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European Network of Crisis Management Laboratories (ENCML)

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Title Network of European Facilities I

Abstract
This policy report focuses on the Network of European Facilities. It draws attention to requirements to initiate the network, methods to carry out experiments and to how the activities of the ENCML will feed into the Disaster Risk Management Knowledge Centre (DRMKC)

Contents

Foreword

This policy report deals with the revisted concept of the Network of European Facilities, established at the European Crisis Management Laboratories, Joint Research Centre, Ispra (Italy). It focused both on the overall rationale behind the network and the requirements for partners to join. Moreover, in the conclusions the report contextualized the activities of the network in the context of the Disaster Risk Management Knowledge Centre (DRMKC).

Executive summary

This report focuses on the Network of European Facilities by looking at four main dimensions:

- The European landscape of partnerships, networks of platforms in order to position the initiative in an already existing background
- The structure of the network and minimum requirements for partners to join
- An experimental approach that can be used in carrying out experiments within the network
- How the network contributes to the DRMKC

Policy context

European policies give specific emphasis to the importance of building on existing knowledge at all stages of the disaster risk management cycle. The European Network of Crisis Management Laboratories (ENCML) responds to the need of capitalising on existing capabilities to enhance collaboration, share knowledge and plan activities that can be of interest to crisis centres. The policy context consists of the Union Civil Protection Mechanism which underlines the importance of, inter alia, knowledge, methodology and good practices as well highlights the central role of synergies across partnerships and networks for improving coordination efforts.

Key conclusions

The network contributes to all the three main pillars of the DRMKC as it deals with:

- Partnership, through the establishment of a formal structure to initiate collaboration between several entities
- Knowledge, through a) knowledge sharing among partners b) contributing to knowledge by suggesting an agile experimental approach to be used in the field of crisis management
- Innovation, through ad hoc activities, for instance testing new solutions in distributed experiments.

Related and future JRC work

The activities of the network will continue in the next few years by developing a roadmap of activities for partners and by planning technical workshops at the European Crisis Management Laboratory.

1 Introduction

The Network of European research and testing facilities stems from the preparatory activities carried out at European Crisis Management Laboratories (ECML) of the Joint Research Centre, Ispra. As outlined in the policy report published in 2015, 7 ECML technology workshops which took place between March 2012 and October 2016 drew attention to a specific set of needs and paved the ground for the establishment of European Network of Crisis Management Laboratories (ENCML). In particular, the following needs emerged from the outcomes of the workshops:

- The need for developing a dedicated community that plans activities (e.g. exercises) relevant for crisis coordination centres on a regular basis;

- The need for collaboration and information sharing on best practices and lessons learned with regards to innovative solutions in crisis management;
- The increasing need for interoperability (technical, semantic or organizational);
- The need for pooling together academia, industry and end-users to drive the process of continuous improvement of technology supporting crisis management and disaster relief.

The ENCML, which is a part of the activities of the Disaster Risk Management Knowledge Centre (DRMKC) aims at addressing these needs through a well-defined structure that has been reconsidered in the course of last year. The structure has been reassessed in order to provide a more formal organization drawing on the so-called *technical*, *human*, *organizational* and *regulatory* approach (THOR) that partners of the network must have to participate in the activities. Furthermore, one of the needs mentioned above (facilitating experiments or exercises relevant for crisis coordination centres) has been more clearly identified.

In this policy report we focus on three main dimensions which contribute to define:

1. The position of the network in the context of existing European initiatives (chapter 2)
2. The revisited organisational structure of the ENCML (chapter 3)
3. An experimental approach to experiments in crisis management that can be helpful to plan and execute different types of activities (chapter 4)
4. How the ENCML will feed into the activities of the DRMKC (Conclusions)

In the document we often refer to the Driving Innovation in Crisis Management for European Resilience (DRIVER), FP7 project. This is due to the fact the project contributes to specify the requirements needed to join the network.

2 Background

There are many initiatives in Europe that bring together researchers, practitioners and other stakeholders for different purposes. While a comprehensive overview of existing platforms and networks is outside the scope of this report, in the following pages the main initiatives will be mentioned to contextualise the position of the ENCML in an already existing and rich landscape.

Active networks of scientists and policy makers have been identified by the Disaster Risk Management Knowledge Centre[1]. Some of these networks or scientific partnerships have operative mandates, for instance Global Disasters Alerts and Coordination System (GDACS) that estimates the impact of natural disasters and provides alerts after major disasters, or European Flood Awareness System (EFAS) which monitors and forecasts floods across Europe. GDACS was conceived as a cooperation framework between the United Nations and the European Commission in 2004 and it is considered, along with similar initiatives, as a *scientific partnership* to "improve the science-policy interface in prevention activities" (e.g. the identification of gaps and improvement of methodology). Additionally, groups of experts have been identified which are *de fact*o networks like the EU Disaster Prevention

[1] http://drmkc.jrc.ec.europa.eu/partnership/Scientific-Partnerships

Expert Group led by DG ECHO that works on national risk assessment and supports the development of an overview of risks and risk assessment methodology[2]. The above-mentioned cooperation frameworks and experts' groups aim at mitigating the impact of disasters through clusters or science-policy interface partnerships focused on, *inter alia*, information exchange or operational preparedness. Another good example is the EU Loss and Damage Expert Group led by JRC. Representatives of the Member States work alongside international experts in workshops (e.g. the series of the EU loss data workshops) to build and expand a network of professionals "willing to participate in the process of the development of the European disaster loss guidelines" (De Groeve et.al. 2014: 13). Preparedness, prevention, information exchange and policy impact are key elements in these kind of initiatives.

Furthermore, there are networks which pool different stakeholders (e.g. innovation R&D managers, first responders etc.), like the European First Responder Innovation Managers Platform (EFRIM) that is an informal multi-disciplinary network dealing with strategic, tactical and operational challenges of European first responders[3]. Or The International Emergency Management Society (TIEMS)[3], a global forum for education, training, certification and policy in Emergency and Disaster Management. There are also ad hoc first-responders networks, like the International Association of Fire and Rescue Service (CITF) which is one of the largest network in Europe that provides world fire statistics by publishing annual reports.

The initiative of the Office for the Coordination of Humanitarian Affairs (OCHA) is also worth mentioning here as it relates to activities relevant to crisis centres. It entails the creation of a community of practice for crisis centres and minimum interoperability standards to allow timely and qualitative information exchange among them. The community of practice was one of outcomes of a workshop organized by OCHA and carried out in Geneva in 2015 on minimum interoperability standards for regional and national crisis centres[4]. One of the recommendations was in fact the creation of a community in order to identify and develop solutions for interoperability, building on collective knowledge and best practices. This initiative goes hand-in-hand with the Crisis Centre Network. Crisis centre collaboration was tested during the TRIPLEX exercise[5] (September 2016). In the evaluation of TRIPLEX, it was agreed that crisis centres will meet at the Humanitarian Networks Partnership Week in Geneva (NHPW 6-10 February 2017)[7] as "Crisis Centres Network" to explore further collaboration in the community of practice.

In addition to the above-mentioned partnerships, networks and communities, there are also *ad hoc* networks such as the Europe's New Training Initiative for Civilian Crisis Management (ENTRi) or the Academic network for Disaster Resilience to Optimise educational development which deal with capacity building, awareness raising, innovation and knowledge. There are also many universities and research centres that have a number of activities which range from disaster preparedness to multi-risk assessment (e.g. Lund University, University of Portsmouth, Copenhagen Center for Disaster Research). These centres are well known and are certainly involved in wide European and non-European networks.

[2] http://drmkc.jrc.ec.europa.eu/partnership/Science-Policy-Interface [3]
https://efrim.org
[3] http://tiems.info
[4] The JRC was among the participants of the workshop.
[5] TRIPLEX is a large scale field simulation exercise focused on strengthening preparedness and response. [7]
https://vosocc.unocha.org/GetFile.aspx?xml=4108dcjy_l1.html&tid=4108&laid=1

As far as European platforms are concerned, they mainly belong to National or Regional fire fighters training schools. Some examples are provided in the table below:

Table 1- Main European Platforms

Country	Owner	Focus
England	London Fire Brigades (LFB)	Any kind of incidents
France	SDIS13	Forest Fire/Incident Command
France	ECASC	Forest Fire, Flood, Chemical Risk, Search and Rescue, Incident Command
France	ENSOP	Chemical Risk, Urban fire
France	BMPM	Forest and urban fire
Germany	Frankfurt Fire & Rescue Training Center (FRTC)	Urban fires, road traffic accidents, tunnel incidents and chemical incidents
Italy	ISA – Istituto Superiore Antincendi	Forest and urban fire
Portugal	Centro Ciencia Viva (CCV)	Forest Fire
Portugal	Escola National Bomberos	Forest Fire
Sweden	MSB	Any kind of incidents

Furthermore, in the project DRIVER there are also other important platforms such as the City of the Hague, which is an operational crisis management organization included in an extensive network at Den Haag Safety Region the Security and Aerospace actors for the Future of the Earth (Safecluster) in France focused on security issues.

Platforms can also be privately owned. For example, during the EU large-scale crisis management exercise SEQUANA, carried out in France in March 2016, one of players involved in the exercise (Orange Company) hosted a platform, after an agreement signed with the Paris Police Prefecture who was in charge of the exercise. The platform, used for communication purposes and exchange of information during the exercise, is still on going and maintained by Orange.

Sometimes platforms are developed within EU-funded projects. This is the case of, *inter alia*, ReDIRNET (Emergency Responders Data Interoperability Network)[6] which offers public safety agencies the ability to interconnect their communication infrastructures and

[6] http://www.redirnet.eu/

systems free of charge via a gateway. The project will ultimately provide a common platform for safety agencies.

The ENCML aims to establish a fruitful dialogue with already existing communities, working groups and networks. For instance, potential collaboration has been explored (and it will be further explored at the Network Humanitarian Partnership week in February 2017) with the community of practice for crisis centres. In doing so, potential overlaps will be avoided and cross network synergies are likely to emerge.

The Network of European facilities plans to act as a hub for major European platforms. In doing so it aims at pooling and sharing existing capabilities and resources with the objective of facilitating and hosting a set of activities (e.g. distributed trials, workshops etc.). In the chapter 3 we turn to describe a minimum set of requirements needed to initiate the network. As mentioned in the Introduction, the overall rationale and the structure behind the network have been revisited and this has also had an impact on requirements for partners to join.

3 Requirements for the establishment of the ENCML

While the ENCML is an informal network, some minimum requirements must be identified and agreed upon to initiate it. In this chapter, we suggest a distinction between minimum requirements for the structure of the network and requirements for single partners to join. At this stage, the set of requisites cannot be comprehensive. Some intermediate stages, as explained below, are needed before expanding the ENCML.

To initiate a network of facilities, a coupled core group of platforms must draft the mandate of the and agree on roles and responsibilities of the nodes. The minimum requirement to establish the ENCML consists of the first building block of the organizational structure: two platforms or “core partners” that will then coordinate other “associated” partners. The core group consists of the Joint Research Centre (JRC) and another platform. To select the second core partner, we use the so-called technical, human, organisational and regulatory approach, the so-called THOR. While this approach was developed and applied in another domain (cyber security),[7] the four dimensions of the THOR concept are helpful here to assess whether:

[7] The THOR concept was developed in the CAMINO FP& project (Comprehensive Approach to cyber roadmap coordination and development). More information is available here: http://www.fp7-camino.eu/

1. The platform has the *technical* and the *physical* capability to facilitate and host different kind of activities, such as distributed exercises. Interdependent activities carried out at multiple locations within the same timeframe and the same virtual environment will constitute the backbone of an *ad hoc* roadmap. Therefore, the following general technical requirements must be met by core partners:

An open, scalable and flexible architecture which allows the incorporation of real-world and simulated data within a training or decision support system. The platform must provide an environment where solutions can be tested through appropriate means e.g. the inputs foreseen by the scenario designed for the exercise. In order to provide the required assessment information, the platform should be observable (e.g. it should provide specific outputs about its internal processes) and able to collect the outputs of the solution tested. E.g. The performance of a virtual machine hosted in a virtual machine hosting environment can be measured in terms of disk accesses, network throughput, central processing unit and memory usage. A human-machine Interaction capture software should also be used in order to evaluate the quality and the effectiveness of the user interfaces.

Live and virtual CM laboratories that enable people and equipment to interact with models, simulations and visualizations. The environment provided by the platform must therefore be close enough to real implementations to provide the users with a realistic environment. If possible, a real timeline should be followed; in specific cases the laboratory should also be able to compress it and follow the scenarios at an accelerated pace. This will allow following the complete evolution of complex situations (like huge bad weather events) in a reasonable amount of time.

High-speed and reliable Internet with virtual private network (VPN) possibility. In interdependent activities a large amount of data may have to flow freely and securely. A reliable and safe network connection is anyway a basic requirement for a real crisis management facility: its simulations must provide it as well. If possible, the reliability of the connection should be tested with tools like iperf[8] and ttcp[9], and it should be monitored during exercise using tools like prtg[10].

Time synchronization. Many of the key functions of the organization during an exercise are dependent on time synchronization: control of the activities, distributed simulations and data collected for analysis. A Network Time Protocol (like NTP)[13] must be available to synchronize all sites and computers in distributed trials. Lessons learned suggest to register all time reference in Universal Time Coordinates (UTC), i.e. Greenwich Mean Time with no Daylight Saving Time shift, in order to ease the comparison tasks.

Access to collaborative systems such as file share, wiki, teleconferences, collaborative work spaces, chat tools, email lists, telephone lists are advisable.

High levels of interoperability, in terms of standard formats and protocols. Data should in fact be processed, understood and shared by core partners. In this context, interoperability is intended in a broad sense, including syntactical and

[8] iperf – a free cross-platform tool to measure performance in TCP/UDP (https://iperf.fr/)
[9] ttcp – a tool to measure performance in TCP/UDP, preinstalled on CISCO routers (https://en.wikipedia.org/wiki/Ttcp)
[10] prtg - sensors are installed on different nodes in the network that continuously measure performance (https://www.paessler.com/prtg) [13] NTP - http://www.ntp.org/

semantic features. Interoperability entails the adoption of common and wellestablished data formats (e.g. GIS formats like ESRI shape files or Google KML, alert formats like CAP) and standard communication protocols; but it involves also the use of easily recognizable pictograms, like standard icon sets from UN-OCHA.

Furthermore, the platform must have a physical infrastructure which includes laboratories and/or crisis rooms to carry out exercises as well as conference rooms to host meetings.

2. The platform has the *organizational* structure and the *human capital* (people and competences) to plan, execute and evaluate exercises. Depending on the size and the complexity of the activities as well as their format, different organizational set up may be necessary. However, the organizational structure should be flexible enough to support the implementation of different activities (e.g. trials, workshops) and to allocate human resources in the actual execution of the activities. For instance, there are some key functions, or roles, to be fulfilled for the execution of exercises, like the coordination of the overall activity which requires an "exercise manager" and an "exercise execution manager" who will be responsible for, *inter alia*, adjusting the type and the intensity of the events in a given scenario, collecting evaluation data etc. While technical skills are crucial, other aspects are also important and include capacity building to expand the network and more general organizational skills. The organizational structure of core partners must allow the full integration in the ENCML through the active involvement in community building activities, such as workshops, and the involvement in the maintenance of the ENCML capabilities (e.g. the development of a portfolio of scenarios).

3. The platform does not have regulatory constraints or administrative barriers which may limit cooperation with other organizations (e.g. regulatory constraints on data sharing).

In addition to this first set of THOR requirements, core partners must define the needs to be addressed from the onset. Needs assessment of emergency response centers, for instance, constitutes in itself a requirement for the core group. Without assessing the needs, the network cannot be initiated as it would lack the knowledge to invite other partners/laboratories that may address, better than others, specific technical gaps.

Non-core partners are defined as "associated". The main difference between core and associated partners lies in the responsibility and in the level of engagement within the network. While core partners will set up both the network and the governance (e.g. mandate and governance procedures) and they will also provide the physical infrastructure to host a wide range of activities, associated partners will provide support to plan, host and evaluate the activities. For instance, associated platforms can provide support in designing scenarios, in evaluating exercises or selecting solutions to be discussed at workshops. Their hosting facilities can also be used to organize the meeting of the network. Additionally, associated partners will be also involved in developing a roadmap of activities. However, they will not be directly involved in the governance of the ENCML. Nevertheless, the network will rely on both a top-down and a bottom-up approach. If core partners will be ultimately responsible for initiating and maintaining the ENCML, they will also have to ensure platforms' collaboration through mutual learning mechanisms, such as sharing lessons learned and facilitating best practices. Sharing lessons learned, for instance, will be done in the ENCML through the improvement of the use and uptake of the outcomes of exercises.

The facilitation of best practices will be horizontal, meaning that all nodes will exchange knowledge and information through co-coordination dynamics (e.g. each associated partner will host a virtual meeting within the ENCML to share lessons learned after an activity). Core partners will make sure that lessons learned will be taken into account.

The last requirement deals with the organization of a workshop planned by core partners. Associated and core partners will participate in the first ENCML event in order to discuss:

- The mandate and the role of the network in the context of the DRMKC;
- The overall governance;
- Identified needs and recruitment strategies;
- The level of engagement of associated partners as well as security constraints, schedule and availability of platform personnel; - Strategies for collaboration within the network.

This workshop will result in the consolidation of the structure and the objectives of the network. The output of the event will be a document focused on the mandate, the roles of associated partners as well as guidelines for interaction and information sharing.

We now turn to describe minimum requirements for other partners, namely organisations not involved as core or as associated, to join the ENCML. As mentioned at the beginning of this chapter, requirements for external organizations cannot be comprehensive at this stage. However, we can outline a few general conditions. Interested organisations should express their interest through a letter of intent. The ENCML is open to different kind of stakeholders, from first responders to research centres, who declare a genuine interest in the network. Despite being of informal nature, interested stakeholders are expected to declare their intent to join the network and to participate in the activities and/or be informed of the outcomes of the activities. The level of engagement of external entities will depend on their expertise and on the actual interest in the network. It can be foreseen that some organizations would be willing on participating in distributed exercises (e.g. national or regional training schools), while some others would be willing on developing the roadmap of activities without taking part in simulation exercises. Some others will participate only in workshops. Either way is feasible but the role of additional nodes should be clearly defined through, *inter alia*, a letter of intent. In the letter the following points must be addressed:

1. type of organization and short description;
2. expression of interest in the ENCML; 3.
type of involvement in the network.

On a general level, technical, human, organizational and regulatory aspects should also be taken into account. For the participation in interdependent activities, for instance, depending on the size and the complexity of the activity as well as its format, different organizational set ups may be necessary for planning, execution and evaluation.

A few functions (or roles) and subsequent requirements that would be necessary to effectively plan and execute distributed exercises are:

- from the overall experiment management perspective, ICT competence is a minimum requirement and ICT technicians should be assigned to help the actual execution of the exercise. To create the initial experiment plan collaboratively, some ad hoc exercise management system tool should be used (e.g. Exonaut[11]). In the absence of specific tools, Gantt charts, combined with a wiki or file share, must be made available.

- The experiment execution management handles the detailed planning of the experiment, execution of that plan, know what data to collect, collect the data and perform data analysis of the collected data. To be able to do this efficiently, methods and tools to support these activities are needed. Examples of software and methods are F-REX (Anderson 2009), PROCeed[15]. Additionally, an aggregated E-COP (Experiment Common Operational Picture) may be needed. This aggregated E-COP may be shared in simple form using collaborative work spaces which may put a big strain on people to update it. On the other hand, using automatic E-COPs fed from simulation control may be less flexible and expensive. Elements of Experiment execution management need a detailed E-COP to be able to control the experiment in more detail. Elements of the Experiment execution management needs to be able to contribute the simulated state to the common operational picture of the experiment, manually or automatically.

  Additionally, tools to support common formats are needed, such as OGC (Open Geospatial Consortium), WMS (Web Map Service), CAP (Common Alerting Protocols) and KML (Keyhole Markup Language).

- From the organizational point of view, external stakeholders must allocate human resources in the preparation of the exercise or during the activity, if needed. The same holds true for the preparation of technical workshops.

For other activities, such as participation in ENCML online meetings or teleconferences, robust communication channels as well as specific communication features are needed (e.g. video-conference, real-time transfer, wireless local area network – WLAN -).

In chapter 4 we describe an experimental approach to experiments in crisis management. If, on the one hand, we acknowledge that the network of European facilities has not the primary objective of carrying out only experiments, on the other we aim at filling a current gap in the field crisis management. Research and literature on how to test new solutions and concepts using a common frame of reference (from planning to execution) are in fact fragmented. In the following pages, drawing on the Concept Development and Experimentation approach (CD&E), we suggest an agile 6-step approach that can also be useful when organizing distributed experiments in the ENCML. At this stage, the approach is generic enough to be adapted to different kind of activities. It will be refined during the activities planned within the network with the aim of contributing to one of the key pillars of the DRMKC, namely innovation. In the context of the DRMKC, innovation is closely linked

[11] https://www.4cstrategies.com/exonaut-products/training-and-exercise-manager#.WDhJto-cFaQ [15] PROCeed – tool by ITTI, described in D22.21

to the idea of a European test-bed for crisis management technologies where tools and services for designing, running and evaluating experiments are considered as an integral part of the test-bed. Chapter 4 constitutes the first "building block" of the frame of reference mentioned above.

4 An experimental approach to experiments in crisis management

The term experiment used in this chapter draws on the Concept Development and Experimentation approach (CD&E). In the CD&E the implications of experimentation seem of particular relevance to the field of crisis management. It is worth considering that, in the military field and more specifically in the US Department of Defence, different types of experiments have proliferated to improve defence capabilities and to assess new *solutions* (from new ideas to technology). In the Code of Best Practice of Experimentation (2002), experiments are divided into discovery, demonstration and hypothesis testing. Discovery experiments involve introducing new "systems, concepts, organizational structures, technologies or other elements to a setting where their use can be observed and catalogued" to identify potential benefits (2002: 19-20]. In demonstration experiments, technologies are used to show how they can be employed effectively in given conditions (e.g. in a given scenario). While hypothesis testing is used to test theories or observable hypothesis derived from such theories 2002: 22). The formulation of these three types of experiments needs to be designed around issues of traditional research methodology, such as the articulation of hypothesis and the nature of variables, the sample size etc.

In the CD&E framework, "new solutions and ideas are iteratively tested (multiple scenarios, interoperability etc.) by a series of controlled experiments addressing different research questions. Results […] are then used to further develop the concept, which is again followed by an experimentation phase, until operational capability is reached. Concepts can also be rejected, if it turns out that they do not provide added value or are not cost-efficient".

This framework is also characterised by, *inter alia*, a) the identification and description of capability gaps, b) a systematic analysis of solutions that might fill these gaps and, c) the participation of stakeholders who are carefully selected in order to exploit expertise. Hence this approach is of particular relevance for the aims of the ENCML and can be helpful in planning a roadmap of activities based on:

- The identification of capability gaps of specific stakeholders
- The systematic analysis and testing of technical solutions which may fill these gaps and serve as basis for planning ad hoc activities with the partners of the partners of the network.

In particular, demonstration experiments may be considered in the ENCML, specifically when new technologies or solutions are tested to assess their real added value or applicability. These experiments can in fact enable practitioners to learn more about their potential to really improve crisis management operations.

Currently, there is no standardized approach to experimentation in crisis and emergency management. Instead, the most common method used in this field refers to comprehensive exercises carried out at different levels (e.g. tactical, strategic etc.). We suggest using an experimental methodology which relies on a six-step approach which goes from the formulation of research questions to drawing conclusions:

4.1 Research Questions

Before starting anything else, the goals of the experiment and/or research questions must be identified. When testing new solutions, some typical goals may include:

- Test functioning and features of a single technology: Can a task be performed (e.g. is it possible to collect relevant static and dynamic information)? Does the tool contribute to the function it is supposed to contribute to?
- Test a particular configuration of technologies (interoperability, benchmarking): are technologies working seamlessly with other tools to provide a given function or in conjunction with other functions (and tools therein) at system of systems level?
- Test effectiveness of (configuration of) technology in a given setting (for a particular user group or in a given cooperation scenario): are tasks performed faster and/or better? Does the tool facilitate crisis mangers?
- Test functioning and features of a single concept or functionality (part of an existing technical solution): can a task be performed faster and/or better?
- Test effectiveness of an organizational / procedural approach: are tasks performed faster and/or better?
- Networking and awareness / creation of market: are mature technologies of interest to a certain user group that is currently not using them? What is the maturity level of the technologies tested?
- Evaluate cost-benefit of solutions / approaches: are certain technologies / approaches a good investment option for an organization (operational benefit in relation to life-cycle costs)?

It is worth noting that goals and questions depends on the methodology used and on the solutions tested. Furthermore, in order to develop accurate questions, it is crucial to take into account the tradition of work that already exists on a subject. For instance, it is worth exploring:

- previous lessons learned (what has been done already? What were the results? What did work, and what did not? Why was that?)
- Reports or other relevant documents on experiments of similar nature,
- Findings of previous research projects which have identified gaps (e.g. ACRIMAS) and/or the need to explore specific areas.

If results of previous experiments are used, it must be clearly explained which results are taken into account, why and which not.

Experiments are not stand-alone activities. They are typically preceded by an idea that is worked out in the Concept Development phase of the experimentation campaign cycle. A "conceptual model" should be defined. The conceptual model is a mechanism for the communication of the problem space among stakeholders in the experiment. It is a (conceptual) model of the system of interest that is under experimentation. For example, the model shows the CM organization, roles, responsibilities, activities performed, C2 systems used. The model shows where new concepts are introduced that are subjected to an experiment. E.g. an adapted organization to improve efficiency, or new C2 systems to improve situational awareness.

The creation of an initial experimentation plan must include:

1) A clear formulation of goals and research questions;
2) An overall e methodology must be decided to gather evidence to address these questions;
3) A list of expected outcomes (break-down of goal in different outcomes in terms of technology, user groups etc);
4) Definition of criteria for success of the experiment.

Secondly, experiments will be designed differently depending on which level of crisis management is addressed. Experiment objectives must address expected outcomes, and tasks and metrics must be designed appropriately. The initial methodology considers the following levels:

- Technological test device or software (e.g. experiment). ○ Operational: improve operations in the field (e.g. observational study).
- Tactical: improve situation awareness, command and control; improve decision making (e.g. quasi-experiment).
- Strategic: guide investments in innovation; improve preparedness, capabilities, etc. (e.g. workshops).
- Systemic: influence Civil Protection system in a MS and in the EU.

A third element to consider is the level of complexity and realism needed in the experiment. A key component of experimentation is the controlled setting. In order to produce relevant results, the environment may have to be controlled (e.g. fixing variables to provide, for instance, level playing field) or realistic (e.g. allow or encourage random events). Some examples of different levels of complexity include:

- Single device.
- Single technology in controlled environment (e.g. comparison of mobile devices).
- Range of connected technologies in controlled environment (e.g. information exchange between field and HQ). ○ Exercise in realistic environment.

- Human-computer interaction in lab (short experiment). ○ Human-computer interaction in lab (experiment over days or weeks).
- Human-computer interaction in exercise (many participants).
- Human-computer interaction, combined with technology testing, in large scale exercise.
- Large scale exercise combining all

Also, at highest complexity level it has to be taken into consideration that crisis management functions, solutions or capabilities have to be experimented in various (crossborder) configurations reflecting the operational reality of EU crisis management crossborder operations.

4.2 Select participants

Once the methods and goals are defined, the participants needed to complete the experiment successfully must be selected. While at the early stage it is not necessary to identify individual participants, the various groups must be defined from the beginning. Typically, the groups include:

- Technology providers / Process providers: what will be experimented with.
- Scientists: provide input / feedback / learn on R&D issues / methodological support.
- Facilitators: help experimenters to carry out the activities.
- Industry: provide input / feedback / learn on innovation, existing solutions, bringing to market.
- Crisis management practitioners: execute the experiment / evaluate the experiment
- External observers: observe the experiment without being directly involved.

The selection of participants must cover all roles that are needed for the experiment:

- **Experiment lead**: makes the final decisions in the preparation and execution of the experiment; coordinates the contributions of the participating partners; assures the readiness for the experiment execution, controls the experiment execution, gives instructions and provides input; data monitors the schedule and the adherence to the script.
- **Facilitators**: organizational support and guidance during the preparation and execution of the experiments; take records of the experiment and collect feedback of the participants.
- **Technical supporters**: prepare the technical conditions and the input data; pretest the experiment configuration; tackle technical problems prior and during experiment execution; archiving of the tested configuration and the data.
- **Process supporters**: professional experts, supporting the experiments from functional point of view provides input to the scenario script in order to keep it realistic and significant.
- **Coaches**: provide appropriate training on the used tools and processes prior the experiment introduce the experiment performers to the exercise scenario support them in case of ambiguity or confusion

- **Experiment performers**: play their role according to the script bring-in their professional experience give feedback in questionnaires and free statements.
- **Evaluators**: control the alignment of the experiment set-up and execution with the pre-defined goals; observe the experiment from a neutral perspective act as conciliator in case of disagreements summarize the feedback and metrics evaluate the results of the experiment.

For each role, the expected outcomes of the experiments must be specified. Expectation management is critical to keep participants engaged in future experiments. Realistic and clear outcomes must be defined for each group of participants in advance.

4.3 Prepare experiment

Experiment preparation takes at least 6 months, but will usually take longer for more complex experiments. Because it is a complex and lengthy process, each experiment will be designed differently, focusing on issues important for the particular goals, expected outcomes and participants.

At least the following steps are mandatory:

- Calendar of actions. The calendar must include the period before, during and after the actual experiment. It includes all phases, including scenario building meetings, experiment dates, evaluation period, and report drafting.
- Agenda setting. The agenda of the experiment is primarily focused on expectation management of the participants. It must include: (1) programme of activities, (2) role of participants, (3) expected outcomes for participant groups, (4) introduction of experiment goal, and (5) follow-up process and expected date of experiment conclusions.
- Tasks to be completed in experiment. In light of the goal and expected outcomes, specific tasks must be designed that will produce evidence to prove or disprove them.

In many cases, test data will be generated or distributed during the experiment. This may include simulations (e.g. flood simulations), injects (e.g. event happening or information available at predefined times) or base data (e.g. critical infrastructure locations). It is essential that the simulated environment is well tested before and is not a source of failure.

In the case the experiment involves the use of a scenario, it may be necessary to draw on past disasters data which can guide the creation of evidenced-based scenarios. The following databases may be considered when dealing with loss past disasters, in particular with lost data (De Groeve et.al. 2013):

1. EM-DAT[12], maintained by CRED, the Centre for Research on the Epidemiology of Disasters (Louvain University, Belgium) which is the first public available database on disasters at national resolution. Loss accounting was initiated in 1988 to provide information for humanitarian actions;

[12] http://www.emdat.be/databae

2. NatCat SERVICE (Munich RE)[13] and
3. Sigma CatNet Service (Swiss RE)[18]. Both 2 and 3 are global databases with no public access. They are maintained by the two largest re-insurers in the world (Munich RE and Swiss RE) and are mainly used to perform trend analysis.
4. DesInventar (la Red)[14] which is a national-based accounting system implemented in a large number of countries. It is becoming a global open source depository of national databases. It is worth mentioning that UNPD and UNISDR sponsored the implementation of DesInventar in Latin American, Asia and Africa to archive the loss data of historical events (human loss, physical damage and economic loss) and collect relevant data of emergent situations.

4.4 Running the experiment

During the experiment, the following steps are required:

- **Introduction**: all operative participants to the experiment must be made aware of the purpose, objectives and steps of the experiment, as well as the expected outcomes and evaluation methods. This should include:
  - A description of the context and the basic setup: What is the scenario about? What will happen in the background? What will/should you see?
  - The evaluation criteria: What should the audience watch specifically (e.g. benefits of different data formats)? What is not within the focus of the experiment (e.g. symbols used) and therefore is not within the foreseen evaluation?
  - The scenario of experiment: What is the code of conduct? Who will guide through the experiment? When is it allowed to ask questions? When is the time for feedback? Shall everybody make notes during the experiment for later discussion?
  - The handling of tools and processes: sufficient user training and introduction to the executed processes has to be performed prior to the experiment execution.
  - The intended publication of results and dissemination activities related to the experimentation
- **Roles and tasks**: all participants (including the audience) must be assigned clear roles and tasks. This may range from specific tasks in the experiment (act as users) to a more generic role (provide feedback at the end).
- **Evaluation**: it is recommended to prepare a number of evaluation steps, including
  - Hot wash-up: short discussion immediately after the experiment.
  - Cold wash-up: discussion after a few weeks in order to consider carefully all relevant aspects which emerged during the experiment.

[13] https://www.munichre.com/en/reinsurance/business/non-life/natcatservice/index.html [18] http://www.swissre.com/clients/client_tools/about_catnet.html
[14] http://www.desinventar.org

- Moderated discussions: longer, moderated discussions organized along the expected outcomes and following the evaluation criteria.

Moreover, the evaluation should be as structured as possible, namely using specific evaluation sheets in order to collect only important data.

4.5 Interpret evidence

After the experiment, the gathered data must be analysed and interpreted according to a predefined method. This is done for each task, and for the experiment as a whole. Qualitative and quantitative data is interpreted in the light of the goals and outcomes set out at the start.

Three dimensions must be included:

- Analyse evidence and results for experiment. Analyses will be executed after the experiment according to evaluation approach. A timeline for the analysis and production of an associated report must be well defined.
- Analyse effectiveness of experiment set-up
- Analyse effectiveness from dissemination and sustainable impact perspective.

4.6 Draw conclusions (defined lessons learned and way forward)

One of the most important parts of the experiment design is to draw meaningful conclusions. These conclusions are mainly related to the research questions defined at the onset, but may and should include results of relevance for the European Civil Protection system as a whole.

The conclusions must at least cover:

- The goals for next experiment. Learning from the experiment, new goals must be suggested for the next iteration, or for the next level of complexity. Ideally, these conclusions are discussed with the responsible for the next experiment.
- Identify gaps and solutions. Given the results of the experiment, conclusions must be drawn on the next steps for development and for design of forthcoming experiments.

Identify gaps and solutions for developing EU Crisis Management capabilities. Conclusions should be formulated in a way that they are useful for the Civil Protection system as a whole: they should identify the most useful mechanisms for addressing the identified gaps, including a need for fundamental research, Platform development, industry R&D, creating markets, legislative changes and other mechanisms.

As specified above, this frame of reference is, at this stage, generic but it will be refined during the activities of the network.

5 Conclusions: the ENCML in the context of the DRMKC

In this report we explored the revisited concept of Network of European Facilities by drawing attention to the rationale behind the network, the structure and experimental methodology to carry out experiments. The initiative of the ENCML should be positioned in the context of the DRMKC as it contributes to its main pillars. Specifically:

- The ENCML contributes to partnerships as it establishes a formal structure to initiate a network of laboratories with the aim of strengthen collaboration and sharing knowledge,
- The ENCML contributes also to knowledge as it suggests pragmatic methods that can be used to plan, conduct and evaluate experiments in the field of crisis management. The experimental approach outlined in chapter 4 will be used to test innovative solutions with the partners of the network,
- The ENCML contributes to innovation as it has as at its core the assessment of technology through different types of activities which range from technological workshops to ICT experiments.

In 2017 the network will also develop a roadmap of activities which aims at focusing mainly – but not exclusively - on innovation

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List of abbreviations and definitions

CM Crisis Management

DRIVER Driving Innovation in Crisis Management for European Resilience

DRMKC Disaster Risk Management Knowledge Centre

ENCML European Network of Crisis Management Laboratories

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Contents

Foreword

This policy report deals with the revisted concept of the Network of European Facilities, established at the European Crisis Management Laboratories, Joint Research Centre, Ispra (Italy). It focused both on the overall rationale behind the network and the requirements for partners to join. Moreover, in the conclusions the report contextualized the activities of the network in the context of the Disaster Risk Management Knowledge Centre (DRMKC).

Executive summary

This report focuses on the Network of European Facilities by looking at four main dimensions:

- The European landscape of partnerships, networks of platforms in order to position the initiative in an already existing background
- The structure of the network and minimum requirements for partners to join
- An experimental approach that can be used in carrying out experiments within the network
- How the network contributes to the DRMKC

Policy context

European policies give specific emphasis to the importance of building on existing knowledge at all stages of the disaster risk management cycle. The European Network of Crisis Management Laboratories (ENCML) responds to the need of capitalising on existing capabilities to enhance collaboration, share knowledge and plan activities that can be of interest to crisis centres. The policy context consists of the Union Civil Protection Mechanism which underlines the importance of, inter alia, knowledge, methodology and good practices as well highlights the central role of synergies across partnerships and networks for improving coordination efforts.

Key conclusions

The network contributes to all the three main pillars of the DRMKC as it deals with:

- Partnership, through the establishment of a formal structure to initiate collaboration between several entities
- Knowledge, through a) knowledge sharing among partners b) contributing to knowledge by suggesting an agile experimental approach to be used in the field of crisis management
- Innovation, through ad hoc activities, for instance testing new solutions in distributed experiments.

Related and future JRC work

The activities of the network will continue in the next few years by developing a roadmap of activities for partners and by planning technical workshops at the European Crisis Management Laboratory.

1 Introduction

The Network of European research and testing facilities stems from the preparatory activities carried out at European Crisis Management Laboratories (ECML) of the Joint Research Centre, Ispra. As outlined in the policy report published in 2015, 7 ECML technology workshops which took place between March 2012 and October 2016 drew attention to a specific set of needs and paved the ground for the establishment of European Network of Crisis Management Laboratories (ENCML). In particular, the following needs emerged from the outcomes of the workshops:

- The need for developing a dedicated community that plans activities (e.g. exercises) relevant for crisis coordination centres on a regular basis;
- The need for collaboration and information sharing on best practices and lessons learned with regards to innovative solutions in crisis management;
- The increasing need for interoperability (technical, semantic or organizational);
- The need for pooling together academia, industry and end-users to drive the process of continuous improvement of technology supporting crisis management and disaster relief.

The ENCML, which is a part of the activities of the Disaster Risk Management Knowledge Centre (DRMKC) aims at addressing these needs through a well-defined structure that has been reconsidered in the course of last year. The structure has been reassessed in order to provide a more formal organization drawing on the so-called *technical*, *human*, *organizational* and *regulatory* approach (THOR) that partners of the network must have to participate in the activities. Furthermore, one of the needs mentioned above (facilitating experiments or exercises relevant for crisis coordination centres) has been more clearly identified.

In this policy report we focus on three main dimensions which contribute to define:

1. The position of the network in the context of existing European initiatives (chapter 2)
2. The revisited organisational structure of the ENCML (chapter 3)
3. An experimental approach to experiments in crisis management that can be helpful to plan and execute different types of activities (chapter 4)
4. How the ENCML will feed into the activities of the DRMKC (Conclusions)

In the document we often refer to the Driving Innovation in Crisis Management for European Resilience (DRIVER), FP7 project. This is due to the fact the project contributes to specify the requirements needed to join the network.

2 Background

There are many initiatives in Europe that bring together researchers, practitioners and other stakeholders for different purposes. While a comprehensive overview of existing platforms and networks is outside the scope of this report, in the following pages the main initiatives will be mentioned to contextualise the position of the ENCML in an already existing and rich landscape.

Active networks of scientists and policy makers have been identified by the Disaster Risk Management Knowledge Centre[1]. Some of these networks or scientific partnerships have operative mandates, for instance Global Disasters Alerts and Coordination System (GDACS) that estimates the impact of natural disasters and provides alerts after major disasters, or European Flood Awareness System (EFAS) which monitors and forecasts floods across Europe. GDACS was conceived as a cooperation framework between the United Nations and the European Commission in 2004 and it is considered, along with similar initiatives, as a *scientific partnership* to "improve the science-policy interface in prevention activities" (e.g. the identification of gaps and improvement of methodology). Additionally, groups of experts have been identified which are *de fact*o networks like the EU Disaster Prevention Expert Group led by DG ECHO that works on national risk assessment and supports the development of an overview of risks and risk assessment methodology[2]. The above-mentioned cooperation frameworks and experts' groups aim at mitigating the impact of disasters through clusters or science-policy interface partnerships focused on, *inter alia*, information exchange or operational preparedness. Another good example is the EU Loss and Damage Expert Group led by JRC. Representatives of the Member States work alongside international experts in workshops (e.g. the series of the EU loss data workshops) to build and expand a network of professionals "willing to participate in the process of the development of the European disaster loss guidelines" (De Groeve et.al. 2014: 13). Preparedness, prevention, information exchange and policy impact are key elements in these kind of initiatives.

Furthermore, there are networks which pool different stakeholders (e.g. innovation R&D managers, first responders etc.), like the European First Responder Innovation Managers Platform (EFRIM) that is an informal multi-disciplinary network dealing with strategic, tactical and operational challenges of European first responders[3]. Or The International Emergency Management Society (TIEMS)[4], a global forum for education, training, certification and policy in Emergency and Disaster Management. There are also ad hoc first-responders networks, like the International Association of Fire and Rescue Service (CITF) which is one of the largest network in Europe that provides world fire statistics by publishing annual reports.

The initiative of the Office for the Coordination of Humanitarian Affairs (OCHA) is also worth mentioning here as it relates to activities relevant to crisis centres. It entails the creation of a community of practice for crisis centres and minimum interoperability standards to allow timely and qualitative information exchange among them. The community of practice was one of outcomes of a workshop organized by OCHA and carried out in Geneva in 2015 on minimum interoperability standards for regional and national crisis centres[5]. One of the recommendations was in fact the creation of a community in order to identify and develop solutions for interoperability, building on collective knowledge and best practices. This

[1] http://drmkc.jrc.ec.europa.eu/partnership/Scientific-Partnerships
[2] http://drmkc.jrc.ec.europa.eu/partnership/Science-Policy-Interface
[3] https://efrim.org
[4] http://tiems.info
[5] The JRC was among the participants of the workshop.

initiative goes hand-in-hand with the Crisis Centre Network. Crisis centre collaboration was tested during the TRIPLEX exercise[6] (September 2016). In the evaluation of TRIPLEX, it was agreed that crisis centres will meet at the Humanitarian Networks Partnership Week in Geneva (NHPW 6-10 February 2017)[7] as "Crisis Centres Network" to explore further collaboration in the community of practice.

In addition to the above-mentioned partnerships, networks and communities, there are also *ad hoc* networks such as the Europe’s New Training Initiative for Civilian Crisis Management (ENTRi) or the Academic network for Disaster Resilience to Optimise educational development which deal with capacity building, awareness raising, innovation and knowledge. There are also many universities and research centres that have a number of activities which range from disaster preparedness to multi-risk assessment (e.g. Lund University, University of Portsmouth, Copenhagen Center for Disaster Research). These centres are well known and are certainly involved in wide European and non-European networks.

As far as European platforms are concerned, they mainly belong to National or Regional fire fighters training schools. Some examples are provided in the table below:

Table 1- Main European Platforms

Country	Owner	Focus
England	London Fire Brigades (LFB)	Any kind of incidents
France	SDIS13	Forest Fire/Incident Command
France	ECASC	Forest Fire, Flood, Chemical Risk, Search and Rescue, Incident Command
France	ENSOP	Chemical Risk, Urban fire
France	BMPM	Forest and urban fire
Germany	Frankfurt Fire & Rescue Training Center (FRTC)	Urban fires, road traffic accidents, tunnel incidents and chemical incidents
Italy	ISA – Istituto Superiore Antincendi	Forest and urban fire
Portugal	Centro Ciencia Viva (CCV)	Forest Fire
Portugal	Escola National Bomberos	Forest Fire
Sweden	MSB	Any kind of incidents

[6] TRIPLEX is a large scale field simulation exercise focused on strengthening preparedness and response.
[7] https://vosocc.unocha.org/GetFile.aspx?xml=4108dcjy_l1.html&tid=4108&laid=1

Furthermore, in the project DRIVER there are also other important platforms such as the City of the Hague, which is an operational crisis management organization included in an extensive network at Den Haag Safety Region the Security and Aerospace actors for the Future of the Earth (Safecluster) in France focused on security issues.

Platforms can also be privately owned. For example, during the EU large-scale crisis management exercise SEQUANA, carried out in France in March 2016, one of players involved in the exercise (Orange Company) hosted a platform, after an agreement signed with the Paris Police Prefecture who was in charge of the exercise. The platform, used for communication purposes and exchange of information during the exercise, is still on going and maintained by Orange.

Sometimes platforms are developed within EU-funded projects. This is the case of, *inter alia*, ReDIRNET (Emergency Responders Data Interoperability Network)[8] which offers public safety agencies the ability to interconnect their communication infrastructures and systems free of charge via a gateway. The project will ultimately provide a common platform for safety agencies.

The ENCML aims to establish a fruitful dialogue with already existing communities, working groups and networks. For instance, potential collaboration has been explored (and it will be further explored at the Network Humanitarian Partnership week in February 2017) with the community of practice for crisis centres. In doing so, potential overlaps will be avoided and cross network synergies are likely to emerge.

The Network of European facilities plans to act as a hub for major European platforms. In doing so it aims at pooling and sharing existing capabilities and resources with the objective of facilitating and hosting a set of activities (e.g. distributed trials, workshops etc.). In the chapter 3 we turn to describe a minimum set of requirements needed to initiate the network. As mentioned in the Introduction, the overall rationale and the structure behind the network have been revisited and this has also had an impact on requirements for partners to join.

[8] http://www.redirnet.eu/

3 Requirements for the establishment of the ENCML

While the ENCML is an informal network, some minimum requirements must be identified and agreed upon to initiate it. In this chapter, we suggest a distinction between minimum requirements for the structure of the network and requirements for single partners to join. At this stage, the set of requisites cannot be comprehensive. Some intermediate stages, as explained below, are needed before expanding the ENCML.

To initiate a network of facilities, a coupled core group of platforms must draft the mandate of the and agree on roles and responsibilities of the nodes. The minimum requirement to establish the ENCML consists of the first building block of the organizational structure: two platforms or "core partners" that will then coordinate other "associated" partners. The core group consists of the Joint Research Centre (JRC) and another platform. To select the second core partner, we use the so-called technical, human, organisational and regulatory approach, the so-called THOR. While this approach was developed and applied in another domain (cyber security),[9] the four dimensions of the THOR concept are helpful here to assess whether:

1. The platform has the *technical* and the *physical* capability to facilitate and host different kind of activities, such as distributed exercises. Interdependent activities carried out at multiple locations within the same timeframe and the same virtual environment will constitute the backbone of an *ad hoc* roadmap. Therefore, the following general technical requirements must be met by core partners:

   An open, scalable and flexible architecture which allows the incorporation of real-world and simulated data within a training or decision support system. The platform must provide an environment where solutions can be tested through appropriate means e.g. the inputs foreseen by the scenario designed for the exercise. In order to provide the required assessment information, the platform should be observable (e.g. it should provide specific outputs about its internal processes) and able to collect the outputs of the solution tested. E.g. The performance of a virtual machine hosted in a virtual machine hosting environment can be measured in terms of disk accesses, network throughput, central processing unit and memory usage. A human-machine Interaction capture software should also be used in order to evaluate the quality and the effectiveness of the user interfaces.

   Live and virtual CM laboratories that enable people and equipment to interact with models, simulations and visualizations. The environment provided by the platform must therefore be close enough to real implementations to provide the users with a realistic environment. If possible, a real timeline should be followed; in specific cases the laboratory should also be able to compress it and follow the scenarios at an accelerated pace. This will allow following the complete evolution of complex situations (like huge bad weather events) in a reasonable amount of time.

   High-speed and reliable Internet with virtual private network (VPN) possibility. In interdependent activities a large amount of data may have to flow freely and securely. A reliable and safe network connection is anyway a basic requirement for a real crisis management facility: its simulations must provide it as

[9] The THOR concept was developed in the CAMINO FP& project (Comprehensive Approach to cyber roadmap coordination and development). More information is available here: http://www.fp7-camino.eu/

well. If possible, the reliability of the connection should be tested with tools like iperf[10] and ttcp[11], and it should be monitored during exercise using tools like prtg[12].

Time synchronization. Many of the key functions of the organization during an exercise are dependent on time synchronization: control of the activities, distributed simulations and data collected for analysis. A Network Time Protocol (like NTP)[13] must be available to synchronize all sites and computers in distributed trials. Lessons learned suggest to register all time reference in Universal Time Coordinates (UTC), i.e. Greenwich Mean Time with no Daylight Saving Time shift, in order to ease the comparison tasks.

Access to collaborative systems such as file share, wiki, teleconferences, collaborative work spaces, chat tools, email lists, telephone lists are advisable.

High levels of interoperability, in terms of standard formats and protocols. Data should in fact be processed, understood and shared by core partners. In this context, interoperability is intended in a broad sense, including syntactical and semantic features. Interoperability entails the adoption of common and well-established data formats (e.g. GIS formats like ESRI shape files or Google KML, alert formats like CAP) and standard communication protocols; but it involves also the use of easily recognizable pictograms, like standard icon sets from UN-OCHA.

Furthermore, the platform must have a physical infrastructure which includes laboratories and/or crisis rooms to carry out exercises as well as conference rooms to host meetings.

2. The platform has the *organizational* structure and the *human capital* (people and competences) to plan, execute and evaluate exercises. Depending on the size and the complexity of the activities as well as their format, different organizational set up may be necessary. However, the organizational structure should be flexible enough to support the implementation of different activities (e.g. trials, workshops) and to allocate human resources in the actual execution of the activities. For instance, there are some key functions, or roles, to be fulfilled for the execution of exercises, like the coordination of the overall activity which requires an "exercise manager" and an "exercise execution manager" who will be responsible for, *inter alia*, adjusting the type and the intensity of the events in a given scenario, collecting evaluation data etc. While technical skills are crucial, other aspects are also important and include capacity building to expand the network and more general organizational skills. The organizational structure of core partners must allow the full integration in the ENCML through the active involvement in community building activities, such as workshops, and the involvement in the maintenance of the ENCML capabilities (e.g. the development of a portfolio of scenarios).

3. The platform does not have regulatory constraints or administrative barriers which may limit cooperation with other organizations (e.g. regulatory constraints on data sharing).

[10] iperf – a free cross-platform tool to measure performance in TCP/UDP (https://iperf.fr/)

[11] ttcp – a tool to measure performance in TCP/UDP, preinstalled on CISCO routers (https://en.wikipedia.org/wiki/Ttcp)

[12] prtg - sensors are installed on different nodes in the network that continuously measure performance (https://www.paessler.com/prtg)

[13] NTP - http://www.ntp.org/

In addition to this first set of THOR requirements, core partners must define the needs to be addressed from the onset. Needs assessment of emergency response centers, for instance, constitutes in itself a requirement for the core group. Without assessing the needs, the network cannot be initiated as it would lack the knowledge to invite other partners/laboratories that may address, better than others, specific technical gaps.

Non-core partners are defined as "associated". The main difference between core and associated partners lies in the responsibility and in the level of engagement within the network. While core partners will set up both the network and the governance (e.g. mandate and governance procedures) and they will also provide the physical infrastructure to host a wide range of activities, associated partners will provide support to plan, host and evaluate the activities. For instance, associated platforms can provide support in designing scenarios, in evaluating exercises or selecting solutions to be discussed at workshops. Their hosting facilities can also be used to organize the meeting of the network. Additionally, associated partners will be also involved in developing a roadmap of activities. However, they will not be directly involved in the governance of the ENCML. Nevertheless, the network will rely on both a top-down and a bottom-up approach. If core partners will be ultimately responsible for initiating and maintaining the ENCML, they will also have to ensure platforms' collaboration through mutual learning mechanisms, such as sharing lessons learned and facilitating best practices. Sharing lessons learned, for instance, will be done in the ENCML through the improvement of the use and uptake of the outcomes of exercises.

The facilitation of best practices will be horizontal, meaning that all nodes will exchange knowledge and information through co-coordination dynamics (e.g. each associated partner will host a virtual meeting within the ENCML to share lessons learned after an activity). Core partners will make sure that lessons learned will be taken into account.

The last requirement deals with the organization of a workshop planned by core partners. Associated and core partners will participate in the first ENCML event in order to discuss:

- The mandate and the role of the network in the context of the DRMKC;
- The overall governance;
- Identified needs and recruitment strategies;
- The level of engagement of associated partners as well as security constraints, schedule and availability of platform personnel;
- Strategies for collaboration within the network.

This workshop will result in the consolidation of the structure and the objectives of the network. The output of the event will be a document focused on the mandate, the roles of associated partners as well as guidelines for interaction and information sharing.

We now turn to describe minimum requirements for other partners, namely organisations not involved as core or as associated, to join the ENCML. As mentioned at the beginning of this chapter, requirements for external organizations cannot be comprehensive at this stage. However, we can outline a few general conditions. Interested organisations should express their interest through a letter of intent. The ENCML is open to different kind of stakeholders, from first responders to research centres, who declare a genuine interest in the network. Despite being of informal nature, interested stakeholders are expected to declare their intent to join the network and to participate in the activities and/or be informed of the outcomes of the activities. The level of engagement of external entities will depend on their expertise and on the actual interest in the network. It can be foreseen that some organizations would be willing on participating in distributed exercises (e.g. national or regional training schools), while some others would be willing on developing the roadmap of activities without taking part in simulation exercises. Some others will participate only in workshops. Either way is feasible but the role of additional nodes should be clearly defined through, *inter alia*, a letter of intent. In the letter the following points must be addressed:

1. type of organization and short description;
2. expression of interest in the ENCML;
3. type of involvement in the network.

On a general level, technical, human, organizational and regulatory aspects should also be taken into account. For the participation in interdependent activities, for instance, depending on the size and the complexity of the activity as well as its format, different organizational set ups may be necessary for planning, execution and evaluation.

A few functions (or roles) and subsequent requirements that would be necessary to effectively plan and execute distributed exercises are:

- from the overall experiment management perspective, ICT competence is a minimum requirement and ICT technicians should be assigned to help the actual execution of the exercise. To create the initial experiment plan collaboratively, some ad hoc exercise management system tool should be used (e.g. Exonaut[14]). In the absence of specific tools, Gantt charts, combined with a wiki or file share, must be made available.

- The experiment execution management handles the detailed planning of the experiment, execution of that plan, know what data to collect, collect the data and perform data analysis of the collected data. To be able to do this efficiently, methods and tools to support these activities are needed. Examples of software and methods are F-REX (Anderson 2009), PROCeed[15]. Additionally, an aggregated E-COP (Experiment Common Operational Picture) may be needed. This aggregated E-COP may be shared in simple form using collaborative work spaces which may put a big strain on people to update it. On the other hand, using automatic E-COPs fed from simulation control may be less flexible and expensive. Elements of Experiment execution management need a detailed E-COP to be able to control the experiment in more detail. Elements of the Experiment execution management needs to be able to contribute the simulated state to the common operational picture of the experiment, manually or automatically.

  Additionally, tools to support common formats are needed, such as OGC (Open Geospatial Consortium), WMS (Web Map Service), CAP (Common Alerting Protocols) and KML (Keyhole Markup Language).

[14] https://www.4cstrategies.com/exonaut-products/training-and-exercise-manager#.WDhJto-cFaQ
[15] PROCeed – tool by ITTI, described in D22.21

- From the organizational point of view, external stakeholders must allocate human resources in the preparation of the exercise or during the activity, if needed. The same holds true for the preparation of technical workshops.

For other activities, such as participation in ENCML online meetings or teleconferences, robust communication channels as well as specific communication features are needed (e.g. video-conference, real-time transfer, wireless local area network – WLAN -).

In chapter 4 we describe an experimental approach to experiments in crisis management. If, on the one hand, we acknowledge that the network of European facilities has not the primary objective of carrying out only experiments, on the other we aim at filling a current gap in the field crisis management. Research and literature on how to test new solutions and concepts using a common frame of reference (from planning to execution) are in fact fragmented. In the following pages, drawing on the Concept Development and Experimentation approach (CD&E), we suggest an agile 6-step approach that can also be useful when organizing distributed experiments in the ENCML. At this stage, the approach is generic enough to be adapted to different kind of activities. It will be refined during the activities planned within the network with the aim of contributing to one of the key pillars of the DRMKC, namely innovation. In the context of the DRMKC, innovation is closely linked to the idea of a European test-bed for crisis management technologies where tools and services for designing, running and evaluating experiments are considered as an integral part of the test-bed. Chapter 4 constitutes the first "building block" of the frame of reference mentioned above.

4 An experimental approach to experiments in crisis management

The term experiment used in this chapter draws on the Concept Development and Experimentation approach (CD&E). In the CD&E the implications of experimentation seem of particular relevance to the field of crisis management. It is worth considering that, in the military field and more specifically in the US Department of Defence, different types of experiments have proliferated to improve defence capabilities and to assess new *solutions* (from new ideas to technology). In the Code of Best Practice of Experimentation (2002), experiments are divided into discovery, demonstration and hypothesis testing. Discovery experiments involve introducing new "systems, concepts, organizational structures, technologies or other elements to a setting where their use can be observed and catalogued" to identify potential benefits (2002: 19-20]. In demonstration experiments, technologies are used to show how they can be employed effectively in given conditions (e.g. in a given scenario). While hypothesis testing is used to test theories or observable hypothesis derived from such theories 2002: 22). The formulation of these three types of experiments needs to be designed around issues of traditional research methodology, such as the articulation of hypothesis and the nature of variables, the sample size etc.

In the CD&E framework, "new solutions and ideas are iteratively tested (multiple scenarios, interoperability etc.) by a series of controlled experiments addressing different research questions. Results […] are then used to further develop the concept, which is again followed by an experimentation phase, until operational capability is reached. Concepts can also be rejected, if it turns out that they do not provide added value or are not cost-efficient".

This framework is also characterised by, *inter alia*, a) the identification and description of capability gaps, b) a systematic analysis of solutions that might fill these gaps and, c) the participation of stakeholders who are carefully selected in order to exploit expertise. Hence this approach is of particular relevance for the aims of the ENCML and can be helpful in planning a roadmap of activities based on:

- The identification of capability gaps of specific stakeholders
- The systematic analysis and testing of technical solutions which may fill these gaps and serve as basis for planning ad hoc activities with the partners of the partners of the network.

In particular, demonstration experiments may be considered in the ENCML, specifically when new technologies or solutions are tested to assess their real added value or applicability. These experiments can in fact enable practitioners to learn more about their potential to really improve crisis management operations.

Currently, there is no standardized approach to experimentation in crisis and emergency management. Instead, the most common method used in this field refers to comprehensive exercises carried out at different levels (e.g. tactical, strategic etc.). We suggest using an experimental methodology which relies on a six-step approach which goes from the formulation of research questions to drawing conclusions:

4.1 Research Questions

Before starting anything else, the goals of the experiment and/or research questions must be identified. When testing new solutions, some typical goals may include:

- Test functioning and features of a single technology: Can a task be performed (e.g. is it possible to collect relevant static and dynamic information)? Does the tool contribute to the function it is supposed to contribute to?
- Test a particular configuration of technologies (interoperability, benchmarking): are technologies working seamlessly with other tools to provide a given function or in conjunction with other functions (and tools therein) at system of systems level?
- Test effectiveness of (configuration of) technology in a given setting (for a particular user group or in a given cooperation scenario): are tasks performed faster and/or better? Does the tool facilitate crisis mangers?
- Test functioning and features of a single concept or functionality (part of an existing technical solution): can a task be performed faster and/or better?
- Test effectiveness of an organizational / procedural approach: are tasks performed faster and/or better?
- Networking and awareness / creation of market: are mature technologies of interest to a certain user group that is currently not using them? What is the maturity level of the technologies tested?
- Evaluate cost-benefit of solutions / approaches: are certain technologies / approaches a good investment option for an organization (operational benefit in relation to life-cycle costs)?

It is worth noting that goals and questions depends on the methodology used and on the solutions tested. Furthermore, in order to develop accurate questions, it is crucial to take into account the tradition of work that already exists on a subject. For instance, it is worth exploring:

- previous lessons learned (what has been done already? What were the results? What did work, and what did not? Why was that?)
- Reports or other relevant documents on experiments of similar nature,
- Findings of previous research projects which have identified gaps (e.g. ACRIMAS) and/or the need to explore specific areas.

If results of previous experiments are used, it must be clearly explained which results are taken into account, why and which not.

Experiments are not stand-alone activities. They are typically preceded by an idea that is worked out in the Concept Development phase of the experimentation campaign cycle. A "conceptual model" should be defined. The conceptual model is a mechanism for the communication of the problem space among stakeholders in the experiment. It is a (conceptual) model of the system of interest that is under experimentation. For example, the model shows the CM organization, roles, responsibilities, activities performed, C2 systems used. The model shows where new concepts are introduced that are subjected to an experiment. E.g. an adapted organization to improve efficiency, or new C2 systems to improve situational awareness.

The creation of an initial experimentation plan must include:

1) A clear formulation of goals and research questions;
2) An overall e methodology must be decided to gather evidence to address these questions;
3) A list of expected outcomes (break-down of goal in different outcomes in terms of technology, user groups etc);
4) Definition of criteria for success of the experiment.

Secondly, experiments will be designed differently depending on which level of crisis management is addressed. Experiment objectives must address expected outcomes, and tasks and metrics must be designed appropriately. The initial methodology considers the following levels:

- Technological test device or software (e.g. experiment).
- Operational: improve operations in the field (e.g. observational study).
- Tactical: improve situation awareness, command and control; improve decision making (e.g. quasi-experiment).
- Strategic: guide investments in innovation; improve preparedness, capabilities, etc. (e.g. workshops).
- Systemic: influence Civil Protection system in a MS and in the EU.

A third element to consider is the level of complexity and realism needed in the experiment. A key component of experimentation is the controlled setting. In order to produce relevant results, the environment may have to be controlled (e.g. fixing variables to provide, for instance, level playing field) or realistic (e.g. allow or encourage random events). Some examples of different levels of complexity include:

- Single device.
- Single technology in controlled environment (e.g. comparison of mobile devices).
- Range of connected technologies in controlled environment (e.g. information exchange between field and HQ).
- Exercise in realistic environment.
- Human-computer interaction in lab (short experiment).
- Human-computer interaction in lab (experiment over days or weeks).
- Human-computer interaction in exercise (many participants).
- Human-computer interaction, combined with technology testing, in large scale exercise.
- Large scale exercise combining all

Also, at highest complexity level it has to be taken into consideration that crisis management functions, solutions or capabilities have to be experimented in various (cross-border) configurations reflecting the operational reality of EU crisis management cross-border operations.

4.2 Select participants

Once the methods and goals are defined, the participants needed to complete the experiment successfully must be selected. While at the early stage it is not necessary to identify individual participants, the various groups must be defined from the beginning. Typically, the groups include:

- Technology providers / Process providers: what will be experimented with.
- Scientists: provide input / feedback / learn on R&D issues / methodological support.
- Facilitators: help experimenters to carry out the activities.
- Industry: provide input / feedback / learn on innovation, existing solutions, bringing to market.
- Crisis management practitioners: execute the experiment / evaluate the experiment
- External observers: observe the experiment without being directly involved.

The selection of participants must cover all roles that are needed for the experiment:

- **Experiment lead**: makes the final decisions in the preparation and execution of the experiment; coordinates the contributions of the participating partners; assures the readiness for the experiment execution, controls the experiment execution, gives instructions and provides input; data monitors the schedule and the adherence to the script.
- **Facilitators**: organizational support and guidance during the preparation and execution of the experiments; take records of the experiment and collect feedback of the participants.
- **Technical supporters**: prepare the technical conditions and the input data; pre-test the experiment configuration; tackle technical problems prior and during experiment execution; archiving of the tested configuration and the data.
- **Process supporters**: professional experts, supporting the experiments from functional point of view provides input to the scenario script in order to keep it realistic and significant.
- **Coaches**: provide appropriate training on the used tools and processes prior the experiment introduce the experiment performers to the exercise scenario support them in case of ambiguity or confusion
- **Experiment performers**: play their role according to the script bring-in their professional experience give feedback in questionnaires and free statements.
- **Evaluators**: control the alignment of the experiment set-up and execution with the pre-defined goals; observe the experiment from a neutral perspective act as conciliator in case of disagreements summarize the feedback and metrics evaluate the results of the experiment.

For each role, the expected outcomes of the experiments must be specified. Expectation management is critical to keep participants engaged in future experiments. Realistic and clear outcomes must be defined for each group of participants in advance.

4.3 Prepare experiment

Experiment preparation takes at least 6 months, but will usually take longer for more complex experiments. Because it is a complex and lengthy process, each experiment will be designed differently, focusing on issues important for the particular goals, expected outcomes and participants.

At least the following steps are mandatory:

- Calendar of actions. The calendar must include the period before, during and after the actual experiment. It includes all phases, including scenario building meetings, experiment dates, evaluation period, and report drafting.
- Agenda setting. The agenda of the experiment is primarily focused on expectation management of the participants. It must include: (1) programme of activities, (2) role of participants, (3) expected outcomes for participant groups, (4) introduction of experiment goal, and (5) follow-up process and expected date of experiment conclusions.
- Tasks to be completed in experiment. In light of the goal and expected outcomes, specific tasks must be designed that will produce evidence to prove or disprove them.

In many cases, test data will be generated or distributed during the experiment. This may include simulations (e.g. flood simulations), injects (e.g. event happening or information available at predefined times) or base data (e.g. critical infrastructure locations). It is essential that the simulated environment is well tested before and is not a source of failure.

In the case the experiment involves the use of a scenario, it may be necessary to draw on past disasters data which can guide the creation of evidenced-based scenarios. The following databases may be considered when dealing with loss past disasters, in particular with lost data (De Groeve et.al. 2013):

1. EM-DAT[16], maintained by CRED, the Centre for Research on the Epidemiology of Disasters (Louvain University, Belgium) which is the first public available database on disasters at national resolution. Loss accounting was initiated in 1988 to provide information for humanitarian actions;
2. NatCat SERVICE (Munich RE)[17] and
3. Sigma CatNet Service (Swiss RE)[18]. Both 2 and 3 are global databases with no public access. They are maintained by the two largest re-insurers in the world (Munich RE and Swiss RE) and are mainly used to perform trend analysis.

[16] http://www.emdat.be/databae
[17] https://www.munichre.com/en/reinsurance/business/non-life/natcatservice/index.html
[18] http://www.swissre.com/clients/client_tools/about_catnet.html

4. DesInventar (la Red)[19] which is a national-based accounting system implemented in a large number of countries. It is becoming a global open source depository of national databases. It is worth mentioning that UNPD and UNISDR sponsored the implementation of DesInventar in Latin American, Asia and Africa to archive the loss data of historical events (human loss, physical damage and economic loss) and collect relevant data of emergent situations.

4.4 Running the experiment

During the experiment, the following steps are required:

- **Introduction**: all operative participants to the experiment must be made aware of the purpose, objectives and steps of the experiment, as well as the expected outcomes and evaluation methods. This should include:
    - A description of the context and the basic setup: What is the scenario about? What will happen in the background? What will/should you see?
    - The evaluation criteria: What should the audience watch specifically (e.g. benefits of different data formats)? What is not within the focus of the experiment (e.g. symbols used) and therefore is not within the foreseen evaluation?
    - The scenario of experiment: What is the code of conduct? Who will guide through the experiment? When is it allowed to ask questions? When is the time for feedback? Shall everybody make notes during the experiment for later discussion?
    - The handling of tools and processes: sufficient user training and introduction to the executed processes has to be performed prior to the experiment execution.
    - The intended publication of results and dissemination activities related to the experimentation
- **Roles and tasks**: all participants (including the audience) must be assigned clear roles and tasks. This may range from specific tasks in the experiment (act as users) to a more generic role (provide feedback at the end).
- **Evaluation**: it is recommended to prepare a number of evaluation steps, including
    - Hot wash-up: short discussion immediately after the experiment.
    - Cold wash-up: discussion after a few weeks in order to consider carefully all relevant aspects which emerged during the experiment.
    - Moderated discussions: longer, moderated discussions organized along the expected outcomes and following the evaluation criteria.

Moreover, the evaluation should be as structured as possible, namely using specific evaluation sheets in order to collect only important data.

[19] http://www.desinventar.org

4.5 Interpret evidence

After the experiment, the gathered data must be analysed and interpreted according to a predefined method. This is done for each task, and for the experiment as a whole. Qualitative and quantitative data is interpreted in the light of the goals and outcomes set out at the start.

Three dimensions must be included:

- Analyse evidence and results for experiment. Analyses will be executed after the experiment according to evaluation approach. A timeline for the analysis and production of an associated report must be well defined.
- Analyse effectiveness of experiment set-up
- Analyse effectiveness from dissemination and sustainable impact perspective.

4.6 Draw conclusions (defined lessons learned and way forward)

One of the most important parts of the experiment design is to draw meaningful conclusions. These conclusions are mainly related to the research questions defined at the onset, but may and should include results of relevance for the European Civil Protection system as a whole.

The conclusions must at least cover:

- The goals for next experiment. Learning from the experiment, new goals must be suggested for the next iteration, or for the next level of complexity. Ideally, these conclusions are discussed with the responsible for the next experiment.
- Identify gaps and solutions. Given the results of the experiment, conclusions must be drawn on the next steps for development and for design of forthcoming experiments.

Identify gaps and solutions for developing EU Crisis Management capabilities. Conclusions should be formulated in a way that they are useful for the Civil Protection system as a whole: they should identify the most useful mechanisms for addressing the identified gaps, including a need for fundamental research, Platform development, industry R&D, creating markets, legislative changes and other mechanisms.

As specified above, this frame of reference is, at this stage, generic but it will be refined during the activities of the network.

5 Conclusions: the ENCML in the context of the DRMKC

In this report we explored the revisited concept of Network of European Facilities by drawing attention to the rationale behind the network, the structure and experimental methodology to carry out experiments. The initiative of the ENCML should be positioned in the context of the DRMKC as it contributes to its main pillars. Specifically:

- The ENCML contributes to partnerships as it establishes a formal structure to initiate a network of laboratories with the aim of strengthen collaboration and sharing knowledge,
- The ENCML contributes also to knowledge as it suggests pragmatic methods that can be used to plan, conduct and evaluate experiments in the field of crisis management. The experimental approach outlined in chapter 4 will be used to test innovative solutions with the partners of the network,
- The ENCML contributes to innovation as it has as at its core the assessment of technology through different types of activities which range from technological workshops to ICT experiments.

In 2017 the network will also develop a roadmap of activities which aims at focusing mainly – but not exclusively - on innovation

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De Groeve, T., Poljansek K., Ehrlich Daniele "Recording Disaster Losses: Recommendations for European Approach" 2014, Publications Office of the European Union.

List of abbreviations and definitions

CM Crisis Management

DRIVER Driving Innovation in Crisis Management for European Resilience

DRMKC Disaster Risk Management Knowledge Centre

ENCML European Network of Crisis Management Laboratories

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