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Report on technical needs for integrating the e.cenaris platform for cloud monitoring of hazards in crisis situations

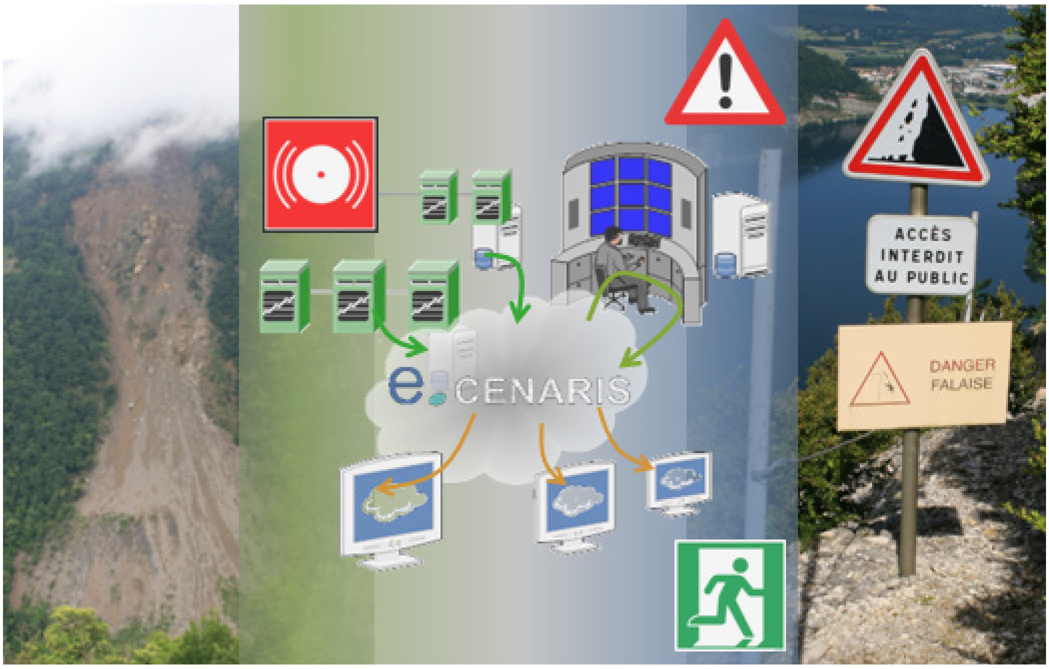

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Table of Content

Executive Summary

The scope of Task 2.4 as described in the DoW, was to "*study the technical needs for using detection systems and cloud monitoring as input to incident management of crises*".

A number of installations and regions have a large amount of sensors installed for monitoring and for security (e.g. Structural Health Monitoring (SHM), Close-circuit television (CCTV) security cameras, smoke detection). The advantage of installing such systems is that they enable to access and to record continuous or regular information about a vulnerable or a sensitive area (feature parameters) in a remote way that may even become inaccessible under specific conditions. Within Task 2.4 it has been proposed to develop solutions to merge together these acquired data through the use of cloud monitoring technologies and to evaluate the benefit of integrating such methodologies into CascEff Incident Evolution Tool (IET).

In deliverable 2.4, corresponding to the description of the work achieved within this task, cloud monitoring concept is introduced with the illustration of e.cenaris platform. e.cenaris initially provides near-real time data visualization and downloading solutions on e.g. ground stability monitoring, which comes from ground measurements located in vulnerable areas. For the purpose of the CascEff project, improvement options of the e.cenaris platform are developed in relation to 1) data fusion, 2) multi-criteria analysis, and 3) the creation and personalization of alarms addressed to the stakeholders after expertise has been approved. Direct application is effectively proposed in a beta version on Séchilienne landslide scenario. Indeed, setting combined alarms on varied monitored variables (feature parameters) is shown to optimize the vigilance and, if possible, the organization of surveillance duty periods, by ensuring data and notification transfer, especially in the case of the occurrence of an incident.

Additional examples taken from CascEff scenarios (the Nut warehouse and Festival scenarios) are considered to prove the exportability of cloud monitoring methodologies (such as defined in e.cenaris) to help in managing cascading effects incidents of other kinds (respectively fire with water contamination risk; and people evacuation management because of explosion risk with water contamination).

Finally, cloud monitoring solution is regarded as being a beneficial decision-support tool, whose results can be used as inputs to incident management of crises (purpose of the Incident Evolution Tool) for which an integration solution could be considered in a successive project. However, it is also pointed out that such solution would in no instance prevent an incident from happening, but it may help in assessing the real hazard likely to happen and hence in adapting the human actions and measures to be taken.

Nomenclature

DoW: Description of Work
IET: Incident Evolution Tool
SHM: Structural Health Monitoring
WP: Work Package

1 Introduction

The aim of the CascEff project is to improve the understanding of the cascading effects in crises situations, in order to reduce the consequences of escalating incidents in complex environments. To this purpose, the project works on the identification of initiators (both natural and anthropogenic), dependencies, and key decision points. These are used to develop an Incident Evolution Tool (IET), which will enable improved decision support in escalating incidents, contributing to the reduction of collateral damages and other unfortunate consequences associated with large crises.

A possibility to improve the IET quality of results is to integrate to the IET input observations as measured by local monitoring networks and made accessible through cloud monitoring infrastructures.

The present report constitutes the deliverable for Task 2.4, which consists of the **Study of the technical needs for using detection systems and cloud monitoring as input to incident management of crises**.

1.1 Objectives and scope of Task 2.4

The objective of this task is to work on the strengthening of monitoring networks and data-transfer systems to improve crisis management. Indeed, as introduced in the DoW, a number of installations and regions have a large amount of sensors, for monitoring and for security reasons, installed by research organizations, Local Authorities, industries, engineering groups and state agencies, (e.g. Structural Health Monitoring (SHM), Close-circuit television (CCTV) security cameras, smoke detection).

Fusing these information sources may offer a breakthrough in the concept of full integration of monitoring services for incident management. To this purpose, it has been proposed, within Task 2.4, to take benefit of the use of monitoring networks to face crises through a threefold approach, evaluating the needs for:

1. Techniques of data fusion (signal harmonization, cleansing/artifact detection) for improving feature extraction and discriminating noise from signal,
2. Multi-criteria analysis for prioritizing the sensor data information (e.g. risk to be emphasized like collapse-movement-deformation),
3. The development of an alert system on measurable originators and dependencies in potential incidents (as identified in D2.3), i.e. by transferring the cleaned signals to the different stakeholders with personalized alert system message.

The e-infrastructure e.cenaris, a comprehensive cloud monitoring platform, has been conceived beforehand for the purpose to provide an easy access to monitored data acquired on vulnerable areas subject to geohazards. Using this platform as a development support, the main scope of Task 2.4 was thus to improve the use of such cloud monitoring platform as a decision-support tool and to extend its applicability not only to geohazards, in order to finally show the benefit of using the cloud monitoring technologies in the case of crises situation management.

The expected deliverable (cf. the DoW) is *a 'Report on technical needs for integrating the e.cenaris platform for cloud monitoring of hazards in crisis situations'.*

1.2 Overview of links to other CascEff tasks

Task 2.4 has a strong interaction both between the incident management methodology that has been introduced in work package 1 (WP1) and the current development of the IET in WP4.

Using cloud monitoring platforms enables to have an overview of the evolution of an incident; the accuracy will depend on how and what the monitoring sensors are set up for. Indeed, sensor type and location will be strongly influenced by the IET if tested in a preparatory mode. In addition to this, the output from sensors monitoring for multiple hazards will help in the response to an incident by providing updated and accurate information, assisting in validation of other information provided. From this, it becomes possible to propose automatic alert systems by sending adjusted relevant information to different end-users, and enabling hence an optimization in crisis management.

At this stage of the CascEff project, links to other tasks can be summarized as listed in Table 1.1 and illustrated in Figure 1.1.

Table 1.1 Overview links to other CascEff tasks.

Input from/Output to other tasks	for the methodology of 2.4
Task 1.4 – scenario identification for testing of methodology	Identifying the risks enables to determine critical physical parameters that may be significant in the evolution of an incident and hence to be monitored.
Task 1.5 – recommenda-tion for improvement of incident management	One of the objectives of Task 2.4 is to prove the benefit of using cloud monitoring technologies as a decision-support tool to improve incident management.
Task 2.3 – identification of dependencies and originators	Within Task 2.3, recent incidents have been reviewed in a database, highlighting parameters that were measurable and others that were not but that could have been useful to monitor in order to predict the evolution of the incident. Such feedback helps in identifying which kind of sensors could be useful to be integrated into a potential monitoring network.
Task 4.2 – methodology for IET	Monitored parameters may have a variable meaning depending on where and when they are observed along with the evolution of an incident. They need to be selected with care and evaluated with an impact weight as input data into the IET.
Task 4.3 – definition of IET architecture	Cloud monitoring outputs can be used as relevant inputs to the IET (alarm messages – human action).
Task 5.2 - initial testing and feedback to WP 1-4	This can be tested on Séchilienne scenario, which has been selected as one of the reference scenarios within CascEff project.

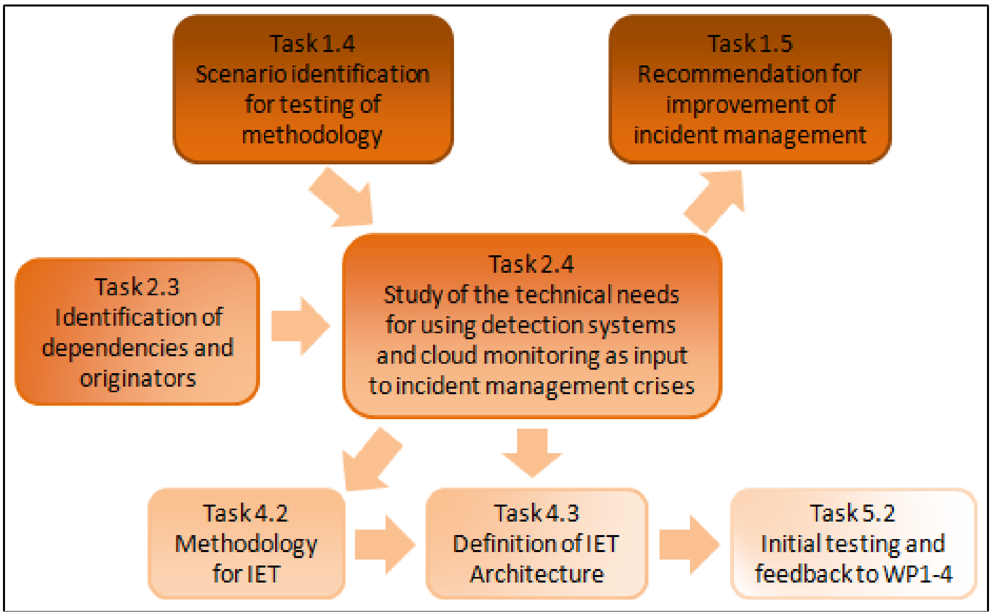

Figure 1.1 Overview links to other CascEff tasks.

1.3 Deliverable approach

This deliverable is outlined as follows:

- Chapter 2: cloud monitoring infrastructure and beforehand-existing functionalities of e.cenaris are introduced, as a platform for data transfer and visualization. Additional functions as highlighted to be helpful for crisis management, such as **merging monitored data**, based on a **multi-criteria analysis** and **personalizing alarms notifications**, are developed within CascEff and illustrated on Séchilienne geohazard scenario.
- Chapter 3: from Chapter 2 development, it is proposed to export the cloud monitoring benefit to other incident scenarios not necessarily relative to geohazards. **Festival** and **Nut warehouse** scenarios as referred in Deliverables 1.4 and 5.1 are analyzed for this purpose.
- Chapter 4: the main conclusions on the usability and benefits of cloud monitoring techniques as a decision-support tool are presented.

2 Cloud monitoring approach

2.1 Presentation of e.cenaris infrastructure – initial development

e.cenaris is a cloud monitoring-based e-infrastructure dedicated to scientific observation and real-time monitoring (http://cenaris.ineris.fr). It has been initially developed for geotechnical and geological risks related to georesources and geostructures to provide an easy access to monitored data visualization and download, and can thus potentially be used as part of an early-warning system.

2.1.1 General overview

The access to monitored data is provided in a limited way to the concerned people (Figure 2.1) to prevent from abusive uses of the monitoring or improper and inadequate interpretation of the data measured. In this way, monitored data and results are easily shared by the internet with experts and stakeholders in order to optimize the analysis and decision making.

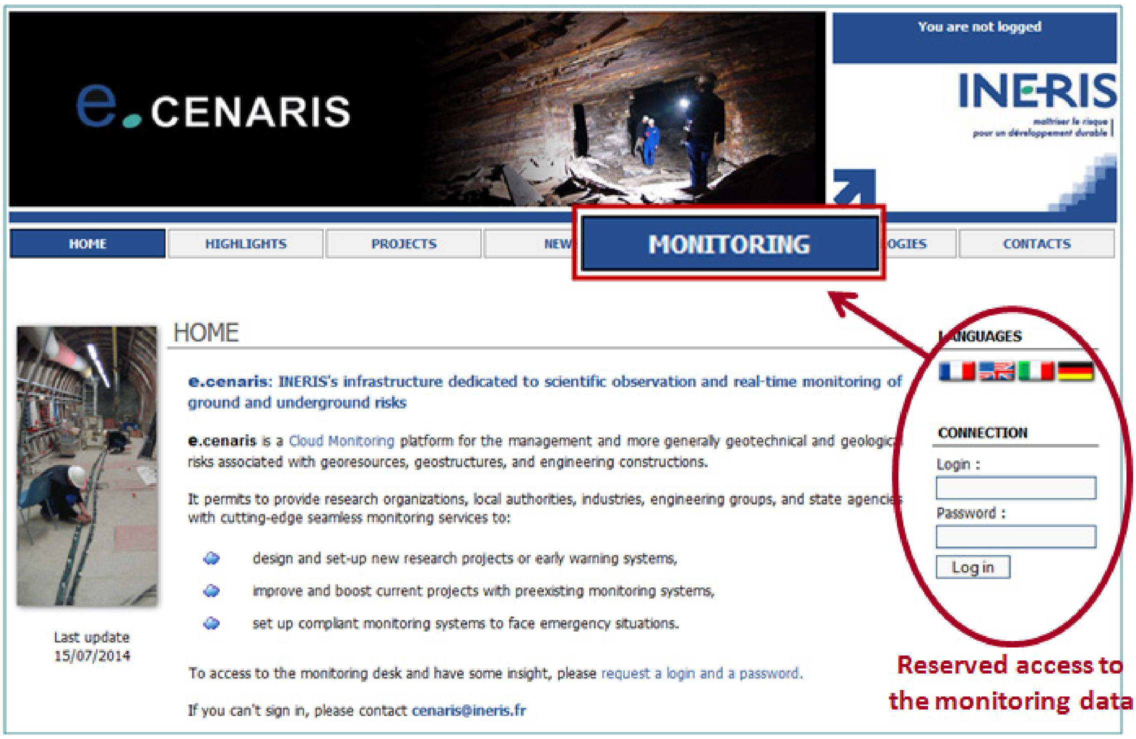

Figure 2.1 e.cenaris homepage and access modalities.

Various institutions such as research organizations, local authorities, industries, engineering groups and state agencies that are concerned by vulnerable areas likely to induce geohazards and crises already use e.cenaris tool as a web platform. Indeed, it facilitates the remote visualization and management of the data coming from in situ monitoring systems with limited or critical access. So far, most of the projects carried out with e.cenaris have dealt with the monitoring of abandoned or active mines subject to collapses or rockburst hazard, underground storage areas, landslides evolving over or close to inhabited areas, etc., for which a major incident may have a significant impact on the security and the facilities for people, infrastructure and environment, at local or wider scale.

Being already equipped with monitoring sensors and likely to induce geohazards, Séchilienne landslide, for which a cascading effect scenario has been proposed to be analyzed within WP1 and WP5, has been selected as the most adapted initial study case for the improvement of e.cenaris infrastructure for crises management purposes.

2.1.2 Presentation of Séchilienne scenario

As introduced in Deliverables D1.4 and D5.1, the Séchilienne incident is not a past event but a potential scenario, which may lead to huge consequences. It concerns a potential ground movement of more than 3 million cubic meters in a village named Séchilienne. It may produce the following sequence of events: landslide over a road and a river; creation of a natural dam over the river; creation of a lake behind the dam; dam rupture; flooding of the valley downstream (several villages concerned); flooding of a big chemical plant located downstream; potential industrial accidents due to the flooding (Figure 2.2).

Such cascading effects and consequence damages may concern the transportation system, access to some villages, access to major skiing stations, supply chain of several companies, which will require a multi-scale commandment to be overcome from different stakeholder organizations (public and private), from municipalities to regional and even national scales.

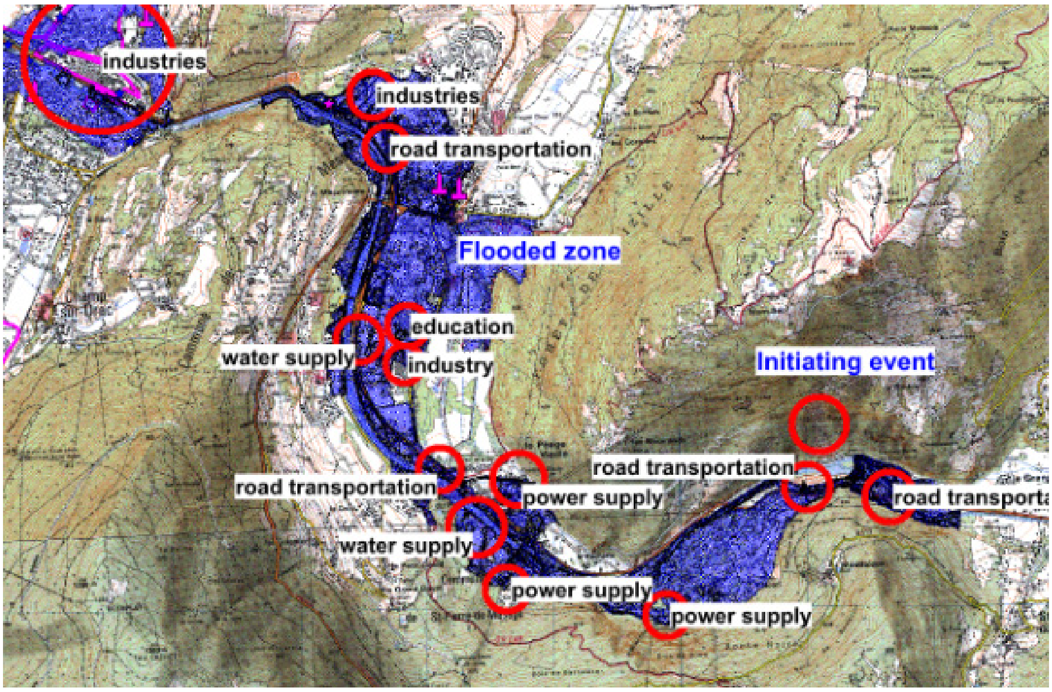

Figure 2.2 Vulnerable systems situated close to Séchilienne landslide, identified as "Initiating event" (on IGN map).

2.2 Data acquisition performances – CascEff improvements

In the following sections, additional functions applicable on cloud monitoring are presented that can be helpful for crisis management, such as merging monitored data based on a multi-criteria analysis and personalizing alarm notifications. These additional functions have been developed within the realm of the CascEff project under e.cenaris platform.

2.2.1 Data fusion principle

To have an overview of the state of a vulnerable area, it is advised to monitor different kinds of data of variable meanings (e.g. displacements, strains, levels, pressure, stress, tilt, etc.).

Merging these different kinds of data hence enables assessment of the evolution of the monitored area under different angles. For instance, a precipitation sensor will indicate if it rains or not – at a local point; but to check whether the global meteorological conditions are bad or not, wind and temperature sensors will also be useful, and there will need to be several sensors at different locations (i.e. global overview) to prevent from artifact values (e.g. electrical parasites, one sensor might have fallen and be not correctly receptive anymore…).

Additional monitoring such as SHM can also be implemented to provide an overview of the working state of the device and its reliability (e.g. temperature of the acquisition box in case it may affect the sensor integrity).

To carry out efficient monitoring, data are recorded either continuously, or at fixed times, or using detection thresholds. Using detection thresholds enables to limit data acquisition, data storage and data transfer but requires testing beforehand the trigger acquisition parameters to prevent from not recording important data. For instance, knowing that 1 truck is passing over a maximum 10-truck-holding bridge is not necessary; however it could be useful to know when at least more than 5 trucks are on the bridge at the same time.

The outputs of the sensors collected into e.cenaris database are raw data. This means that they can only be evaluated by experts before being integrated and then plotted and/or listed into tables for “official” information release. Indeed, for instance, among 7 sensors, 4 can present the same range of values, whereas 3 can give different set of values. In those conditions, evaluating data coherence and the risks therefore is not an easy task.

As such, Séchilienne landslide has been equipped with various sensors (thermometer, GPS markers, microseismic probes, etc.) to follow the continuous and near-to-real time on-going contexts and ground movements. Figures 2.3 and 2.4 are examples of graphical visualizations of such physical parameters monitored at Séchilienne and made directly accessible in a remote way thanks to cloud monitoring developed under e.cenaris.

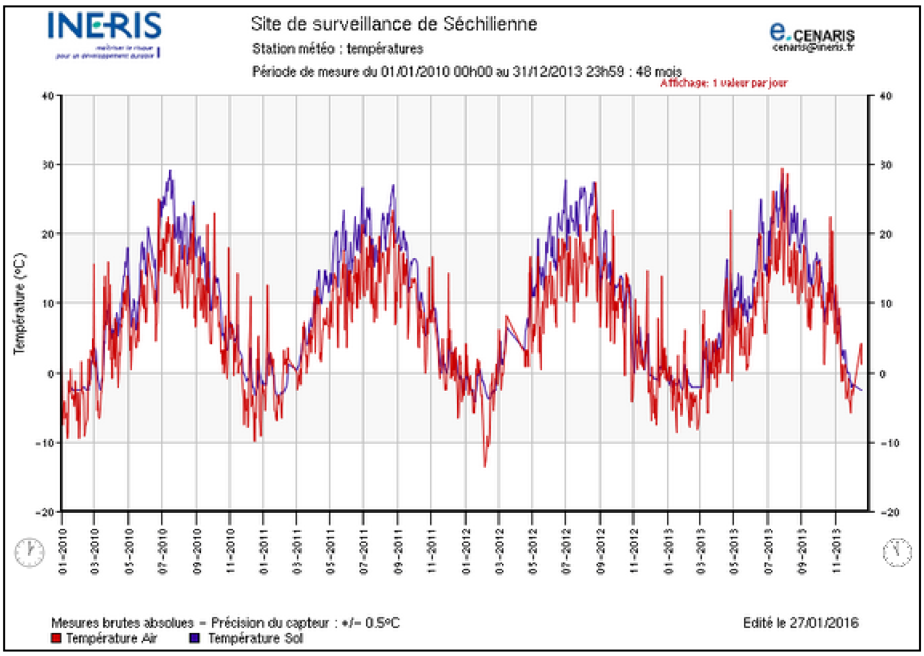

Figure 2.3 **Example of graphical visualization developed for Séchilienne monitoring: temperature variations along the years of the air (red) and the ground (purple).**

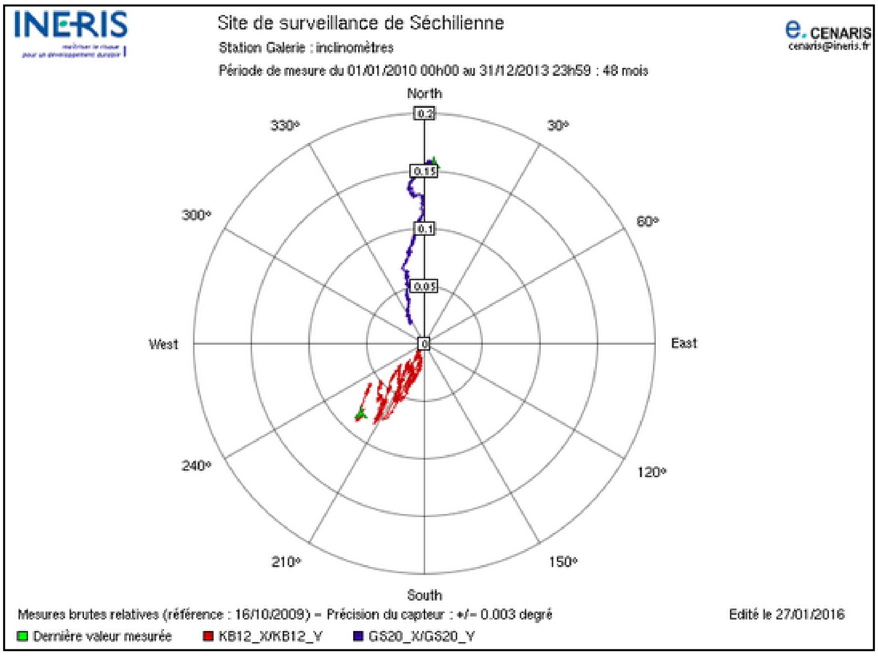

Figure 2.4 Example of graphical visualization developed for Séchilienne monitoring: inclinometer data from two sensors (red and purple) located in two vulnerable areas.

2.2.2 Complex variable

Additional specific processing can be defined for in-depth plotting such as combining different sensors, filtering time series, etc (i.e. data processing). By “complex variable”, it is intended the variables that have been processed or combined with others or that have been retrieved from calculations on the raw output data. Such processing is achieved to improve the accuracy of the interpretation of the data and hence justify better the necessity to activate crisis management cell or not.

For instance for Séchilienne monitoring, Figure 2.5 shows the numbers of microseismic events detected within two vulnerable areas of the landslide and their variations with time. Microseismic events are recorded when they are detected on a pre-defined number of sensors with possibly specific conditions on the physical parameters (e.g. event duration, event maximum amplitude, etc.). These conditions are taken into account as triggering threshold parameters if record is parameterized to be activated with triggering.

Such microseismic events need to be processed with accuracy (e.g. applying filters to only take into account the seismic oscillations that are due to the landslide ground movement, removing the tide phenomena, the storm noise or electrical artifacts coming from close power plant) before taking decision on whether they could originate cascading effects or not. Indeed, activating crisis management cells implies to mobilize people and structures from different authorities and concerns, which may have financial and social consequences and hence is considered only if facts and/or monitored data (observations) have been proven to be likely to originate cascading effect incidents.

Looking deeper into the data, after processing, it has been proposed to display additional data features such as in Figure 2.6, which illustrates the corresponding seismic energies of the seismic sensors that have triggered when microseismic events occurred. This additional information enables to estimate whether triggering microseismic events are regular (e.g. there might be more triggered events but they are very weak in energy so this should not induce a cascading effect incident) or irregular (e.g. an abnormal increase of seismic signals, in number and in energy, is observed) and hence subject to complementary analysis, which may necessitate to check other monitored parameters, if available.

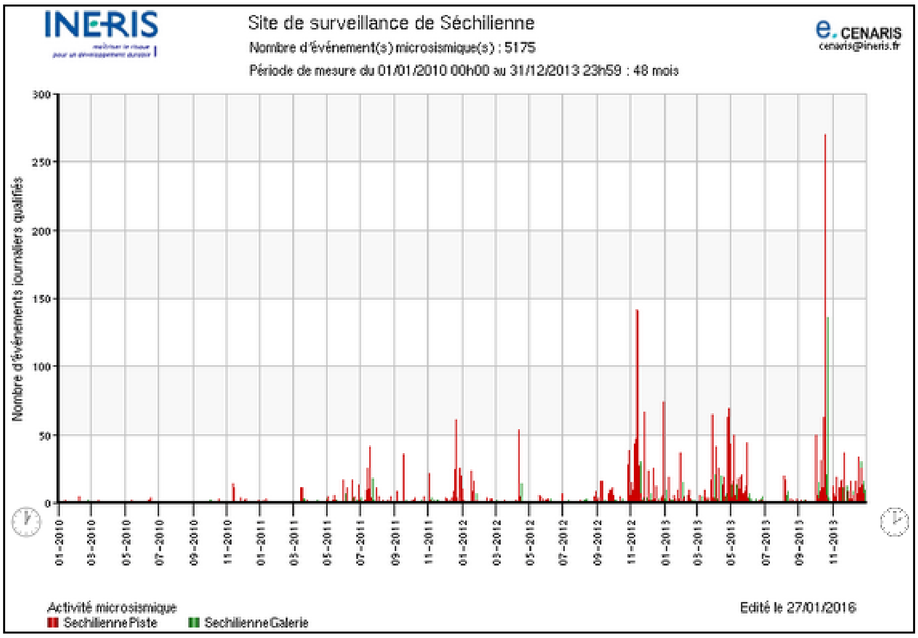

Figure 2.5 Example of graphical visualization developed for Séchilienne monitoring: microseismic events located in two vulnerable areas (red and green).

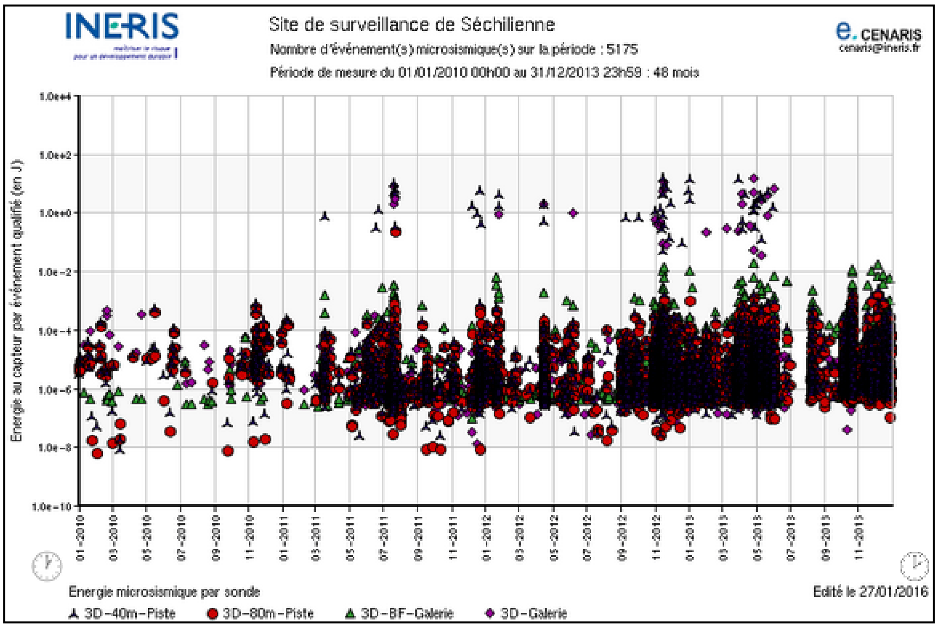

Figure 2.6 Example of graphical visualization developed for Séchilienne monitoring: microseismic energy as recorded at four sensors (black, red, green and purple) retrieved from the microseismic events.

As a conclusion, fusion of raw data and processed complex variables enables, with an expert assessment, to have a complementary overview of the evolution of a vulnerable area that is monitored with different kinds of sensors. The advantage of processing these outputs through cloud monitoring technologies is that they are made available in a remote way in a near real time simply by means of an internet connection and a computer.

2.3 Alarm implementation, as a CascEff decision support tool

To ensure continuous and reliable monitoring, it might be necessary to define alarm systems that will activate only for specific conditions and lead to the transfer of alarm notifications to concerned people. Indeed, although the vulnerable areas are monitored continuously (with triggering or not) and data are made available in near real time, people cannot stand behind the data 24/7. An alternative is to define duty periods during which people in charge of the monitoring network are reachable on alarms notifications, in order to ensure a systematical check of any sensitive data and to propose deeper expertise when necessary.

The first objective of cloud monitoring of vulnerable areas is to ensure an easy access to the monitored data, basically, using raw visualization. Going into data interpretation in depth has been emphasized in section 2.2 with the development of data fusion and the consideration of “complex variables” from transformed raw data.

Within CascEff project and in transition with section 2.2, further improvement actions have been carried out for the development of:

- a multi-criteria analysis for prioritizing the sensor data information,
- an alarm system where the signal is transferred to the different authorities with personalized notification message.

2.3.1 Multi-criteria analysis and action priority

To this purpose, a remote alarm management tool has been established according to the following criteria:

- simple alarm: alarm from a direct sensor measure,
- simple alarm on complex variables: alarm from calculation results (e.g. average value, ratio value, etc.),
- complex alarm: operational alarm (“and”, “or”) binding together several simple alarms.

The module to define this tool consists in three steps (Figure 2.7):

- a script is coded to define the alarm thresholds for their activation and deactivation,
- a multilingual web interface is developed to set the alarms and list the log and historical information (Figure 2.8),
- new databases are defined to save settings, logs and correlated operations (personalization of alarm messages, etc.).

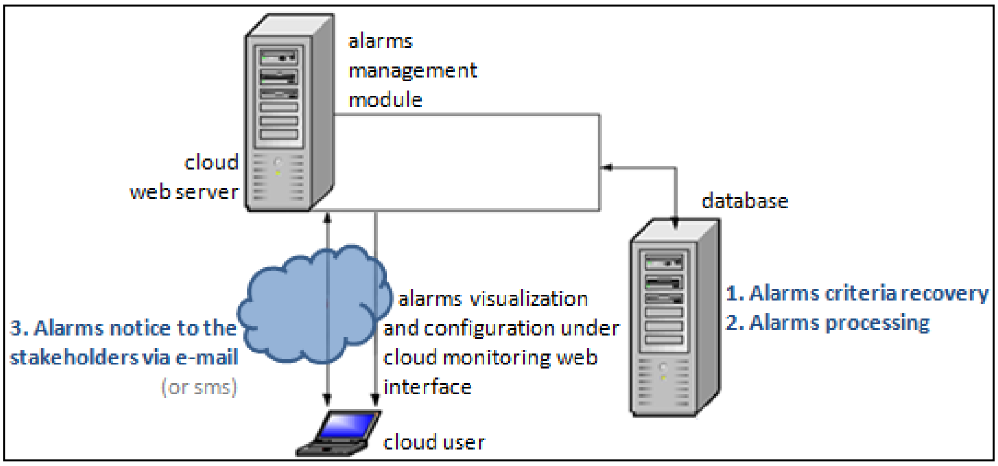

Figure 2.7 Developed cloud monitoring alarm management workflow.

Being available online, experts in charge of the monitoring (and stakeholders, if requested) can easily access not only the output data but also the alarm web interface for control and management using their own computer or tablet and it might be optimized for smartphones also.

2.3.2 Alert system development and personalization

The following step is to make sure notifications in case of alarm activation are sent to the relevant people at the right time, with the right comments and the correct attachment if necessary.

This parameterization and prioritization for notification is also defined into the alarm creation. In its initial version, notifications are sent via e-mail. Successive solutions such as sending SMS or programming automatic calls could be considered. These solutions are already proposed by the software called ALERT (www.micromedia-int.com) and can be easily integrated in cloud monitoring tools but because of time limitations it was not considered within the CascEff project. Receiving e-mails or even SMS and automatic calls, it becomes possible to be informed in shorter times and hence to identify and to analyze signals of significant meaning in case either of a major incident or of precursory symptoms meaning that a crisis would be likely to occur.

At the time of the publication of this deliverable, the alarm module is available under e.cenaris in a debugged beta version and validated for Séchilienne use. Examples of the web interfaces that were developed for the creation of alarms and management are illustrated in Figures 2.8 and 2.9.

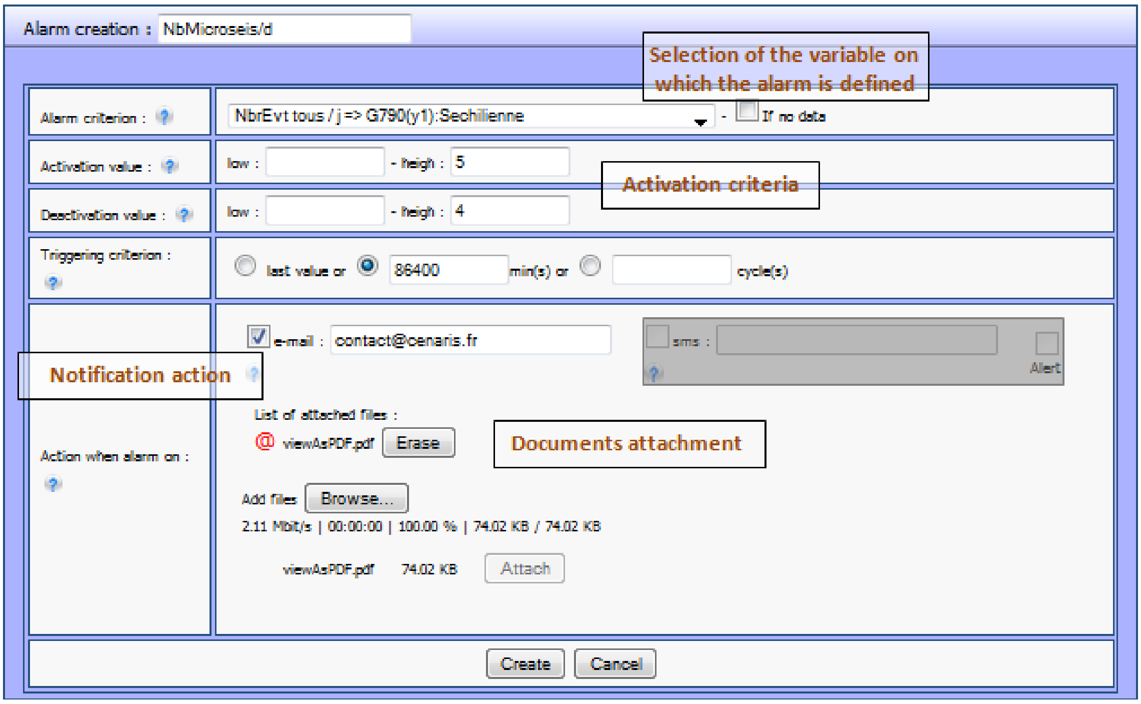

Figure 2.8 Web interface for the creation and modification of alarms. SMS and Alert alarm notification options are darkened because they are not validated in the beta version (e.cenaris development). Question marks are help bubbles.

As a perspective, when applied on other vulnerable sites, improvements will be suggested on the basis of the demands of the monitoring objectives and the stakeholders.

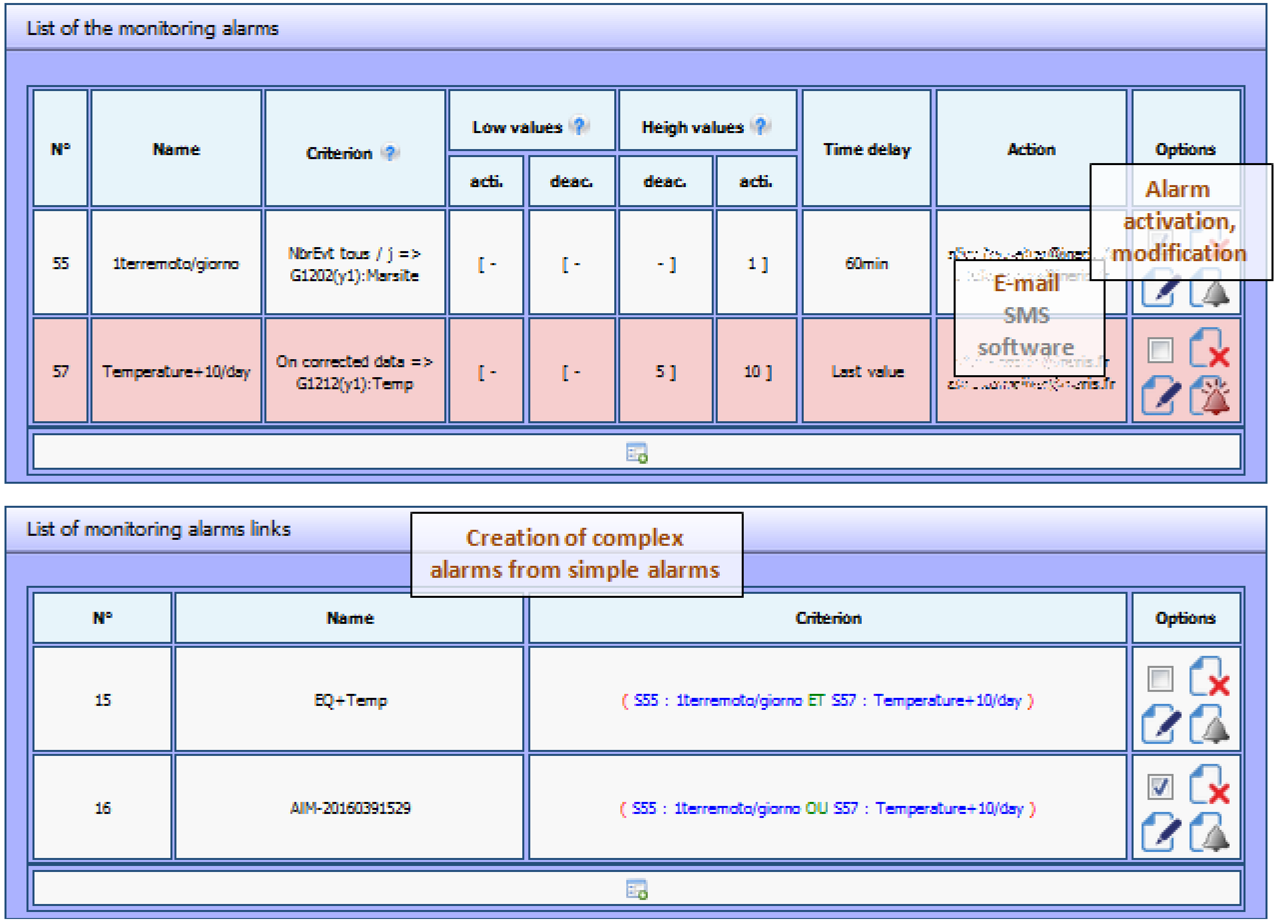

Figure 2.9 Web interface listing the simple and complex alarms that have been created and that are activated or not.

2.4 Use as input information for the IET (Incident Evolution Tool)

In relation to the CascEff objectives, the benefit of using cloud monitoring tools is to access monitored data in a remote way that can be used or reprocessed in near real time as input data for defining or updating better in the IET the context of a cascading-effect incident and its evolution. In this way, cloud monitoring is used as a decisive tool for taking decision in case of crises management.

To conclude this section, taking into account outputs derived from cloud monitoring technologies have been proven to be of interest for the development of the IET in WP4. However, because of the necessity to deal with the points of view of experts to judge on the reliability of the data (from data fusion, alarm notifications, etc.), it remains essential to have a human action before entering cloud monitoring output information to the IET as real truth observations. In other words, including cloud monitoring acquisition and data transfer is useful for IET but not without a human expertise interface to ensure its reliability.

3 Applicability to other scenarios

3.1 Cloud monitoring benefit and caution

So far, using cloud monitoring tool has been proved to be of high interest to have a remote overview of the evolution of an incident. If available, it is hence possible to access in details the physical parameters that are likely to significantly evolve during a cascading effect incident, which may even not have been as easily perceived by the human beings (e.g. ground vibration before a major collapse).

In the following paragraphs, a brief reflection is proposed on the benefit of having used cloud monitoring techniques for two scenarios that were selected within the CascEff project, which are the Nut warehouse and the Festival scenario. These two scenarios were selected for their socio-geographical context and their impact scale to be different enough from Séchilienne landslide to demonstrate the exportability of the cloud monitoring tool (including new additional functionalities) as developed under e.cenaris. Consequently, having monitored and provided access to these parameters and making them available through cloud monitoring tool could have helped in appreciating better the evolution of the incident. These are only suggestions, which may be financially and contextually more or less realistic, to prove the applicability of cloud monitoring methodologies as decision-support tool not only in the case of ground instability context.

However, it has to be pointed out that cloud monitoring methodologies would in no instance prevent an incident to happen, but it may help in preventing the induction of some cascading effects as well as in minimizing the consequences.

3.2 Exportability to cloud monitoring of the Nut warehouse scenario

As introduced in Deliverable D1.4, the Nut warehouse incident occurred because of the initiation of a fire inside a nut storage building. Once water provisions used by the fire brigade were run out, decision-making issues were:

- whether to use the water from a local pond with the risk to contaminate a natural environment (fishes and wildlife) and water supply,
- or leaving the fire slowly burning and extinguishing itself with the risk to suffocate people leaving in the neighborhood and to need to stop traffic because of the dense smoke.

In this scenario, the challenge was to face the timeline, i.e. to manage the priorities in order to prevent from catastrophic consequences. Indeed, it took 3 weeks to fully close the incident, with contamination problems and intoxication risk for the population and wildlife in spite of the precautions taken.

From the post-analysis of the incident, it results that more knowledge of the industrial area, especially about the nearby pond, would have helped in taking faster and safer resolutions of the incident. This could have been supported by cloud monitoring data sharing such as knowing:

- the local wind/weather conditions: with or without wind, the dispersion of the smoke and the fire itself follow different directions (toward inhabited areas, towards woods, toward roads, etc.),

- the water flow and contamination level: having access to a shared database with the fluvial ways and their uses, as well as equipping the pond with contamination sensors (since it was designed indeed to capture polluted water in the case of chemical spills), e.g. heavy metals concentration rate, or along the water path (with potentially threshold alarms) provides information on the water uses and its necessity level to be saved,
- the traffic flow: having access to a shared database with the roads accesses and their uses (using passing sensors) enables to define priority and strategic road axis to access the incident location and to enable regular traffic in spite of it.

3.3 Exportability to cloud monitoring of the Festival scenario

The Festival scenario (cf. Deliverable D1.4) was imagined by combining two existing scenarios: a hazmat boat transportation incident and the evacuation of an outdoor music festival, requiring coordination between multiple agencies and authorities to deal with.

Disregarding the additional terrorist threat that was suggested in the combined scenario, the complexity of decisions to face the hazmat fire and spill risk and the crisis eruption among the festival participants stays in the following dilemma:

- either to let the Ammonium Nitrate ship sink and pollute the river for years and obstruct shipping for months, with direct victims from the festival with breathing problems,
- or to try to tow the ship away with self-sustained decomposition (SSD) reaction on-going and to risk explosion causing fatalities amongst emergency responders and fires and injuries in the immediate vicinity with damage on infrastructures, including the festival area.

Because of the risk of an explosion, the fire brigade decides to evacuate the entire festival area and all surrounding buildings located in a 2-km radius from the incident location. Such decision could have been quickly proposed and optimized having access to cloud monitoring data such as:

- information on the wind/weather conditions: available from meteorological stations, to estimate the smoke and toxic fluid dispersion,
- information of the harbor traffic: available from the control tower, to assess the accessibility to the incident location,
- information on the festival participants number in each area of the festival and on emergency ways: using passing sensors, to optimize evacuation ways out,
- information of the traffic road and accessibility close to the incident: available from city traffic regulation offices, to define priority and strategic road axis,
- information on the SHM data from the hazmat boat: from SHM sensors (with potentially malfunctioning alarms) beforehand set on the boat according to health and safety obligations, to anticipate the fire and explosion risk.

3.4 Need of additional development for the exportability of e.cenaris

e.cenaris has been initially developed for the scope to monitor geotechnical and geological risks related to georesources and geostructures. To this purpose, coding and computing development have been adjusted to the functioning and outputs of sensors and acquisition units (e.g. computer, dataloggers, etc.) that may differ for the surveillance of areas that will necessitate the use of other kinds of sensors than the once already used for the monitoring of geohazard.

For instance, developments that could be useful to export the Nut warehouse and/or the Festival scenario to e.cenaris are:

- for the implementation of CCTV cameras on a highway or a public/visited place and for providing the access to the records on e.cenaris, film visualization plug-in activation will be needed with the risk to increase data loading time;
- for the determination of the concentrations of heavy metals in a river due to a defective industrial draining flow, the extraction of new “complex variables” will be needed from row measures (i.e. river flow, draining flow, heavy metals concentration measured in the draining cistern), as well as readjusting the plots and tables to visualize these parameters on the web interface.

Finally, for vulnerable areas that would not be related to geohazard but that may be considered into an IET and hence necessitate to be controlled with cloud monitoring technologies, enhancing e.cenaris for the monitoring of such areas could be recommended but further coding and computing development might be formerly required to:

- update acquisition and processing systems,
- adapt sensors and acquisition units output formats to be readable by e.cenaris.

4 Conclusions

This deliverable presents the benefits in using detection systems and in integrating cloud monitoring as input to incident management of crises. The work achieved is illustrated with e.cenaris platform. e.cenaris is initially a cloud monitoring platform used for the remote near-real time observation of vulnerable areas subject to ground and underground hazard that enables data visualization and downloading through an internet interface.

Within CascEff Task 2.4, more than reflecting on the technical needs for integrating this platform as a decision-support tool to help in the management of crises, additional functionalities have also been developed based on data fusion, multi-criteria analysis and alarm personalization. Substantially, the parameterization of alarms on values coming from raw data fusion or processed into complex variables facilitates the focus of the monitoring and its care in totality, so that vigilance thresholds as well as duty periods can be defined if necessary. Handling these outputs through cloud monitoring technologies facilitates the accessibility of the data for expertise and potential stakeholders, geographically and in time since they become available simply by means of an internet connection and a computer.

Such functionalities have been applied in a beta version to Séchilienne scenario. The applicability of cloud monitoring methodologies has then been demonstrated to be also useful in the case of the crisis management of other kinds of scenarios, such as the Nut warehouse and the Festival ones, as introduced within CascEff.

To conclude, the benefit of using cloud monitoring output data as input information into the IET is explained as follows: IET modeling and results will be more or less complete, depending on the input data quality that have been taken into consideration. The advantage of adding sensors, whose data will be accessible through cloud monitoring is to improve the accuracy of the IET results. Results from past incidents or (supposed-to-be) well-known scenarios (such as Séchilienne landslide, the Nut warehouse and the Festival) and new simulations on IET will hence help as a feedback loop in defining which kind of sensors should be integrated (and where) into the monitoring of an area likely to be exposed to cascading effects incidents.

Of course, installing a monitoring network has a cost and might also create fears on a political and social point of view. Hence, its installation will be justified only in case a real hazard has been demonstrated to be likely to occur under specified/known conditions. For instance, for the scenarios considered in this deliverable:

- Séchilienne landslide: stone blocks have been observed to fall down close to the road,
- Nut warehouse: such a big storage area might be subject to dust explosion,
- Festival: emergency exits must be defined and well coordinated by Civil Protection or other organizations.

Finally, IET tests with varying incident evolutions will be needed to justify whether to finance and design a cloud monitoring network or not.

As a perspective, with the implementation of the IET in WP4, it will be possible to propose the installation of monitoring networks with remote access to the monitored data through cloud monitoring platform to be beneficially used as a decision-support tool in the case of crisis-inducing incidents.