used in the **State of Victoria**. The basic principle is quite simple and defined according to 3 levels of risk:

1. Level 1: "*advice warning.*" Low risk incident (no alert, only recommendations).
2. Level 2: "*watch and act.*" Incident with few consequences but lasting more than 24 hours. The local communities must act in accordance with the information received (prepare to evacuate, evacuate immediately, prepare to take shelter, remain indoors, find more information about the evolution of the situation, etc.).
3. Level 3: "*emergency warning.*" High risk level for the community with evacuation or lockdown instructions (depending on the type of risk). In the state of Victoria, regulations do not allow for compulsory evacuation, which is possible in other states, such as New South Wales. But it is possible to prohibit the return home of local inhabitants from the moment they are no longer on their property.

The situation is constantly reassessed all through the event until the alert is at an end. If necessary, all television programs are stopped and the warning message is broadcast every 10 minutes, according to a national agreement.

Strategy and organizational culture

Located at the coordination center, the Incident Controller (IC) is in charge of managing the emergency response and triggering the Public Warning System (PWS). This key role in the alert process can be filled by a member of any relevant agency. Each type of risk is thus overseen by a specific organization: the CFA (Country Fire Authority) or AFAC (Australasian Fire and Emergency Services Authorities Council) are in charge of fires while the SES (State Emergency Service of Victoria) focuses on natural hazards. The BOM (Bureau Of Meteorology) works in partnership with the Tsunami Warning Center (JATWC and Geoscience Australia) and issues warnings for hail, storms, and floods. In the event of a very serious incident, a state organization may be involved. The State Control Center has access to analysis and modelling tools to provide near real-time "Situational Authority." The Australasian Interagency Incident Management System (AIIMS) is part of the Public Information Department. AIIM has been the pillar of command and control for fire and emergency services in Australia and New Zealand for over 20 years.

Not all emergencies result in an alert. Thresholds for triggering a warning (see Risk Matrix in **Figure 5**) have been defined according to predetermined factors, such as wind speed, amount of rain, location, and time of event, etc. For example, BOM triggers impact warnings with different meteorological thresholds: a hail warning is issued for hailstones of a certain size and tropical cyclone alerts are triggered according to wind speed. A combination of factors is used, depending on the type of incident. Experience also counts (i.e. if a tornado takes place at night, no warning is issued as evacuating people would be too risky and could result in loss of life). Whatever the risks, the warning message is issued on a single platform, accessible to all relevant players. Once the message is issued on the platform, the information is automatically transmitted to the media: social media, agency websites, journalists (TV, radio) and SMS so people can find the information on the media of their choice. SES also uses volunteers as "sensors" who send photos to decision-makers so they can confirm the relevance of the alert.

Technical overview

More than **10 channels are used for public information, but only 4 are considered as the main warning tools:**

1. Location-based SMS (LBSMS): compatible with all mobile phones,
2. Cell Broadcast (CBC), more effective for large-scale major emergencies that unfold quickly but compatible only some mobile phones,
3. Sirens,
4. Loudspeakers.

Other channels (TV, radio, social media, smartphone apps, word of mouth, door to door, etc.) are also used, but no longer to inform the local community.

The choice of channel(s) depends on the type of hazard and its impact, but the tools are the same for all types of risks. State and local emergency services use the national PWS "Emergency Alert" system (which combines landline and mobile subscriber records since 2010 and with LBSMS since 2012) for more than 1,500 events in order to send over 15 million warning messages. The teams are continuously monitoring social networks in order to deliver information as quickly as possible. For automated alerts and real-time observation, artificial intelligence, sensors, satellites, cameras, and drones are used. Police forces use cameras and loudspeakers throughout Melbourne within a 45-zone grid, with the city owning the system. Voice messages are issued in the relevant areas but only in the city center. EMV (Emergency Management Victoria) creates the maps and BOM provides the data.

Most people look for information on the official website:
https://www.emergency.vic.gov.au/respond/

Critical analysis

All the tools are deemed **highly effective** by many actors involved, any inconsistencies and issues are mainly due to their use and the content of the communications. An icon can complement the message, but players seem to find it difficult to decide on a single visual code at a national level. This is an ongoing project, led by the coordination of federal services ("warnings group"). This working group is also reflecting on how all aspects of the alert could be made more consistent at a national level, as some inconsistencies have been highlighted during the 2019-2020 fire season, changing the way the national warning system is perceived.

These events led actors to switch from a rigid policy to a hands-on technical approach based notably on the definition of alerting levels and warning zones, better governance, improved data consistency, incident closure, partnerships, journalist accreditation and training, etc.

Figure 5. Risk Matrix, warning thresholds (EMV).

The SMS warning message is also limited to 160 characters, which is too short to give precise information. Therefore, despite the efforts made to improve the clarity of warning messages, the information is not always understood by local communities. Improvements need to be made in message clarity and the way uncertainty is communicated. Among the types of behavior that have been observed among EMV app users, it appears that when users feel they receive too many warning messages or when alerts are not properly targeted, they simply turn off the notifications. On social networks, fake news mostly comes from bots, not humans.

Training exercises are regularly carried out with local communities. Feedback is also collected and shared with services in New Zealand.

Potential solutions and requirements

All players consider **climate change** as the main threat. The bushfires that occurred from October 2019 to February 2020 produced a large amount smoke, which then became a health hazard. This smoke spread over an area equivalent to 1/3 of Europe. BOM is also currently working on heat waves in partnership with the Australian Bureau of Statistics and the National Department of Health. The smoke modeling service in place integrates wind speed and provides accurate information. Five years ago, “Thunderstorm asthma” put extreme strain on the emergency system. An ongoing project is also aiming at implementing a weather warning that would help people predict the risk threshold for themselves or their business, independently of PWS. With their impact on the food supply chain, pandemics also raise concern about the capacity to feed cities. Cybercrime and bots, although they are not weapons in the traditional use, must be integrated into the model, increasing its complexity (**Figure 6**).

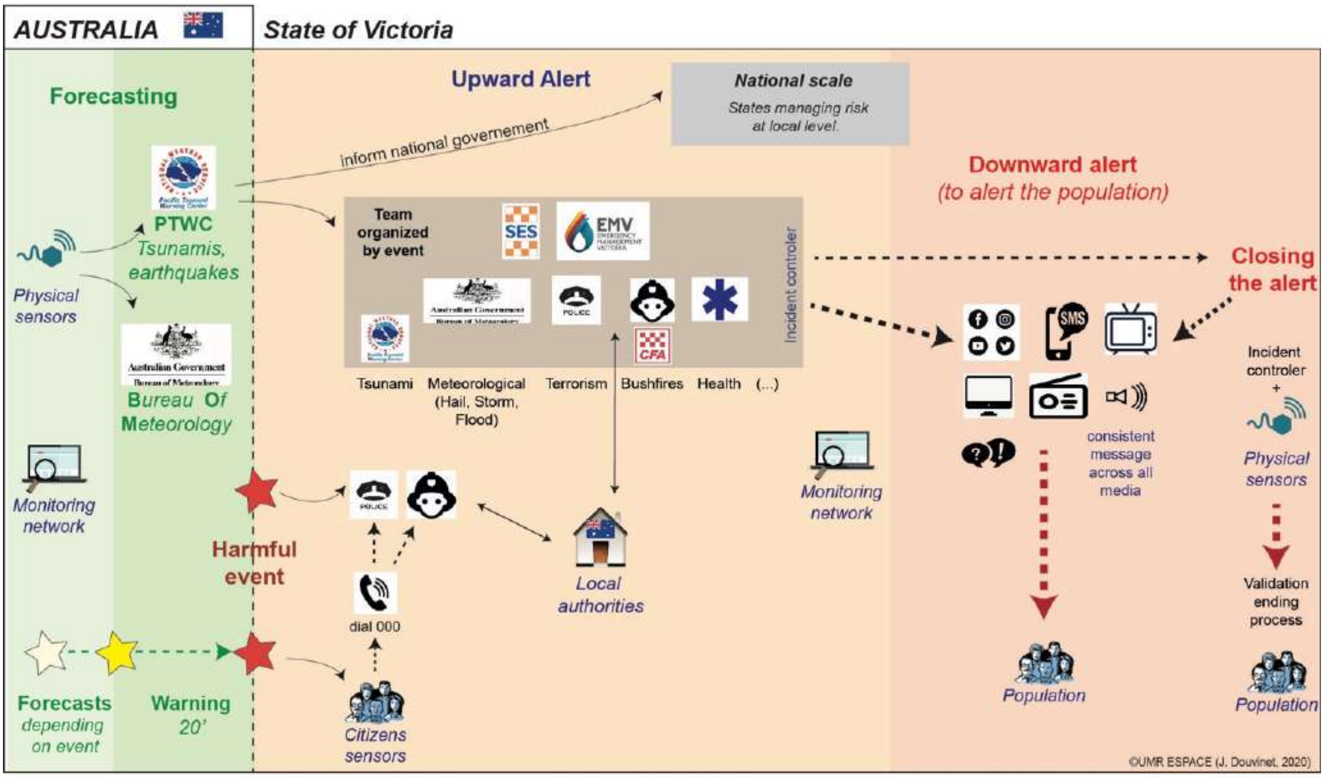


Figure 6. Overview of the alerting process and tools used in Australia.

5.4. Indonesia: harnessing the power of social networks…

Structure and context of the alert

Indonesia is a country particularly exposed to risks: there are many possible hazards and concerns, notably due to the country's particular vulnerability, given its high population density and poverty. According to the Regional Risk and Vulnerability Assessment (RVA), which considers exposure to multiple risks, coping capacities and population vulnerability, Indonesia and the Philippines are the countries in South Asia that obtain the highest scores (AHA Center, 2019). Since the 2004 tsunami, many efforts have been made in this region, both in terms of detection and warning. In addition to Indonesia's exposure to the elements, its great cultural, ethnic, and religious diversity must also be considered in the management of warnings and disasters in general. Indeed, the major role played by community and/or religious leaders must not be neglected in the implementation of solutions aimed at protecting local communities.

Risk monitoring is the responsibility of two governmental agencies (**Figure 7**):

1. BMKG (*Badan Meteorologi, Klimatologi, dan Geofisika* or Meteorology, Climatology and Geophysics Agency), a non-ministerial government agency, monitors drought, earthquake, tsunami, cyclone and flood hazards.
2. PVMBG (*Pusat Vulkanologi dan Mitigasi Bencana Geologi* or Center for Volcanology and Mitigation of Geophysical Hazards) reports to the Ministry of Energy and is responsible for monitoring volcanic hazards and landslides.

Strategy and organizational culture

This division of tasks causes **coordination issues**, as moderate volcanic activity can cause a landslide, leading to a tsunami (i.e. the tsunami of December 22, 2018 in the Sunda Strait). The government thus has to review the monitoring of related risks. These two large national agencies are tasked with warning the local authorities, the media, the police, the army, the BNPB (*Badan Nasional Penanggulangan Bencana* or National Disaster Management Authority) and the BPBD (*Badan Penanggulangan Bencana Daerah* or Provincial Disaster Management Agency) when a destructive event is likely to occur. However, they cannot issue an official alert to the population, as in France, they only have the power to inform (vigilance). Monitoring is also carried locally out by river flood agencies and by the main volcano monitoring centers, such as the BPPTKG geology agency (*Balai Penyelidikan Dan Pemgembangan Teknologi Kebenganaan Geologi*) in Yogyakarta.

In addition, given the transnational nature of hazards in Southeast Asia, the BMKG and the PVMBG cooperate with several international agencies:

1. The *Indian Ocean Tsunami Warning Mitigation System* (IOTWMS), which monitors tsunamis in the Indian Ocean and the archipelagos of Southeast Asia.
2. The *Asean Specialized Meteo Center* (ASMC), which monitors meteorological and hydroclimatic hazards (floods and cyclones) in South-East Asia.
3. The *ASEAN Earthquake Information Center* (AEIC), which monitors earthquakes.

The warning is broadcast by local authorities: the *bupati* (equivalent of our prefects) within the *kabupaten* (subdivision of a province) or the *wali kota* (equivalent of our mayors). Specific individuals or community and/or religious leaders are also in charge of broadcasting the warning message locally, as they can reach people and areas at risk more efficiently than local governments.

Figure 7. The earthquake and tsunami control room at MBKG

Technical overview

As in France, the alerting solutions are diverse and vary from one region to another:

1. **SMS alerts** are used in some cities, including Jakarta, in order to warn the population in certain areas, as well as specific players (police, rescue services, army, etc.). SMS are used to inform the Jakarta police of a bomb threat for example, or to warn hotels in Bali of the risk of a tsunami or terror attack. SMS were also used in Yogyakarta to give instructions to local inhabitants during an earthquake.
2. **Sirens** are used in areas where the risk of tsunami is high as power cuts can occur during an earthquake.
3. **Television and radio** are used nationally but they are also vulnerable to power cuts that can occur in the event of a hazard (especially earthquakes).
4. **Social networks** are used to inform the different ethnic communities, notably WhatsApp, in which groups of up to 200 members can be created. Local or community contacts are identified and are responsible for broadcasting the warnings they receive through specific WhatsApp groups. This is what one could call a “WhatsApp alert chain,” which offers great reactivity, although it is difficult to measure. Other networks (Twitter, Facebook, Instagram) are used, but they seem to be less effective in terms of information broadcasting.
5. *Kentogans* (hollow wooden trunks) are also used in some rural areas.
6. **Smartphone applications** are used by some local councils, such as Semarang, to warn the population of a danger due to natural hazards (*Semarang Disaster Alert*©). The use of these types of tools raises concerns due to their lack of durability as they rely on contracts with network providers. A change of local government often leads to abandoning this type of solution. Thus, this application no longer exists today but people can install other warning applications that are not managed by government bodies (notably *Disaster Alert App*© which operates on a global scale).

Authorities have decided to harness digital technology since 2010, particularly *Twitter* © during the earthquake that occurred on the island of Sumatra in 2012 (Ishino *et al*., 2012) or during the eruption of the Kelud volcano in February 2014 (Anggunia and Kumaralalita, 2014). The National Disaster Management Agency (NDMA) works hand in hand with the Meteorological, Climatological, Geophysical Agency of Indonesia (BMKG) and both post messages on *Twitter*©. The number of users following @BMKGIndonesia (this number went from 300,000 in 2012 to more than 1 million in 2015; Carley *et al*., 2015) is way ahead of the accounts that exist in France (14,500 for the SDIS in the Loire for example).

EXAMPLE 7. The PetaJakarta.org project was carried out by the University of Wollongong (Australia), the Jakarta Disaster Management Agency (AGC) and *Twitter*© to show that local inhabitants can help government agencies by improving the quality and speed of response to floods, long before they cause any damage. The tweets are aggregated in real time and they feed into a situation map. This tool is presented as a self-organized socio-technical system, and individual users are free to consult, contribute or leave the network at any time. Only relevant tweets (addressed to @petajkt with the hashtag #banjir) are aggregated using state-of-the-art technology (CogniCity) in order to minimize errors. The system is based on trust: every posted message must be considered as true, even if errors remain possible.

Critical analysis

But the technologies used in Indonesia also have limitations. The Indonesian surveillance and alert system benefits from proven technology, which enables fast action for certain risks, but not for all of them. International cooperation in monitoring hazards further improves since 2014 the efficiency of the system. Thus, for tsunamis, the warning process is particularly quick (5 minutes) and the BMKG is still hoping to improve it. But detection remains a concern, with all players highlighting the deterioration and theft of sensors at sea, a problem to which no appropriate solution is offered at present.

For the best known and most monitored hazards, such as volcanic activity, the warning process is able to integrate local players (local government, communities, etc.), with simple and effective means (telephone, walkie-talkie). In any case, using social networks is the most common way to issue the warning to local inhabitants, using existing community groups. WhatsApp is currently the most commonly used platform; it is widely used throughout the population, even if one can question the relevance of such a tool in the most remote communities, which often have limited access to digital technology. From a technical point of view, the means are in place and allow a rapid response that seems appropriate, despite the vulnerability of some detection systems (sirens, traditional media).

The main weakness of the Indonesian system is related to the reception of warning messages in the communities, as well as the trust these communities place in them. The first issue lies in the power leaders have within their communities, as they can make the reception of official messages and the application of safety measures more difficult. In case of doubt or contradiction, they hold an unshakeable power over the community, whatever the message or the instructions they transmit. Added to this are the social issues linked to poverty and the marginalization of certain communities. Many players have underlined the importance of better understanding the cultural, social and religious diversity of local communities in order to improve not just the technical aspects of the warning system, but the reception and understanding of the messages, improving the engagement of communities and, ultimately, their resilience (**Figure 8**).

Potential solutions and requirements

Recent research has demonstrated the benefit of connecting physical networks (sensors) with SNS to reduce approval time and broadcast messages quicker to local communities (Ai *et al.*, 2016) in the event of an alert due to a natural hazard, in particular a tsunami. However, these practices need to be better coordinated between organizations, which are not the same depending on the type of hazard. This lack of interoperability creates challenges that technology only cannot overcome (Chatfield *et al.*, 2014), which confirms the relevance of co-building practices *outside* of a crisis.

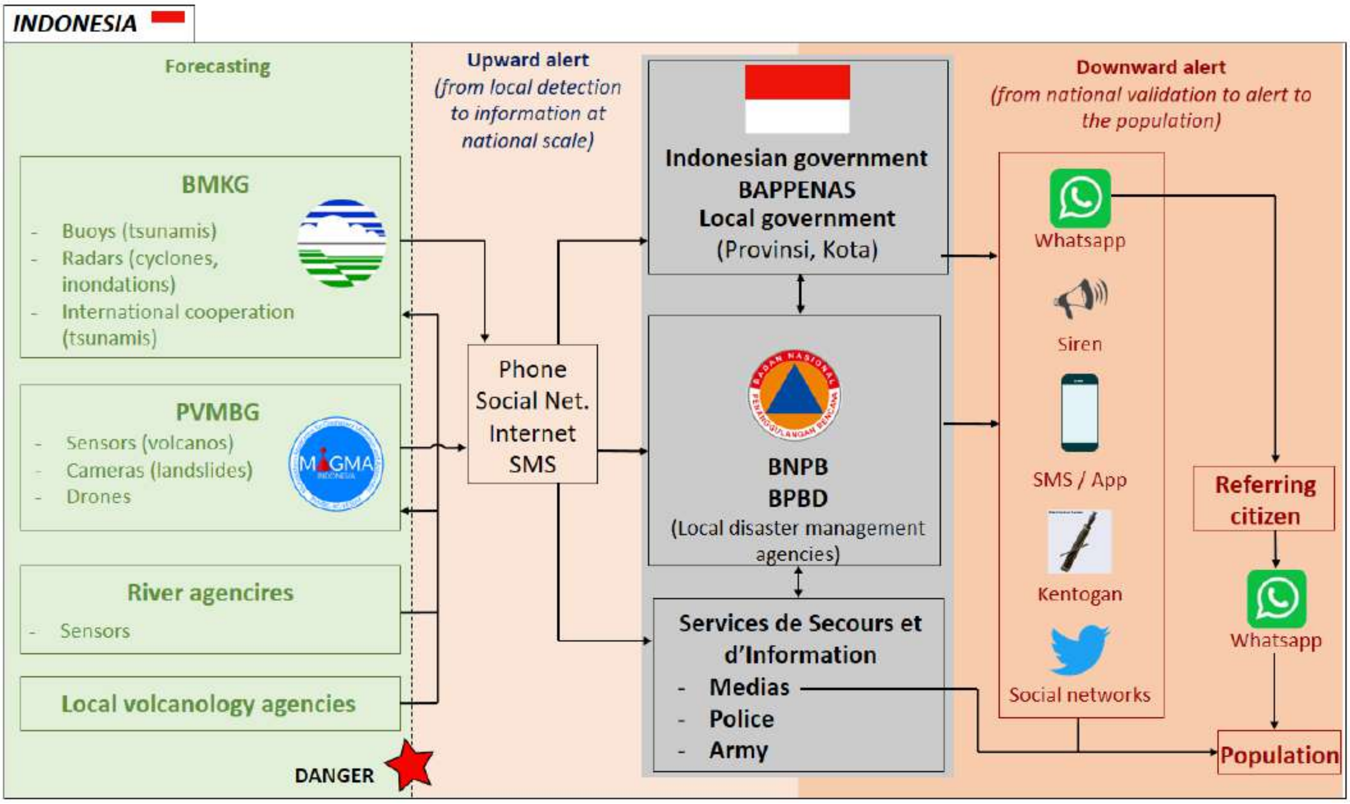


Figure 8. Overview of the alerting process and tools used in Indonesia.

5.5. Early findings

The research carried out has allowed us to better understand **the reasons for the diversity of national systems in place in the countries studied**. These systems are linked to the local organizational culture, but are also dependent on political, economic, and budgetary choices that change according to requirements, expectations, and opportunities. These systems are also dependent on the frame of reference, history, and geopolitical structure of each country. **Finally, there is not just one system, but several alerting systems !**

Significant events can cause a rapid change in existing systems, like the changes initiated in the United States (with the implementation of the IPAWS platform in 2006, following the shortcomings during hurricane Katrina in New Orleans) or in Belgium (with the creation of *Be-Alert©* in 2017, following the terror attacks in Brussels at the end of 2016). A non-exhaustive summary is also provided to illustrate this finding (**Figure 9**). Similarities can be observed elsewhere: there is obvious proximity between the induced change and the occurrence of a disaster. **2012 was a pivotal year**, as 5 countries opted for new systems during that year. **However, changes have not been implemented in all countries, in France in particular. The country must therefore better anticipate future events and build for the future without waiting for a disaster to happen.**

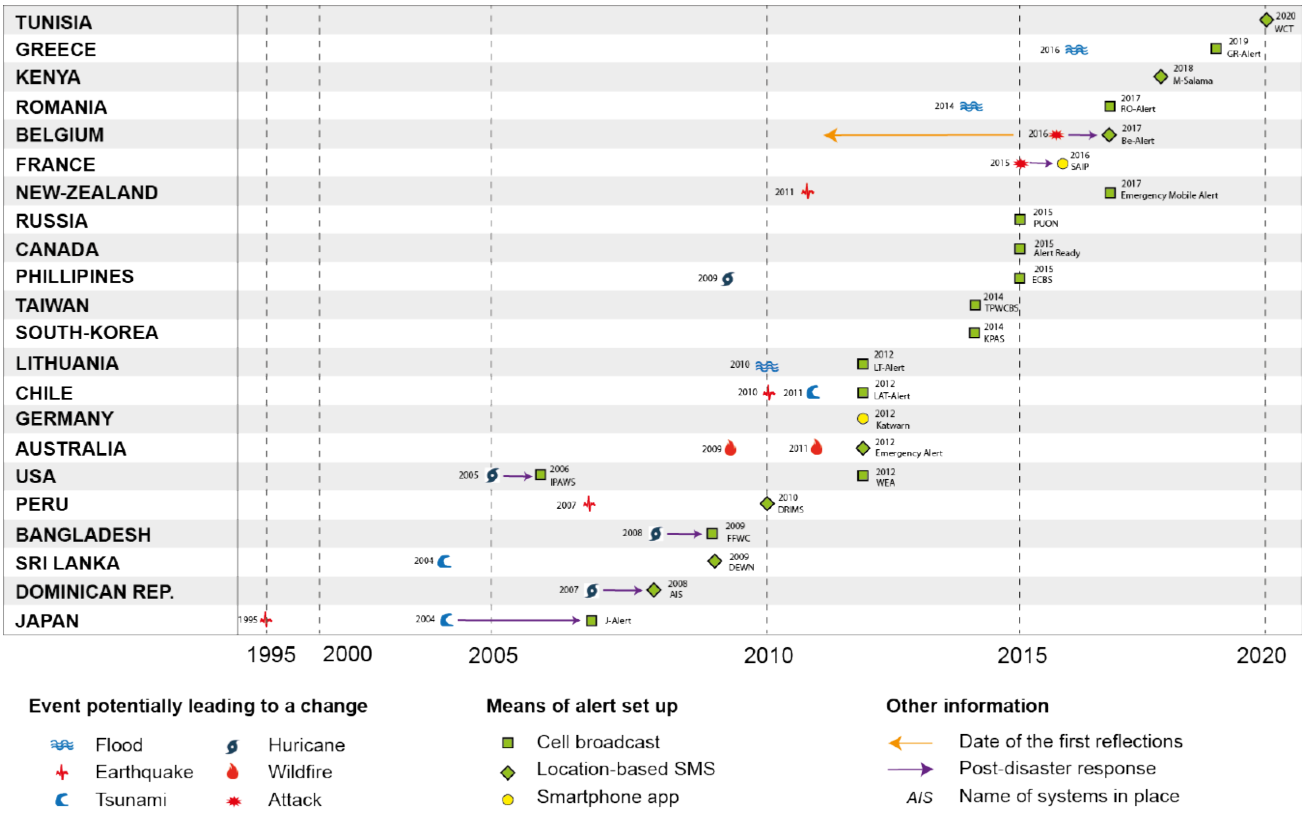


Figure 9. Date of tool implementation in several countries across the world and temporal proximity with one or several major event(s) that play a key role in the change(s) (document available in an A4 format in Appendixes).

The fact that tools are actually in place does not mean that the effort should stop. In the United States, **the technical efficiency** of the IPAWS platform is challenged by the lack of feedback on **social** (acceptance by the population) and even **operational efficiency** (has the scope of the crisis been reduced by warning the population?).

If the system is to be adapted to the needs of the country, it must above all be embedded in the daily lives of individuals. This has two consequences: 1) If the community does not engage with the training exercises offered by and for local inhabitants, resources must be found to better organize them and ensure their appropriation; 2) Warnings must be considered not as a nuisance but as an opportunity to practice safety procedures, coordinated between all players, as a way to support the community, while avoiding disrupting people's daily life.

6. Identification of good practices

In order to assess the **continuity between sub-systems** (and highlight good practices), the answers collected for each question were first compared with each other. The links between the systems were then summarized to show how organizations have evolved to be more flexible and efficient. A record of all the discussions was provided in digital format to CHEMI. The recorded feedback was validated by the interviewees but only reflects the opinion of the people who provided it (not of the organizations they work for). We only provide anonymous answers here to preserve privacy and the neutrality of the opinions collected.

6.1. Organizational objectives

What are the objectives of a Public Alerting System?

The objective mentioned in most interviews is as follows: **the objectives of a warning system is to inform as many people as possible within the area at risk, so that they can take appropriate action.** It is therefore necessary to specify the nature of the danger and the relevant safety measures in the message. Other objectives are also mentioned:

- The warning must be adapted to the context.
- The warning must prompt recipients to search for information.
- The warning must create a reaction from the authorities who trigger it.
- The warning must minimize human and economic losses.

Reaching all people at risk is therefore mandatory (taking linguistic differences into account) with an understandable and clear message, to limit human, economic and social losses, even if, in certain situations, **the number of targeted people is not always known in advance or in real time** (universities, stadiums, major events, etc.).

The alert is a **signal that triggers others.** Time proves to play a key role, as does **uncertainty** regarding the unforeseeable effects an event can have on a community. But the concern is that France has opted for a top-down approach while the population should be used to inform emergency services and the sharing of information and feedback should be continuous. In other words, France must break away from a traditionally **centralist vision**.

What behavior is expected from the population?

Once the warning is received, people are encouraged to:

- **listen** for **advice on individual safety,**
- **follow the instructions** or information provided, depending on the context,
- adopt the behavior for which they have been trained *(hence the need to be consistent with the prevention policy)*, in line with survival mode guidelines (Protect, Alert, Help, the approach used by firefighters),
- **try not to panic**, which can lead to **individual panic** (mass panic can then lead to unpredictable movements of large crowds),
- consider that the message sent takes precedence over other signals,
- **act according to context** (evacuation, lockdown, change of destination).

The information broadcast is supposed to produce an individual (re)action, which must be placed in a context of advice (vigilance), watch (pre-alert) and action (alert).

Are these expectations clear (understandable) during the alert?

In order to obtain a reaction from local inhabitants, it is necessary to:

- specify in the first messages **the nature of the event and its scope and potential consequences**,
- **explain recommendations** and guidelines in simple words,
- **do not separate the signal from the instructions** (there are different sound alerts in the USA, as there are in France, etc.),
- make the warning a priority in a context loaded with other information,
- **adapt to instructions and accept that they may change over time**,
- **translate the message into several languages.**
- know what to do when there are "warning signs" or "weak signals" (as with the Merapi volcano in Indonesia).

For some, the alert must correspond to a specific risk, but we must be careful of domino effects as reactions can become contradictory (Natech risk, i.e. the relations between technological and natural disasters). The risks should be assessed and prioritized (what will cause the least loss of human life?). The key factor is not the means of communication but the content of the message. But the issue is actually obvious: **expectations are not clear, and it is a recurring issue** (when a fire occurs, the brush is cleared the following year, but not the year after).

Which time frame does it follow?

The alerting time must be adapted to a **context.** The time in which the alert will be broadcasted depends on: the hazard (and its kinetics), the challenges (is the population prepared?) and the time estimated to implement safety measures (evacuation? lockdown?). There is therefore **flexibility in the timing**. Some actors advocate a gradual ramping-up, from the vigilance stage to a "phasing" of the alert (advice, vigilance, pre-alert, emergency alert). Closure of the alert must not be neglected (it must be done with the same tools used for the alert itself).

Which steps must be taken upstream?

The actors interviewed confirm the need to take some steps upstream, such as:

- **communication and raising awareness through various means** *(public meetings, press releases, group creation on social networks, newsletters, etc.),*
- **training through exercises***,* among the population and decision-makers *(even if it is difficult to organize and that people's reactions are never the same in a real situation or when facing a risk they haven't been trained for or that they do not understand),*

These steps are taken inconsistently in the different countries, depending on the risks and the expertise level of the organizations (from governmental to corporate level). People get involved because they keep experimenting (like in Belgium or Australia). Some also believe that they would be more effective if they could better prepare the pre-disaster phase (so the post-disaster phase would be easier to implement). **These steps must be integrated into an information strategy in order to implement a "reactive culture," and so that everyone can understand what is happening.** Trust in the authorities and ongoing engagement with local communities during the prevention phase are essential to make sure that instructions and messages are accepted by the population during the event. **Local inhabitants must therefore participate in the training exercises.**

Which steps must be taken upstream?

To improve the effectiveness of an alert, it is necessary to:

- consider the alerting process and tools as the **first step in crisis communication** (*it must therefore be flexible, multi-channel and adapted to the context),*
- **consider the alert as decisive as it helps build trust with the community** (if the warning is not perceived as credible, it is more difficult to create this trust afterwards),
- collect **feedback** to identify the **corrective measures** to implement and evaluate the coordination between the different players, even if it means setting up new collaborations (by creating a link between different organizations for example),
- continue to **reflect on the resources used** (existing), or on those to use later,

Many actors refer to these steps and consider that **the lessons learned through past events are not shared enough.** An interviewee notably suggested the creation of a **national feedback database**. Some shared their needs: better adapt messages to recipients and better train crisis management teams in real information to make the alert "*more credible*." In Australia, if the people who have been warned do not react, the authorities must contact the emergency services, who will then decide what action to take. In Israel, children are trained from the age of 3. In the end, what matters is the way in which individuals take on board the crisis, and they must understand that experts are confronted with many uncertainties (whereas today's society, which idealizes everything, tends to refuse uncertainty).

Additional information

- Two online documents on public warning strategy and communication in Belgium, https://centredecrise.be/sites/default/files/brochure_alerter_pour_sauver_des_vies_fr_1.pdf
- In France, alerts are not perceived in the same way by the population (businesses open to the public, stadiums, neighborhoods, etc.)

What are the main characteristics of organizational objectives?

Organizational objectives are **compartmentalized in France**: authorities apply the provided guidelines and undertake their assigned tasks, while communities seem left out. The objectives must therefore be consistent between all players, who must work "hand in hand," especially as the objectives during the prevention phase, during the alert, or after the event, are basically the same. (**Figure 10**).

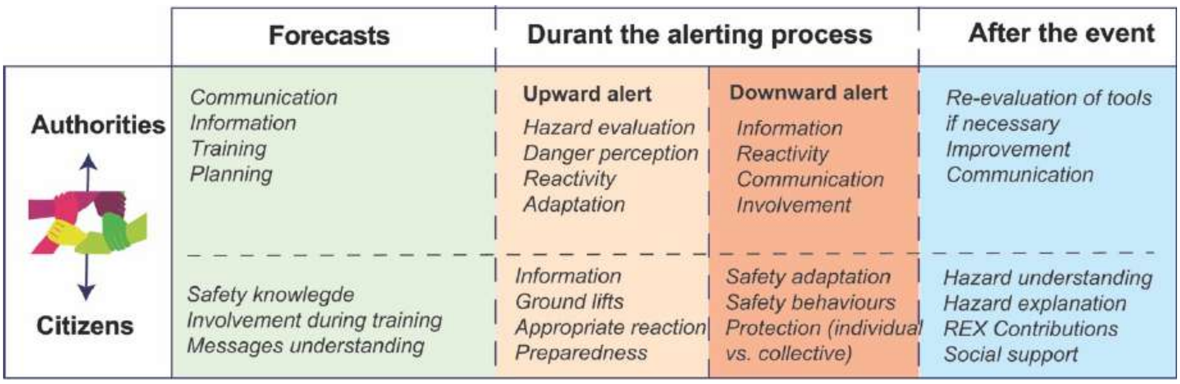


Figure 10. Summary of the main organizational objectives of a Public Warning System

6.2. Structure of organizations

Which organizations and actors are involved?

Authorities, decision-making levels and administrative hierarchy are different from one country to another but **several similarities can be highlighted**:

- **The scope and nature of the event define the level of decision-making** (a warning about a nuclear incident or a terror attack is broadcast nationally; a fire or forest fire is the responsibility of local authorities, the local council, the province or the prefecture, depending on the administrative structure of each country),
- The messages are broadcast locally (whether the alert is at a national level or whether the incident is very localized) by organizations or individuals *(in Indonesia, 2 or 3 selected representatives are in charge of "Safe & Rescue" operations*),
- Emergency services, weather forecasting services and decision-making authorities are considered as key players by interviewees but the way they communicate and organize themselves often differs.
- In France, little change has been made from the traditional methods: each player stays in their own paradigm, and politicians do not have the courage to change (*worse still: some want to impose on others what doesn't even work here…*).

For many interviewees, there must **be a real dialogue between all players**, who must work together on multiple scenarios, and **coordinate the alert.**

Who receives and analyzes upward information?

The upward information channel involves **all the actors in charge of monitoring** (police, emergency services, weather forecasting services, subprefecture, mayors, etc.). These actors can depend on hazards (BOM in Australia and SCHAPI in France, which are responsible for hydrometeorological monitoring for example). Information collection, analysis and modelling of future events can also be undertaken by local inhabitants or emergency service teams located near the affected area. **In order to optimize the pooling of resources and promote information sharing, this channel must be better structured but not centralized. The role of experts should always be to pass the information onto the relevant authorities.**

Who triggers the downward warning process?

Decision making depends on the regulations in place in each country. In Belgium, a police officer has this responsibility (and not the fire services). In France, it is the Operations Director (prefects order and mayors take action – even if, with the future SAIP, prefects will be able to trigger sirens remotely across a whole department) and the process thus follows a "top-down" approach. In the United States and Australia, every state and every governor has this jurisdiction. In Australia, the alert can be triggered by *Incident Controllers* who, depending on the nature of the risk, can be police officers, firefighters or belong to a local authority dedicated to public safety. In Indonesia, it depends on the scale of the risk: the authorities can rely on community or religious leaders to broadcast the warning message. **Automated warning systems (tsunami, flash floods) are currently in place or are being deployed (in this case, the alert does not need to be approved by a human being).**

Who approves the broadcasting of the alert to the population?

Approval depends more on the time the authorities have (and thus on potential impact) than on their expertise. In Belgium, a contact between the mayor and the Crisis Management Center may suffice for localized events, but for a major incident, the Minister's spokesperson himself must approve the message. In France, if safety measures must be implemented, the alert must be approved at a local (closeness with the area, daily presence) or departmental level (for a question of means) but once again, if it is a large-scale event, the decision is taken at a national level. **In Australia, approval is based on "subsidiarity":** depending on the location and type of event, the person responsible for assessing the impact on the community is the person who triggers the alert. In Indonesia, the alert is approved by the authorities: the NDMOs (Local Risk Management Offices) receive the upward alert from forecasting centers (BMKG and PVMBG) and trigger the downward alert. In any case, the approval always relies on human beings, who make their decision based on their understanding of the situation.

Which players are indispensable in the process?

Some actors deem decision-making levels essential (the approval of a local authority, a local safety committee or the mayor is still mandatory in Belgium for example) **as well as weather forecasters**, especially in the case of hazards with fast kinetics (tsunami, flash floods, etc.). Few interviewees suggest a hierarchy between players, which can vary according to the observation perspectives or the scale. Some recommend keeping all current players; others **focus on responsiveness and action. To improve resilience, one needs redundancy and consistency across the whole system (with regular and, above all, identical messages!).**

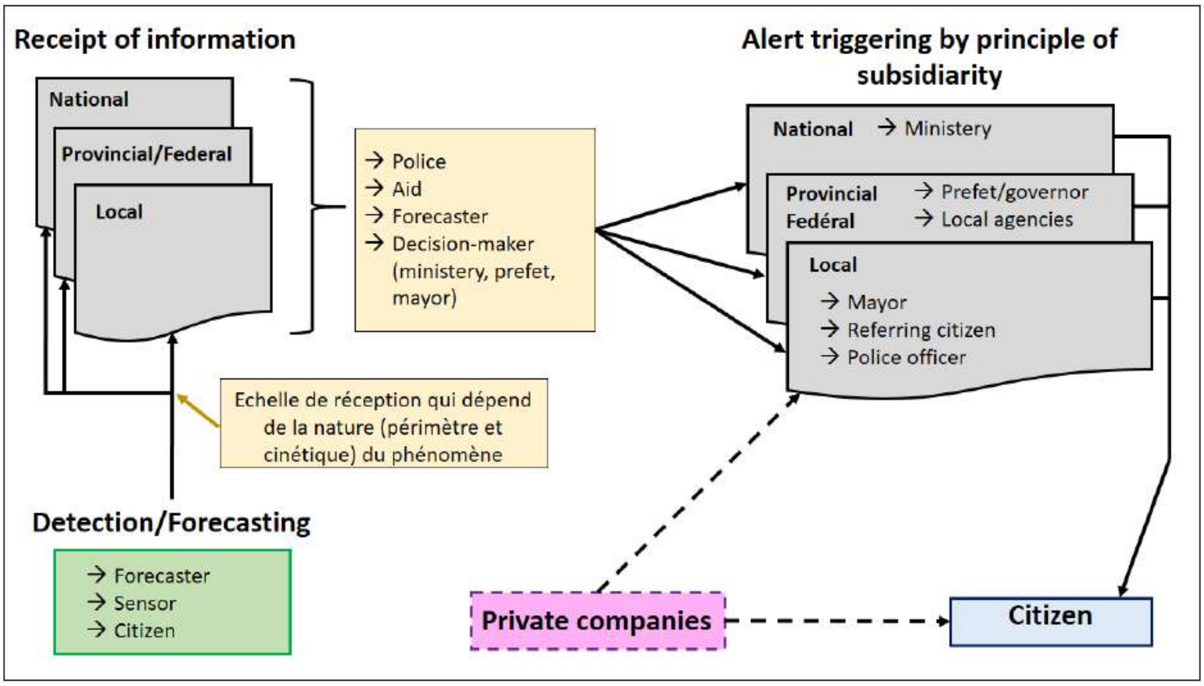


Figure 11. Overview of the organizations involved in the Public Warning System.

Which ones can be done without?

A balance must be found between the speed of the alerting process, and the desired outcome, and this balance depends on the responsiveness of decision-makers, but also on the type of hazard and local context. Private entities interfere with the system, either through ignorance of the governance or because they find it difficult to position themselves in the event of a crisis. But more than organizations as such, **it is people who slow down the decision-making process** (as they want to refine the content of the message, check which specific area is concerned, etc.), often because they are trying to do the right thing. This slows down the process rather than blocking it. **People must therefore become more familiar with communication management and the warning process itself**. In Belgium, thanks to the exercises carried out, during a recent industrial incident, the approval of the *Be-Alert©* process took only **5 minutes**, the mayor and his councilor arriving on site by car to assess the risk level. If the situation is urgent, on the other hand, everyone must be informed at the same time (with CBC for example), therefore accepting the fact that there is no need for approval from the authorities. For others, while everyone has their role to play, leadership and inclusion are nonetheless fundamental.

6.3. Techniques used (how to alert the population?)

Which tools are usually used?

The technology used differs from one country to another. Belgium, the United States and Australia have integrated all alert tools into one single technical platform. Some of the most used tools are:

- sirens (France, USA, Australia, Indonesia),
- e-mails,
- SMS (location-based SMS; CBC or Cell Broadcast),
- social networks (via official accounts),
- door to door,
- signs with variable messages,
- loudspeakers (sometimes with pre-recorded messages),
- television and radio,
- smartphone applications (although it can create discrimination among certain communities),
- websites (to broadcast official information),
- press conferences (as a way of clarifying the situation).

Some actors admit that traditional tools (notably sirens) are obsolete, and they are replaced by social networks during large-scale events. Other players say that some tools are more a means of communication than alerting (SMS). The tools are either triggered through a multi-channel approach (all tools are for everyone and for all types of risk, except terror attacks, and the range of tools available is coordinated in Belgium, Australia, and the USA), or individually. Although the tools exist and are tested, **they are not always used**. It is also interesting to note that some players highlight a **risk of confusion** for some people (sirens located near the coast can warn of a tsunami and people must therefore move inland, but they can also warn of a fire inland and in this case, people must stay on the beach…). In Indonesia, the BMKG can send messages by SMS or WhatsApp to the authorities, notably to inform them about a tsunami.

How are tools chosen?

The tools correspond to different contexts and needs. In France, the choice of tools is left to local councils (for automated calls for example), but interviewees believe that the State should impose **warning methods** on all councils. In Belgium, location-based SMS are adapted to the size of the country since SMS can now be sent throughout Belgium. The multichannel approach also works well. In the Netherlands, the use of CBC is relevant as several areas can be impacted by hazards with ultra-fast kinetics (legacy of the 1956 floods). In Australia, methods are adapted at a regional level to address the diversity of risks and challenges. Mobile apps have returned to the forefront with the current health crisis, as people have understood that digital technology is a means of keeping in contact, even virtually, with local areas. But the benefits still remain to be explained (the name of the SAIP app is a technical name, but it is not clear enough!), the ideal solution being a tool that can reach everybody.

For which hazards are they most relevant?

There are two opposing views. Some interviewees believe **that tools should not be different according to the hazards**: only the warning message should vary (**i.e. tools remain a means to an end**). Others believe that **tools must be adapted to the hazard** (danger level, kinetics) but also to the local context (urban or rural). The **complementarity of the tools** is also highlighted (the siren is more adapted to reach the elderly than social networks).

Did you use them? If yes, why and in which time frame?

Be-Alert© has been used 150 times in two years (but never nationally) and sending the warning message took less than 5 minutes in most cases. In France, some players believe that it is not necessary to warn the population if the danger is contained within a restricted area. In the Netherlands, text messages were sent for 52 events over a period of almost 5 years. In Australia, the national PWS “Emergency Alert” system has been in use since 2012, and more than **15 million warning messages have been sent** (for nearly 1,000 events).

What tools would you need?

In Belgium, the challenge is to **optimize the messages** for people who did not subscribe to *Be-Alert*©, and the Crisis Unit is constantly looking for new strategic partnerships, instead of creating new tools without considering what is already available on the market. In France, a good option would be to develop **a guide of good practices** with regard to the **diversity of individuals and local contexts. It would also be useful to create a platform that compiles and locates current alerts.** The main emergency number (112) must also be differentiated from the number for medical care (113). People get confused, due to a lack of communication, while they are ready to understand it. 116 and 117 (implemented into 3 regions: Pays de la Loire, Corsica, and Bourgogne France-Comté) could also be used across the whole country. There are few people working on future tools, and politicians do not seem to be too concerned (until they actually need them). In Indonesia, players seem to focus more on sensors to detect hazards than on the warning systems themselves. In Australia, work is underway to improve the automatic translation of messages into different languages so they can address the country's social and cultural diversity.

Who is in charge of tool implementation (cost, investment)?

In Belgium, *Be-Alert©* cost around €7 million, to which must be added nearly €300k annually for running costs. In France, **the cost depends on the strategies and policies implemented at each level** (government, department, local council). The SAIP project cost in 2010 more than €83 millions. Some actors believe that the State should be responsible for managing the Public Alerting and Warning System at a national level; others mention the lack of collaboration and consistency between ministries, and advocate the creation of a single ministry (such as the Ministry of Public Security that has just been created in China). The implementation of location-based warning tools (LBSMS, CBC) requires partnerships with telephone operators. In other countries, the government is responsible for implementing national warning tools (Australia, United States – through FEMA – and Indonesia). Management is undertaken in agreement with the federal governments in Australia and the United States. For Indonesia, the choice of tools is left to local councils.

6.4. Operational culture

How efficient are the available tools?

The *Be-Alert©* platform in Belgium is being **used more and more**. Some players emphasize **the need for redundant technical resources**. In France, sirens are highly criticized (lack of meaning for people) and existing tools are considered ineffective as their choice is left up to local players. Some are more resilient than others. In Australia, tools are effective but their misuse causes problems. In the United States, being unable to measure human efficiency makes any assessment impossible. **The understanding of the warning message by the population must be improved** (prevention).

What are the conditions for the appropriation by actors and recipients?

Belgium offers **training** to mayors on how to use the warning platform, like BMKG employees in Indonesia. In France, training **exercises** must be carried out **with local inhabitants** and interviewees highlight the lack of communication between players. It is sometimes necessary to differentiate between the authorities responsible for deciding on triggering an alert and the teams who actually trigger it.

Australia offers more training exercises with local communities (notably with the police for evacuation purposes). **Considering individuals and their perceptions is important** so the danger can be clearly explained to them. In Indonesia, the influence of community leaders (notably religious leaders) can be counterproductive if they have a different opinion from the authorities during a crisis (for example, inhabitants refused to evacuate during an eruption of the Merapi volcano). **Isolated areas must not be neglected either** in times of crisis, as they are forgotten and not warned. During major disasters, technical equipment can be damaged (for example during large bushfires in Australia where isolated populations were difficult to reach). Basically, when tools are used regularly, people become more proficient at using them (even in France!): at the end of November 2018, it took the COD 1 hour 30 minutes to approve the use of sirens; then only 5 minutes the following weekend!

What factors lead to the decision of broadcasting a warning? When do you know it is the "right decision"?

The use of location-based solutions raises some concerns. It is sometimes complicated to oppose the **untimely use** of *Be-Alert*© by Belgian mayors. One must **differentiate between a "security alert" and a "communication alert."** There is an element of intuition in the decision-making process (there is no "theory" about decision-making within government bodies). Decision-making must also address the **reliability** of upward information. Australia has implemented **alert thresholds** (predetermined benchmarks) for some weather hazards. The decision depends on a matrix that includes risks, challenges, and priorities. In Indonesia, the lack of sensors increases the risk of error when making a decision. **Ultimately, a decision is accepted only if it is understood, and then there is no need to justify it.**

Do these tools take into account the diversity of users and communities? How? Is it enough?

In France, this is not the view of the majority. One player mentions the need for an **ethnocentric approach**. Even if it is impossible to warn 100% of the affected population, tools must be **differentiated according to communities.** Belgium is in the same situation as France. Australia carefully chooses which channels to use depending on the location. Hearing impaired inhabitants have also been taken into account. But overall, the issue needs addressing. In Indonesia, warning tools are better at adapting to the type of hazards than to individuals. In some areas, people rely on the behavior of animals (who tend to flee when a volcano is about to erupt for example). This practice, although unofficial, strengthens resilience in certain areas. The use of pictograms and acronyms (common internationally) may be a solution to prevent written messages from being misunderstood...

6.5. Complementary findings

Our cross-sectional study shows that if organizational objectives are identical overall, the actors involved in the alert do not have the same frame of reference or the same approach. The methods used are influenced by the national context and the crises that have occurred in the past, which have contributed either to the transformation or the improvement of the national Public Warning System. **Crises set the pace for the evolution of warning systems, rather than the implementation of new high-performance alert tools. Hypotheses 1 and 2 are therefore valid. More and more actors are also becoming aware of people power during crises.** But alerts are still too vertical and standardized to really empower local communities, despite the use of alert tools that permit it. Although such vertical approach in terms of warning systems is more and more challenged, the pyramid approach remains predominant (especially in France). **Hypothesis 3 is therefore rejected.**

7. What could be the future system in France?

Finally, this report briefly outlines solutions in the short term (2021), but also in the longer term (2030) in order to anticipate the needs and define in which direction the Public Warning System should evolve in France. The ideas developed here do not consider any political and/or budgetary choices or constraints, as they prevent any prediction. It may also be useful to remember here that the *Be-Alert©* system has been implemented in Belgium since 2017 but is the result of several tests and a thought process initiated in... 2010!

7.1. Main concepts to apply in the short term (by 2021)

Three principles must first be observed to guarantee an effective warning system: be consistent in the broadcasting of signals and do not leave any “gray areas;” have the weak signals announcing danger confirmed by the authorities or the relevant organizations, which must provide accurate, complete and honest information on a wider scale, without making assumptions; and use common references to better engage with the community (Matveeva, 2006; Stokoe, 2016; Kuligowski *et al*. 2014).

Other measures should also be quickly applied in France:

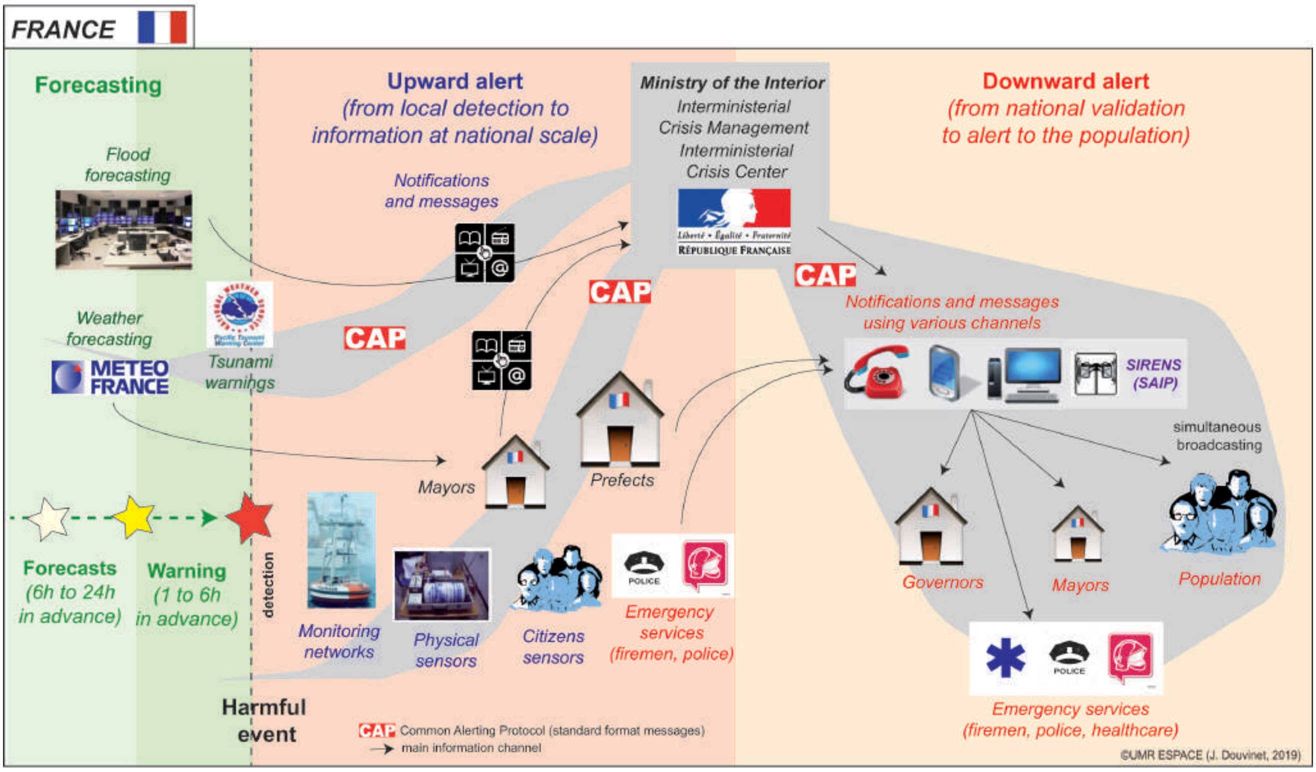
1) Increase the flexibility of the regulatory framework

To decrease the time required to trigger an alert, the current approach must be relaxed, and **the approval process must be improved** (**Figure 13**). Players or organizations that are involved locally on a daily basis (SDIS, SCH API, CENALT, etc.) and are deemed legitimate, could also be responsible for approval. These could be public (such as SDIS) or private players (many providers sell information and alert solutions to local communities, intercommunal organizations (EPCI) and businesses open to the public). As part of the SAIP project (fully operational in 2022), SDIS will be able to request the triggering of sirens in a targeted area from the Prefecture. Approval requires the signing of an agreement and delegation. But more needs to be done, notably if the broadcasting of the alert is undertaken using a single platform.

2) Better understand the scope and time frame of hazards

Depending on the risks involved, the relevant services have more or less time to trigger the tools at their disposal (Péroche, 2016). Reactivity also depends on the predictability of hazards and the delay before first damage (**Figure 12**). Broadly speaking, earthquakes require fully or semi-automated sensors, because the warning time is limited to a few seconds or a few minutes. On the other hand, tornadoes, tsunamis (if an earthquake occurs in Algeria, the first impact would be felt 1 hour 30 minutes later along the French Mediterranean coast) or flash floods occur in a few hours (less than 6 hours, such as in Cannes in 2015 or in the Aude department in 2018). Unspecified risks, on the other hand, are more difficult to integrate into the warning process, which remains binary.

Therefore, if these events can be foreseen, they can be anticipated, and the alert should be broadcast when the triggering thresholds are reached to allow time to implement protective behavior *ex nihilo* or adapt the emergency response to the local context.



CAP stands for Common Alerting Protocol, a standard international protocol

Figure 12. Potential evolution of the French Public Warning System

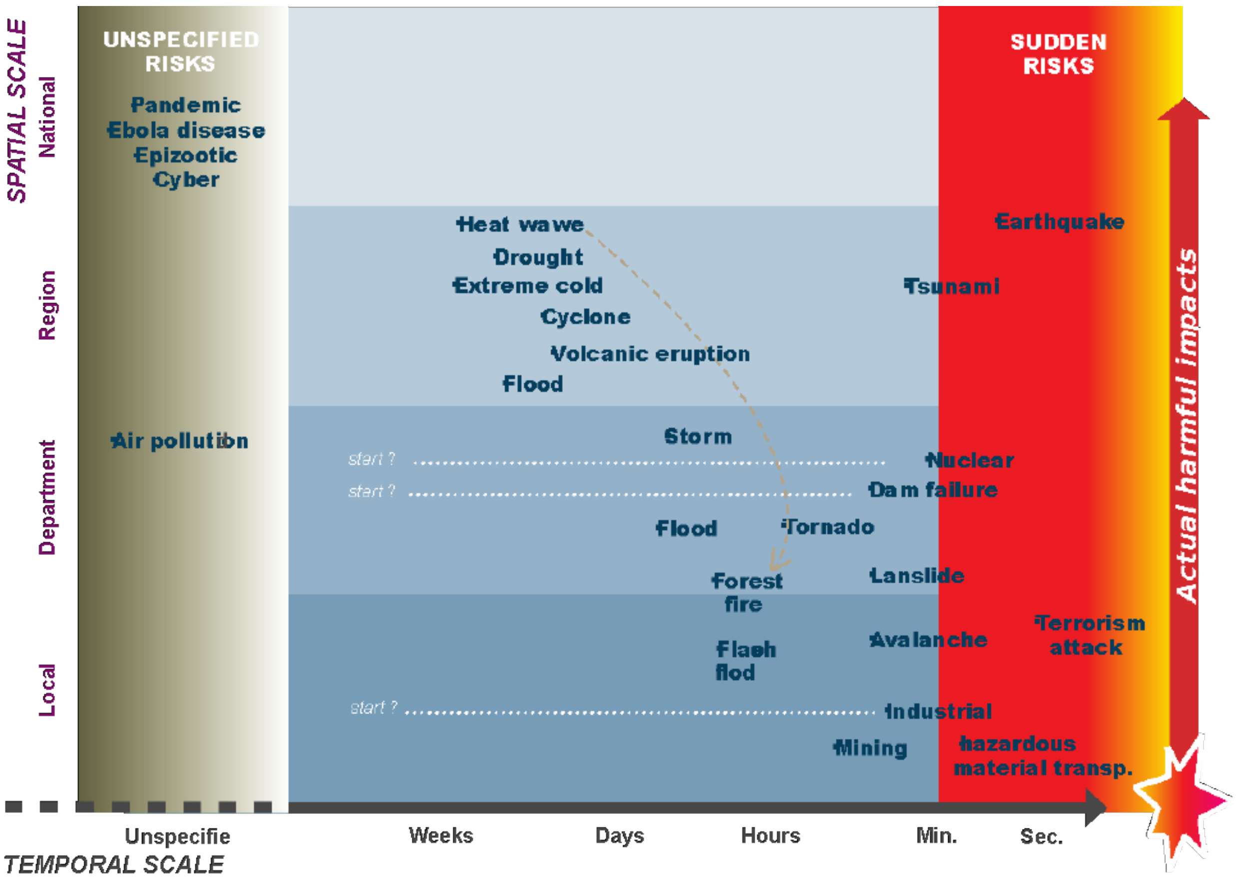


Figure 12. Estimated warning time depending on type of risks

3) Create a single platform *(covering all events and gathering together several organizations)*

Regardless of the nature of the threat or danger, a **single Public Warning System must be developed, free from political contingencies but in permanent contact with prefects** (who could act as delegates) and **local authorities**. This system would be used to coordinate the different warning tools and bring together all relevant players. France must therefore break from its **centralist approach** and **stop creating organizations for each type of risk**: in France, CENALT (National Tsunami Alert Center) is in charge of tsunami; CEA (Atomic Energy Center) monitors earthquakes; SCHAPI (Central Service for Hydrometeorology and Support for Flood Forecasting) is responsible for flood vigilance; and Météo France monitors all climatic hazards (hail, snow, heatwave), etc. Although some emergency call platforms are now shared, such as the platform centralizing calls to 15 and 18 across Greater Paris, or tend to use one single emergency number (112), **France must go much further and adopt an inter-departmental approach by promoting transversality and break from the vertical approach** (**Figure 13**). The "abduction alert" that is the responsibility of the Ministry of Justice and the public prosecutor could also be integrated into this common platform.

4) Combine and assess the human and social dimensions

It seems necessary to **personalize the information that individuals receive** (therefore avoiding standard messages that are not understandable by all) to gradually move towards a **more customized alert**. The use of **artificial intelligence** (AI) can help adapt the alert to individuals and this idea is currently being studied in Belgium. But for that to happen, the process must be **understood and explained upstream**: part of the population remains concerned at the idea of providing personal data or using new technology that appears to be imposed by the State (as shown by the Stop COVID-19 smartphone application). Although personalized alerts seem appropriate, the pros and cons of this approach must be studied carefully before adopting it.

7.2. Other concepts to apply in the longer term (by 2030)

Other concepts must also be applied **in the longer term**. Some are already integrated into international standards, such as the *Common Alerting Protocol* (CAP) or the *Early Warning System Monitoring* (EWSM). These concepts should also be applied in the short term, but it takes time to put them in place.

5) Towards an agile, interoperable, and coordinated solution...

Ideally (**Table 4**), **the platform and the single solution should be agile, interoperable, and coordinated by a single entity.** Each tool should be like a piece of a jigsaw puzzle which, when assembled, creates a coordinated system that must also consider the interactions or domino effects between hazards, for example the flash flood that occurred in the Bagmati valley (Nepal) on April 26, 2015, following an ice jam upstream from the village of Dusel, the blockage in the valley having been created by a landslide, following the earthquake (magnitude 6.7) that occurred the day before, and whose epicenter was located 80km from the capital, Kathmandu (Marahatta and Parajuli, 2015). The POC of this platform is at the heart of ANR's "Cap-4-Multi-Can'Alert" project, and we hope that the French government takes into account such conceptual framework.

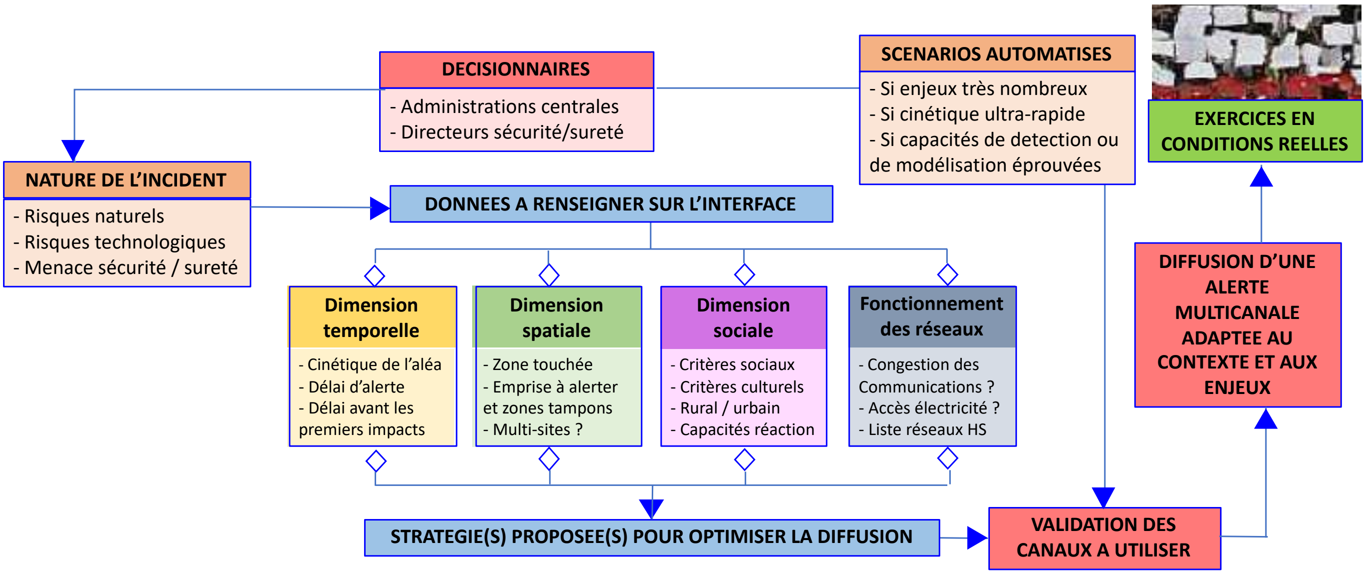


Figure 14. Proof of Concept (POC) on which ANR's Cap-4-Multi-Can'Alert project is based (in French).

6) Devise a strategy and devote an adequate budget to it over the long term...

It will be necessary to ensure that specific channels (for example frequency bands dedicated to alerts on radio waves, on RDS, HDS or UDS channels) have high priority in the event of an alert (like *SafetyCheck*, created by *Facebook*©, which is displayed on the news feed of users located in the impacted area, without changing the appearance of the website for other users). This solution offers the advantage of sending redundant messages, which are particularly useful in the event of a power cut, even if connected users may then receive the message several times. **This requires dedicating the necessary budget to it**, like Maine (United States), which has allocated more than $45 million only to the implementation of standardized technology, and which has encouraged collaboration between several organizations to create common systems. The current debate on CBC or location-based SMS has reached an impasse for financial reasons (but not only) and a solution must be quickly found to solve this problem. According to figures available in June 2020, the deployment of CBC in metropolitan France would cost €20 million and nearly €15 million in overseas regions...

7) A key question: who should be warned, why, and for what?

The debate on tools should not obscure the reflection needed on the objectives of the alert, i.e. who is the target? Can they implement appropriate behavior (to evacuate or not evacuate)? Are the capacities for action, reaction, and decision-making the same for everyone? One of the recurring aspects are **education and the culture of alert**, it is indeed necessary to **improve collaboration**, communicate better and work together, while diversifying the tools and methods of communication. The Public Warning System could be part of the Heritage Days (organized every year in September) or be presented briefly (at the start of a film or a show, like the safety instructions announced on planes just before take-off) but **its benefits must be properly explained and justified, which remains a long term challenge.**

Main concepts	Expected benefits and objectives	References
Create an interoperable solution	Promote interaction between technology and targeted recipients	Landwehr *et al.*, 2016
Coordinate the solution	Address the shortcomings of each solution when used in isolation	IPAWS, 2006
Design a single platform run by a single manager	Avoid the juxtaposition of alert tools and centralize the entire multi-channel solution within a single platform	Sorensen and Sorensen, 2000
Send consistent messages	Avoid contradictory messages or messages that differ depending on organizations to reduce uncertainty and hesitation	IBZ, 2017
Apply an approach capable of addressing diverse hazards	Adapt to the diversity of hazards, and address the interactions between the different types of risk	Nadim *et al.*, 2013; Liu *et al.*, 2017
Adapt the alert to location and time frame	Target the alert according to location and time frame, so that information reaches the right people at the right time	Reghezza-Zitt *et al.*, 2015
Define alert levels adapted to hazards	Adapt the system to different levels of risk, depending on the hazards and the areas concerned	Douvinet, 2018
Define the alert time frame	Adapt the alert process according to the time frame before the first impact	Péroche, 2016
Create a multichannel system	Reach as many people as possible in the shortest possible time	IPAWS, 2006; IBZ, 2017
Adapt the alert to the needs of the targeted population	Be able to respond to the changing needs of local communities, the context and the perception of danger by those targeted	Kouabénan, 2006; Weiss *et al.*, 2011

Tableau 4. Main concepts to apply to improve Public Warning System efficiency in the long term

7.3. Complementary findings

The concepts suggested, whether for the short or the longer term, must be implemented as quickly as possible. Discussions are currently underway in France regarding technology (CBC, location-based SMS, or both), but their **social acceptability** (by authorities and individuals) remains to be measured and the expectations of local communities, which evolve in both time and location, must also be met. Local authorities are not consulted or even involved in the appropriation process. **One of the challenges is to agree on the objectives to meet and to better integrate the social and spatial characteristics of each area, starting at a local level to then reach a national one. This is one of the contradictions of Public Warning Systems. <u>On this point, Hypothesis 4 is rejected</u>.**

8. Conclusion

Main insights gained from the study

The analysis of the alerting process, tools, actors, and operating regulations in other countries allows us to challenge the priority given to sirens in France, and the future warning procedure in the years to come. The current system is the result of a long tradition in which the State is sovereign, and, despite criticism, these warning tools have been maintained by successive governments since the end of World War II. Believing that warning tools can be “non-political” (like the procedure itself) is a myth: firstly, governmental bodies advocate them to justify the funding allocated to them (Matveeva, 2006) and often use them as a “good excuse” (“*We did the best we could*”) but it is not because the tools are available that they are used, and this observation, made in the early 2000s (Sorensen, 2000), is still relevant today.

The use that is made of them depends on a political decision accepted by all players involved in the institutional chain, but the slowness of the approval process and the rigidity of the administrative procedure are obstacles to the efficiency of these tools. A change is therefore necessary, in particular regarding compliance with the *Common Alerting Protocol* (CAP) and the recent adoption of the decree of December 11, 2018 (SMS alert system in Europe).

Then, decisions must be made quickly: people are not familiar with the various alert channels, which increases chaos in the event of danger, and reinforces the “polyphony of ignorance” (Cardon, 2005). The growing distrust towards public authorities, which has increased over the past thirty years, requires developing an easily understandable Public Warning System. This is all the more worrying as local inhabitants, not understanding what is expected of them, cannot implement the required safety measures or behavior if the signal supposed to trigger this implementation is understandable from the start. The whole system must therefore be improved or even reinvented…

Although the warning system must be adapted to the needs of each area, it must also be embedded in people’s daily lives. Regarding this, some community initiatives are good examples of cohesion and engagement. More **crisis training exercises** must therefore be organized with local inhabitants and the approach used must be reviewed to improve the culture of risk and the awareness of the measures to adopt in the event of a crisis. **The alert must not be considered as a constraint, but as an opportunity to put into practice the safety measures learned,** as a way to support the community, and avoid disrupting people’s daily lives. Some specific communities must also be taken into account (the homeless, travelers, illiterate people, people with reduced mobility, etc.). The system must therefore allow for a certain flexibility...

Other issues raised during the final oral presentation

Should the same messages be broadcast in all EU member countries? **No!**

A positive answer would have allowed messages to be understood across the whole of Europe, but it would lead us to ignore the specificities of each country and the influence of cultural factors. The experiments carried out on CBC (England) and on SMS (Belgium and USA) must be studied and compared between all countries to offer an accurate answer to this question. And thus, an European single solution is not, for us, the best solution.

Should a database of ready-to-use messages be created? ***Yes!***
The creation of predefined messages would shorten the alert approval process, and the time before first impact. Specific messages must be designed for hazards with ultra-fast kinetics. When the risk is "complex" or when there is enough time, however, the message should be adapted to the context. On this question, everything depends on hazards, risks, and context.

Should alert messages on phones use a specific sound? ***Yes!***
In order to make it easier for people to understand alert messages, SMS messages must be associated with a specific sound. In some countries, an "aggressive" sound is used (alert messages from the President of the USA, for example). The sound may also differ depending on the risk involved. The ANR is notably testing sounds with various audiences to identify which one is the most suitable.

Should local government officials be called upon? ***On an ad hoc basis!***
During rapidly unfolding events (less than 6 hours), these officials can inform the population with loudspeakers for example, which can be installed on vehicles (at the cost of around €100 per vehicle). This alternative could be effective during flash flooding and in towns and cities. But it is useless in the event of brief events (dam failure or landslides), and in mountainous areas.

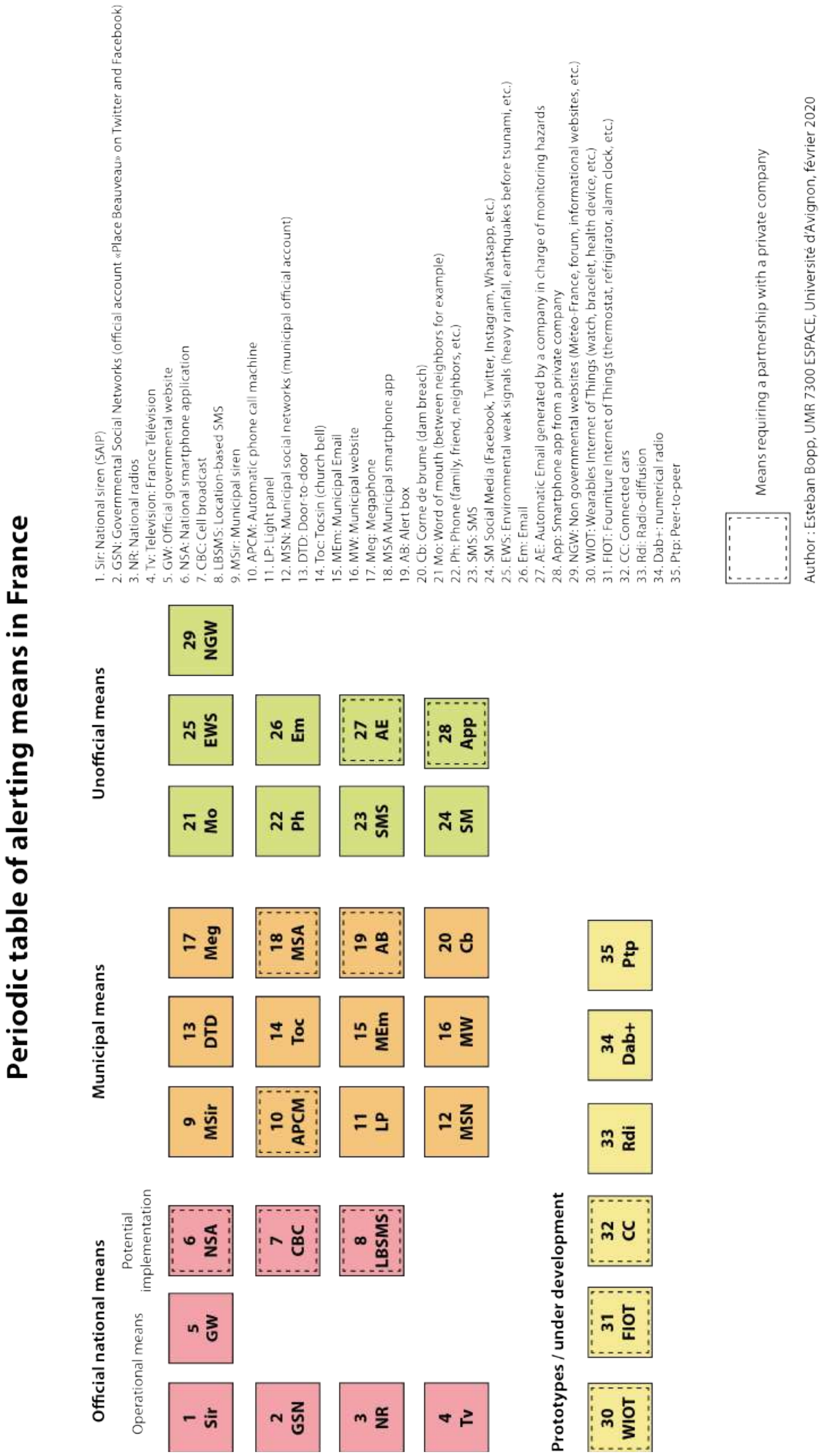
Should mosques also to be contacted in the event of an alert? ***Yes!***
Mosques could be used to broadcast the alert in some areas (Mayotte), or in some countries. Since the solution must be multichannel and redundant, then these tools indeed bring added value to the system in operation throughout the country. Supplements to be integrated into the offer throughout the territory, in the same way as bells churches. Lights could be considered as a useful alerting tool when faced with rapid and short-time hazards (tsunamis).

Isn't the warning process plagued with contradictions? ***Yes!***
The warning process is indeed full of contradictions: the people alerted must act locally, just like the mayors confronted with a potentially damaging event, yet a robust warning system must be implemented nationally to reduce costs and support local communities…

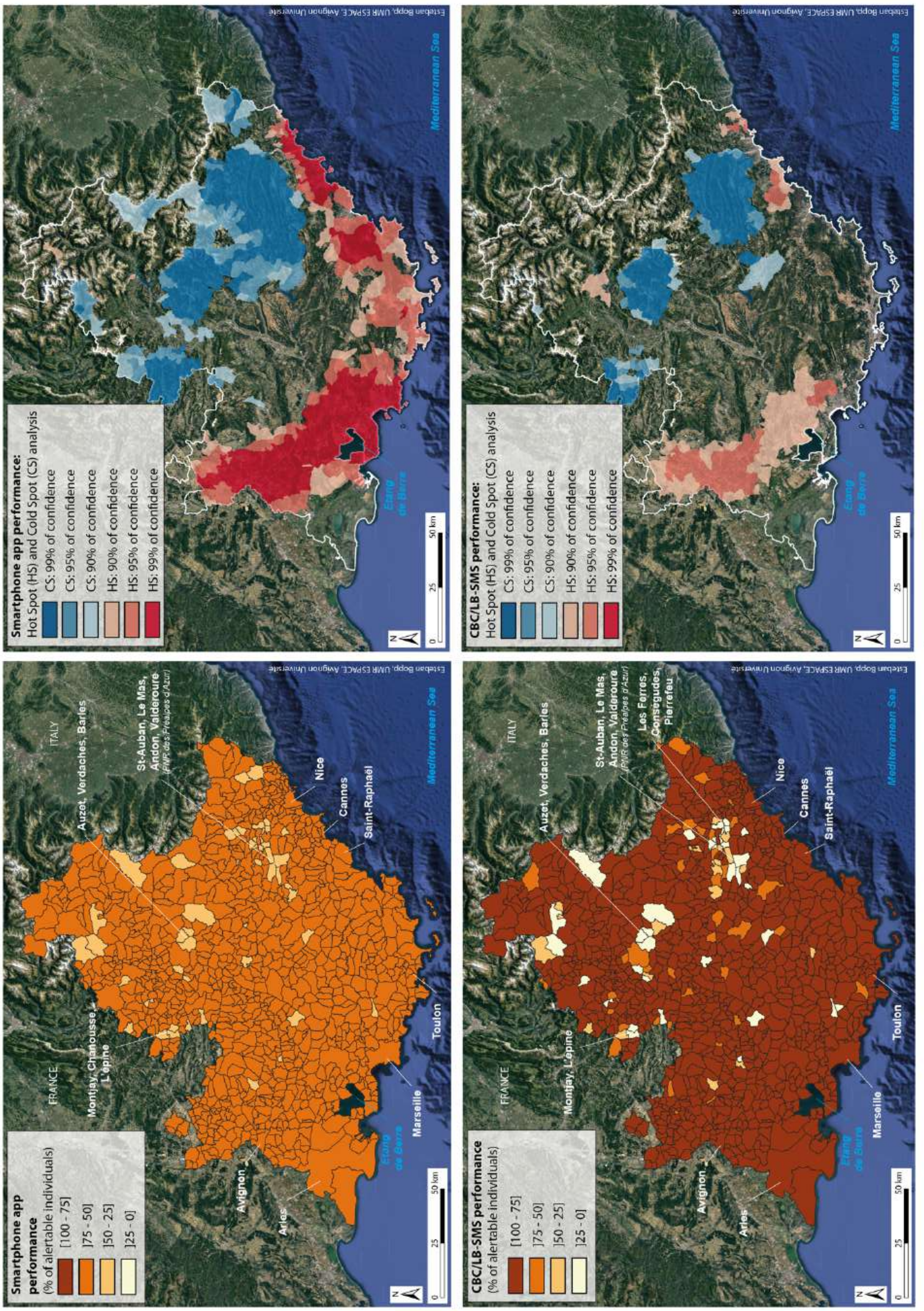
Do you have to be absolutely certain to trigger an alert? ***No!***
People indeed do not like "false alarms" (i.e. they receive a warning then nothing happens) but this issue is highly debatable: until now, alerts have rarely been triggered, while many situations would have required them. The population will accept "false alarms" more readily if they were better trained and made aware of the potential uncertainty in some situations.

9. Appendixes

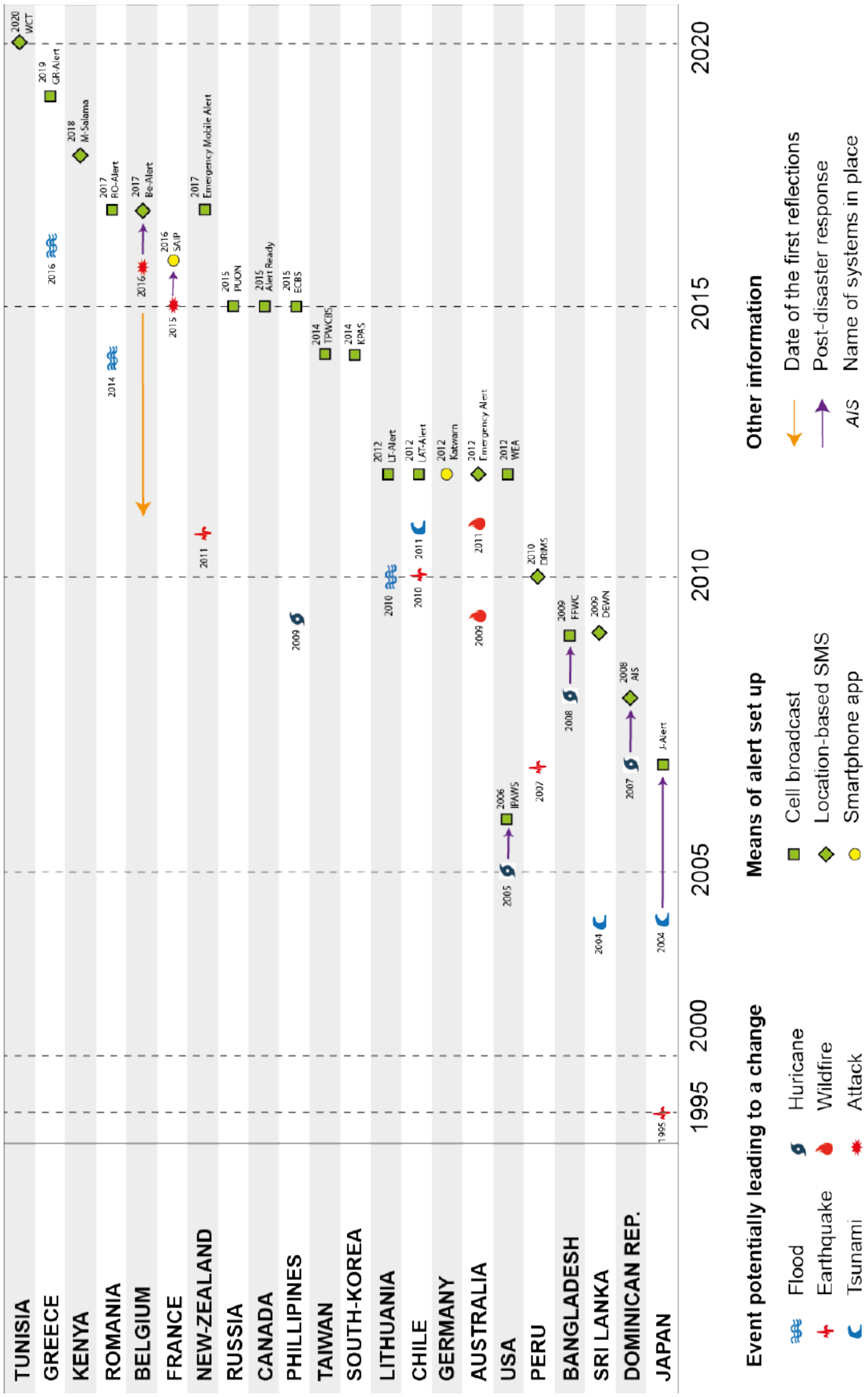
Appendix 1 – Technical comparison of alert tools (official / non-official)



Appendix 2 – Assessment of the technical performance of several alert tools in the Provence Alpes Côte d’Azur region (Bopp, 2020)



Appendix 3 – Date of implementation of alert systems in different countries



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