The rise of regional programmes on critical infrastructure resilience: identification and assessment of current good practices

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Abstract

Effective Critical Infrastructure Protection and Resilience (CIP-R) depends on numerous stakeholders collaborating at different institutional and operational levels and exchanging information by means of a variety of channels. In this regard regional programmes or partnerships, have emerged as one of the key strategies to deal with CIP-R and Emergency Management (EM) issues effectively. Previous research has set the theoretical base of Public-Private Partnerships (PPP) and claimed their high potential for enhancing CIP-R that is vastly unexploited due to challenges in their establishment and management. It is now necessary to move forward to studying practical side of these programmes. MIRACLE (Multi-level Alignment of Regional Approaches to CI Resilience by Learning from Experience) is a research project funded by EC – DG HOME that aims at supporting regional CIP-R strategies in order to improve exiting capacities of the EU Member States to prevent, prepare and protect people against security related risks. This study presents a review of existing Good Practices (GPs), i.e. tools, technologies, activities and processes that are able to support: i) Establishment and management of regional PPPs for CIP-R; ii) Achievement of their main objectives and specific goals. The collected GPs are used to improve resilience levels in different phases of EM. GPs have been identified through an online survey, institutional websites, insights from professionals, available reports, documents and scientific literature. Finally, through engagement of international experts, professionals and researchers the GPs have been evaluated along three main parameters: implementation effort, transferability potential, type and relevance of expected benefits.
Keywords: critical infrastructure, resilience, good practices, regional, PPP.


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1 Introduction

To protect national infrastructure many public safety and other governmental agencies are establishing partnerships with private-sector organizations to assist in planning, resource allocation, communication strategy, and coordinated response to and strategic recovery following all types of hazards [1]. Regional programmes to Critical Infrastructure Protection and Resilience (CIP-R) aim to increase capacity to prevent, protect against, respond to, and recover from major incidents.

PPP models range from big cities, counties/provinces, regions, states/nations all the way to international. In the present study 'regional' is understood as the administrative scale but also as the coherent territory corresponding to a CI system extension.

The aim of the paper is to study existing regional CIP-R programmes and provide a state-of-the-practice analysis when it comes to successful practices in place. It presents a collection of good practices able to support implementation and functioning of regional CIP-R programmes. The practices were also evaluated by experts in the field, to assess their transferability, required effort and expected benefits. The main assumption behind the study is that, if regional CIP-R strategies are properly set and supported, they will allow addressing CIP-R issues at higher levels (e.g. national or continental). Thus, the present study wants to contribute to a better understanding of this emerging phenomenon towards its full alignment with existing CIP policies and strategies.

2 Definition of good practices and related research in the crisis management field

Good practices are generally defined as '*Commercial or professional procedures that are accepted or prescribed as being correct or most effective*' [2]. It is any collection of specific methods that when applied solve an existing problem, produce expected results and bring benefits. In our study it applies to available knowledge to addressing:

- Establishment and management of regional PPPs for Critical Infrastructure Protection and Resilience;
- The achievement of their main objectives and specific goals.

The rationale is to use a practice that have been effective in addressing similar issues in the past and apply it to a current problem. Still, more than often good practices (or 'best practices') offer insight into solutions that may or may not work for a given situation [3]. It can easily happen that a best practice is not applicable, is inappropriate for a particular case or just does not work well as in the original use. Ambler [4] offers an alternative view, 'contextual practice', in which the notion of what is 'best' will vary with the context. Not only the best practice often has to be adjusted for the new application but it can also evolve into its better version as improvements are discovered. Our work is a 'Good Practice' (GP) collection focus is on successful *Activities*, *Procedures*, *Tools*, and *Technologies*.

The study of principles and good practices for public-private collaborations in the crisis management and resilience areas is not new. PADRES (**P**ublicly **A**ccessible, **D**edicated, **R**esourced, **E**ngaged, **S**ustainable) model lays out the set of essential attributes to assess/measure 'state-of-practice' of PPPs in EM [5]. The PADRES model has subsequently been used then to evaluate maturity levels and capabilities of different PPP levels/sizes across the US.

ENISA's (The European Network and Information Security Agency) efforts in this field focus on trying to analyse, understand and promote the models of PPPs at national and pan European levels. In 2009, ENISA issued its *Good Practice Guide (GPG) on Information Sharing* aimed at assisting Member States and other relevant stakeholders in setting up and running Network Security Information Exchanges in their own countries. In 2011, ENISA's *Good Practice Guide* [6] classified PPPs for security and resilience and revealed the main five components addressing *Why*, *Who*, *How*, *What* and *When* questions associated with creating and maintaining PPPs. ENISA offers high-level recommendations to stakeholder on how to successfully build PPPs (for resilient IT security in their context).

BUCOPCI project's Business Continuity Best Practices Report [7] and Security Plan Best Practices Report [8] were based on responses of six CI Operators on Spanish territory. In those reports the project investigated the percentage of compliance to the *BCM* principles/standards [7] and level of compliance to the *Operational Security Management* among CI Operators [8].

RECIPE (Recommended Elements of Critical Infrastructure Protection for Policy Makers in Europe) Project's *Good Practice Manual on CIP Policies* [9] brings a set of GPs for covering areas of interest in CIP policies. Those include Identification of CI, Dependencies, PPPs, Information Sharing, Risk Management and CIP, Crisis Management and CI. Three dimensions that have a strong influence on the attainability of a large part of the practices have been considered:

- Involvement of private parties;
- Mandated or voluntary co-operation structure;
- Required CIP maturity.

3 Study methodology

The primary source of data was the MIRACLE project online survey aimed to review the existing Public-Private collaboration schemes (applied to address CIP-R issues) and to characterise the main features and modes of collaboration for further assessment and gap analysis. The scope of the survey was much broader than the aim of identifying potential GPs. Leveraging on the 159 survey responses, we were able to identify active regional CIP-R programmes and collect additional information such as *references* – public documents, reports and web-presentations, and *direct contacts* of the people involved in existing regional programmes (Figure 1).

The secondary source of data was digging into scientific and professional literature and Institutional websites.

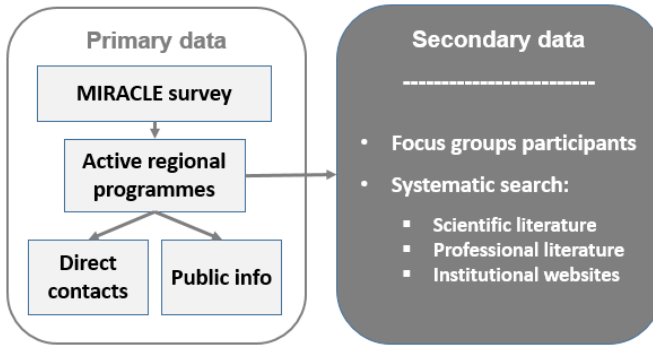

Figure 1: Data collection process.

More detailed information about identified GPs (both from the survey and from the secondary sources) were then collected through available public information or direct contact with people involved in these practices, mainly through focus groups and/or interviews. The final collection contains 21 Good Practices for which a summary, highlighting main characteristics, is given in Tables 2–3.

3.1 Identification and selection of GPs from the survey

When identifying GPs (and active regional programmes) from the survey answers, we adopted criteria according to the study scope. In the first place, we filtered organisations involved in CIP-R collaborative activities or a programme, resulting in 92 organisations out of the 122 mapped in the survey. The focus was on programmes with the objective of improving resilience and/or Emergency Management (EM) in general, in contrast to ones with other main goals (e.g. enhancing service quality); in this way, 76 organisations in 17 different regions were selected. Focusing on these collaboration clusters we further searched for the available information on partnerships and practices in use. In order for a practice to qualify as GP, an organisation must have reported benefits from its adoption in terms of improvement of CIP-R related performance. Organizations that achieved to establish information sharing and stakeholder collaboration process have a significant importance in contrast to the ones that had no success. Finally, we tried to ensure (as much as possible) the coverage of GPs applied in different contexts (i.e. Regional, County/Province, Metropolitan Area, and City) and across all the EM phases (Mitigation, Preparedness, Response and Recovery).

3.2 Secondary sources

Search for GPs was also conducted inside Critical Infrastructure Warning Information Network (CIWIN), which is an initiative of the Directorate-General for Home Affairs of the European Commission. The search included repositories

of National researches, FP6, FP7, CIPS and ISEC projects, their reports, deliverables and websites. Most of the developed tools focus on the technical aspects of communication/info-sharing and have not been embedded in a practical use (mostly in pilot tests of their functionality). These tools fall out of our scope since we are looking for practices that have been successfully used in practice and potentially transferable to another place. Another line of search for GPs included scientific and professional literature where we were able to find some related contributions. An overview of selected GPs is given in Section 4.

3.3 Validation by international experts

The GPs were assessed through engagement of a panel of international experts, professionals and researchers willing to perform as evaluators. They were provided with the full report on GPs and additional information was made available online. The online survey required approximately 15 min, after previous reading of the GPs collection. It assessed the GPs across three dimensions associated with a specific Likert scale, ranging from 1 to 5:

- **Benefits** brought by these Good Practices to the implementing organizations and to the PPP as a whole;
- **Effort** and knowledge required to implement the following Good Practices in an organization or PPP;
- Level of **Transferability** of these Good Practices across different organizations, PPPs and regions.

The responses were collected over one month, during November and December 2014, and the survey received 20 responses, 13 of which complete.

4 Classification and description of selected Good Practices

In context of CIs, resilience in general implies 'the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event' [10]. Comprehensive resilience considers all hazards, all EM phases, all stakeholders and all impacts relevant to disasters [1]. It requires capabilities to dynamically prevent, protect against, mitigate, respond to, and recover from the threats and hazards that pose the greatest risk. Enhancing resilience through improving Emergency Management requires a partnership among different levels of government and the private sector, detailed planning and co-operation among infrastructure sectors. EM is the discipline of avoiding and dealing with disasters in order to lessen their impact. [1]. A commonly used model of Comprehensive EM, firstly introduced by State Governors' Association in the US [11], encompasses four elements – mitigation (prevention), preparedness, response (coping) and recovery (aftermath). We have mapped GP contribution to resilience according to EM phases (Table 1).

Table 1: Classification of Good Practices and their evaluations.

		Location of expected improvements				Assessment		
		Preparedness	Mitigation	Response	Recovery	EFF	TRA	BEN
TOOLS & TECHNOLOGIES	DOMINO tool	P	P			3.67	4.00	3.14
	V-BEOC	P		P	P	3.40	3.17	2.57
	NWWARN	P	P	S	S	3.40	3.00	3.17
	COMBAS Ø			P	S	3.60	2.80	3.00
	SUSI	P		P	S	3.67	3.40	3.00
	NAF	P	S			3.83	3.60	2.57
	SATool	P	P	P	S	3.80	3.33	3.00
	LCMS	P	P	P	S	3.57	3.29	3.63
	EMERGEL	P	S	P	S	3.50	3.83	2.50
	GIS Mapping for CI Assets	S	P	P		4.00	4.00	3.50
	Traffic Scotland IS	P	P	P	P	3.50	3.29	3.22
	PRISM	P				3.60	3.33	3.13
ACTIVITIES & PROCESSES	Big Business – Small Business	P	S		P	3.40	3.17	2.86
	Blue Cascades	P	S	S	S	3.20	3.83	2.86
	MICC	P	S	S	S	3.40	3.33	3.38
	Operation Estrela	P		S	S	3.29	3.71	3.00
	CATEX	P		S	S	3.20	3.67	3.00
	Multi-State Fleet Response	P		S	S	3.40	2.67	3.14
	TTF	P	S	S		3.40	3.00	3.00
	Focus on Flows	P		S	S	3.40	3.00	2.43
	Partnership Alignment	P	S	S	S	3.71	3.43	3.22
					Average	3.52	3.37	3.02
					Standard deviation	0.21	0.37	0.31
					Max value	4.00	4.00	3.63
					Min value	3.20	2.67	2.43

P – Primary contribution
S – Secondary contribution

Table 2: Summary of Good Practice tools and technologies.

TOOLS and TECHNOLOGIES	WHO	WHY	WHAT
DOMINO tool	Centre risque & performance (CRP) of École Polytechnique de Montréal	Barriers to information sharing at the point of interdependency identification and analysis	A modelling, mapping, decision and planning assistance tool using a flexible cartography approach which preserves the confidentiality of information. Used for managing interdependencies and analysing domino effects.
Virtual Business Emergency Operations Center (V-BEOC)	NIMSAT Institute, Louisiana (USA)	To incorporate and leverage on nation's best practices in information sharing, lessons learned from research in PPPs, and from experience	A free, web-based information sharing platform that facilitates collaboration between public, private and non-profit organizations. Capable of supporting existing processes and existing incident management systems
Northwest Warning, Alert and Response Network (NWWARN)	Pacific Northwest Economic Region (PNWER)	To encourage cross-sector information sharing	An alert, warning and information sharing platform exploiting experts for particular infrastructure systems. Enables near real-time two-way exchange of critical information and suspicion activity reporting to authorities
Computer Based Alarm System Øresundsbron (COMBAS Ø)	Øresundsbron (Denmark-Sweden)	Need for a stable, effective and rapid alarm system for those involved in emergency preparedness and response	A computer-based alarm system for the Øresund Fixed Link. Information on an accident is efficiently passed to the emergency services. Provides immediate access to action plans, cross-border information sharing and collaboration.
SUSI (Sistema Unico di Scambio delle informazioni)	Lombardy Region, Italy	To support communication between the operators and Civil Protection Authorities	A multimedia platform to share data about disasters or options for prevention and monitoring the events before disaster happens. Interoperable and secure communication channel for timely communication between all involved organizations.
NATO Architectural Framework (NAF)	Developed by NATO. Used in Lombardy Region, Italy.	Standard for presenting operational models of the socio-technical systems. Analysis tool to develop new capabilities, structure organizations and to optimize processes	An Enterprise Architecture framework defines how to organize the structure and views associated with a complex, socio-technical system that comprises interdependent resources of people, information, and technology that must interact with each other and their environment in a common mission. Used as analysis tool to develop new capabilities, structure organizations and to optimize processes.

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Table 2: Continued

TOOLS and TECHNOLOGIES	WHO	WHY	WHAT
CEPP Situational Awareness Tool (SATool)	Colorado Emergency Preparedness Partnership (CEPP)	Smooth lines of communication between and across the public, private and non-profit sectors. To strengthen the region's collective EM capacities	An exclusive, secure, online Situation Center, designed to connect the different organizations responding to an event together. It is a centralised portal to respond to and communicate during critical events and share day to day information.
Dutch National Crisis Management System (LCMS)	Institute For Physical Safety, The Netherlands	Need for all responders within 'safety regions' to form PPP for CIP-R and be able to collaborate very closely. Connection of safety regions	A distributed information system, highly focused on geographical information and linked data. Contains modules for Communication, Coordination and Logistics; efficient exchange and disclosure of information; Drafting a GIS view – Operational Picture, CM and Reporting. Flexible platform that scales to meet circumstances, accessible via a web service.
Emergency Elements: Ontology for Interoperability (EMERGEL)	The European DISASTER Consortium	To achieve a detailed Common Operational Picture shared between organisations with different systems, between regions, or even countries	A technology (and supporting tools) that provides interoperability between EM Systems. Allows exchange of information between EMS facilitating semantic interoperability via translation and mediation
GIS Mapping for CI Assets	Police Scotland, Scottish Government, Scottish Water, Scottish Roads Works	A need for a visual awareness tool to spatially identify CI assets in Scotland, to allow a better understanding of physical and logical interdependencies and locational vulnerabilities.	A GIS Mapping product which could be used to map all CI and other appropriate sites, including network and interdependency relationships. Identification of infrastructure interdependencies, support tool for planning and exercising. Platform for data and information collation.
Traffic Scotland Information Service	Transport Scotland	To provide key partners, responders and the public with up to date traffic and travel information	An accurate, timely, consistent and tailored to the needs of users Information Service. Covers desktop and mobile web sites, internet radio services, mobile web applications and smartphone apps, social media.
Performance & Risk-based Integrated Security Methodology (PRISM)	Harnser Risk Group	Approach to raise concerns amongst stakeholders about how organisations make strategic and operational decisions that affect their exposure to security risk and its impact on their supply chains.	An empirically based, modular risk management tool. Four phases 'Strategy & Planning', 'Risk Assessment', 'Design' and 'Implementation & Review'. Guidance notes and templates for user in each phase – raises awareness and understanding.

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Table 3: Summary of Good Practice activities and processes.

ACTIVITIES and PROCESSES	WHO	WHY	WHAT
Big Business – Small Business	NIMSAT Institute, Louisiana (USA)	Effort to help small businesses, often lacking the resources and knowledge, to be better prepared for all-hazards disasters	Voluntary based Private-Private partnership that promotes proactive (whole community) EM approach.
Blue Cascades Exercise series	Pacific Northwest Economic Region (PNWER), USA/Canada	To explore infrastructure interdependencies, at the same time building relationships and trust – supporting NWWARN use.	A model for bringing together public and private sector stakeholders to discuss cascading impacts across the region.
Major Incident Control Committee (MICC)	14 'top tier' industrial site operators within the Grangemouth industrial complex area, Scotland	To oversee vitally important matters such as Public Warning, Training and Exercising, mutual aid and assistance between companies and the provision of technical advice.	Through regular joint planning, training and exercising, the MICC ensures that integrated public and private sector contingency plans are in place to cover all important issues regarding EM.
Operation Estrela	Developed by Police Scotland. Received funding from Scottish Government. The CPNI assisted in development of the concept	In response to a number of high profile cases involving insider attack. To flag up potential vulnerabilities within an organisation, to exercise and test resilience to an insider attack	An exercise programme examines the recruiting, pre-employment screening, identity verification, personnel/role based risk assessment. It also assesses the potential impact of an 'insider attack' and the relevant consequence management. Business continuity processes are tested to assess their adequacy
'CATEX' Regional Exercises	All Hazards Consortium (USA)	As a part of an integrated planning effort - FEMA Regional Catastrophic Planning Grant Program (RCPGP) To coordinate the efforts of multiple states, federal agencies and private sector owners/operators into the planning process for major events.	Multi-year exercise program that annually engages public and private sector participants in a multi-state tabletop and/or limited functional exercise using a scenario(s) in order to focus on several important areas critical to responding and recovering from catastrophic events and establish a framework for discussion and further promote integrated planning efforts and partnerships.

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Table 3: Continued.

ACTIVITIES and PROCESSES	WHO	WHY	WHAT
Multi-State Fleet Response Initiative	Multi-State Fleet Response Working Group (USA - NJ and Pennsylvania)	The speed up movement of large convoys of resources across multiple State and/or national boundaries to support response and recovery following disasters.	Expediting the movement of private sector resources on a multi-state level in support of response efforts and mutual assistance for rapid CI restoration.
Thematic Task Forces (TTF)	Lombardy Region, Italy	To develop collaborative procedures for coping with specific accident scenarios, mapping of the information flows and communication channels among actors	TTF are result of partnership between the Lombardy Region, transport and energy CI operators in the region, Civil Protection and first responders. Involving operators according to their own interests and concerns.
Focus on Flows	The Resilient Regions Association (Sweden)	The flows which are vital for society are interdependent and taken care of by different actors, both public and private. There is no actor in the system who can singlehandedly ensure that the city's flows function.	Cooperation and the development of functional cities with a focus on the flows of goods, services, money, people, energy and information. Seminars, conferences, breakfast meetings, members' training courses, workshops and study visits
Partnership Alignment for Enhanced Security	The Netherlands Safety Regions	Transfer of responsibilities for the preparation of plans and responses to crises and disasters to the safety regional level of government	Partnerships for alignment of security management and process include coverage of CIR, as follows: ▪ Security Regions Act (defines the partnerships) ▪ Regional Risk Profile ▪ Regional Crisis Management Policy ▪ Regional Crisis Plan ▪ Specific CIP-R Crisis Plans

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5 Assessment of Good Practices

The average values for each GP across the three dimensions are shown in Table 1. All the practices received medium-high values of Benefits and Transferability, which approves them as Good Practices. The results of the GPs assessment exercise are plotted in Figure 2, where the size (width) of the bubble represents the benefits. As the GPs assessments fall quite close to each other, the average values have been rescaled (normalized) for a better representation and distinction.

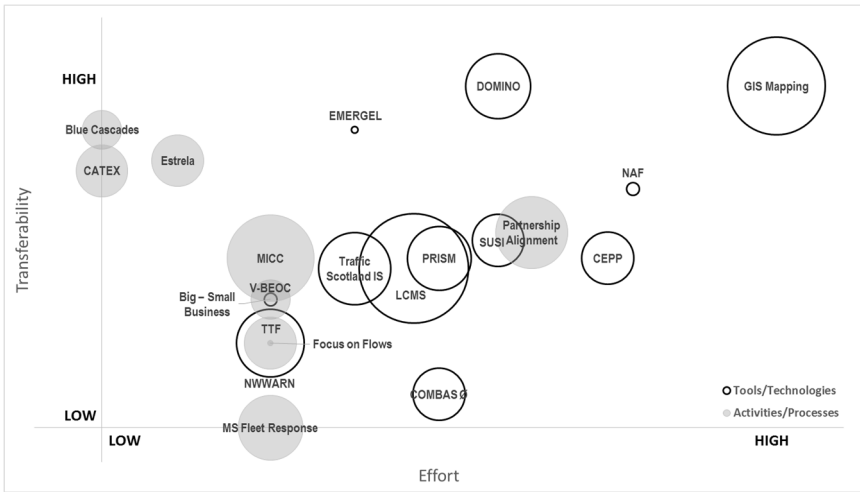

Figure 2: GPs assessment.

The experts feel that fairly enough effort and knowledge is required when it comes to implementing the GPs, which indicates a lack of 'quick wins'. It is understandable that *Activities and Processes* require less implementation effort compared to *Tools and Technologies*, while the latter are able to bring greater benefits and, on average, possess higher transferability. Even though some of the practices share the same guiding principles, each is significantly customised, addressing the specific needs of the regional programme. As practices are rarely directly transferable ('*as such*'), offering a hands-on experience would give practitioners a much better insight – an opportunity to examine the suitability for use, potential benefits, need for adjustments and human training in their own context. Feasibility of providing a first-hand experience is an issue to consider.

While GPs are usable when there is a lack of a practice, looking at the ratio between the benefits and effort it is clear that it would be irrational for any region to substitute a practice already in place with another one of the same type. Of course it does not mean that sharing of GPs between existing regional programmes is not needed. A reasonable action in this case would be to improve

or expand the current practice based on the shared knowledge and experience and advance the existing CIP-R programme. GPs are not only a customised approaches but the ideas that lie behind the practices – the reasoning on how to cope with problems at hand and the base made of common determinants and features. GPs are therefore a source of knowledge on how to address issues, how to improve practices already in place and adopt new ones.

6 Conclusions

The paper studied the regional CIP-R programmes and provided a state-of-the-practice analysis when it comes to successful practices used for establishing and running a regional programme and reaching specific goals. After presenting a collection of GPs, we have involved experienced practitioners to evaluate those GPs along three relevant characteristics. The practitioners can dig into this GPs collection in search for ideas and solutions for their existing problems, leveraging on others experience and experts' opinions. Results may also support policy makers and practitioners to frame and develop regional CIP-R Programmes.

Future research will test implementation of some of the GPs into new environments. Determinants of GP, which are the primary transferable elements (rather than practices as such) should be extracted. Possible alignments and synergies should be further investigated in two aspects: i) Between the two types of GPs (Activities/Processes and Tools/Technologies) – for better mix and match; ii) Between programmes on different levels – i.e. in which way are regional CIP-R strategies able to address CIP-R issues at higher levels, and vice versa, how can CIP-R policies and strategies support a bottom-up approach in the form of regional programmes.

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