

# Towards Projected Impacts on Emergency Domains Through a Conceptual Framework

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## ABSTRACT

In emergency domain, experts must make decisions both usual and unusual. These decisions lead to unpredictable impacts, causing the need for these experts to deal with impacts mitigation. Unexpected need of impacts mitigation consists in an overload of material resources and expert cognitive capacity. After decision making, impacts mitigation demands valuable expert efforts. To address this problem, this paper proposes a decision impact projection in early stages of emergency management, during planning stage. In this way, this paper proposes the method called General Conceptual Framework (GCF) and the Framework of Projected Impact on Emergency Domain (PIED). Through the proposed method, PIED Framework was developed, contributing for the characterization of impact projection in emergency environments.

## Keywords

Projected Impacts, Emergency, Complex decisions, Conceptual Framework, and Method.

## INTRODUCTION

In the world where information enters in the vast world wide web and spreads to all continents, we can know very fast, in a general way, about disasters and accidents that happen on the other side of the world. These events could be both natural disasters, such as the tornado that devastated the city of Moore, near Oklahoma City, in 2013. Or, as accidents caused by human or technical failures. Every incident has a great impact on society, so there is a need to interpret the signals that are generated and happen imperceptibly. In this way, only with the planning of responsible organizations or the awareness of the population and decision makers, it will be possible to build preventive actions for emergency situations.

In emergency situations, experts make complex decision characterized by high risk, time pressure, dynamic environment, multiples involved, goal poorly defined, and low structured problems (Orasanu and Connolly, 1993; Hutchins and Kendall, 2011). This kind of decision lead normally to unpredictable consequences, because the work has to be done by a decision maker that has an overload of his cognitive capacity and functions, and the decision to be made presents characteristics that contribute to a poor analysis (Dirr et al., 2015). The literature provides some strategies to deal with the management of a decision process (Orasanu and Connolly, 1993; Klein et al., 1993), and most of them can be applied to complex decisions. However, to execute these strategies it is necessary time and available resources that are not ever possible in an emergency scenario. Considering it, it is necessary to investigate and analyze the decision characteristic and environment to avoid results against the initial goals.

According to Ochoa et al. (2006), in an emergency domain, "an investigation normally follows any incident in order to discover the causes of the emergency, evaluate the effectiveness of the response, and generate recommendations for future preventive actions". In this context, we consider the need to find ways to prevent undesirable events, respond to warnings and investigate their causes, considering the planning of a complex

decision making. In other words, this paper focus on the difficulty suffered by decision makers in projected impacts of a complex decision in an emergency domain. To address this need, models that use a knowledge organization, respecting the phases of prevention, response and investigation of complex decision impact on emergency situations are necessary.

For the purpose to support decision makers to analyze complex decisions in emergency domain and project impacts of these decision in the future, this paper proposes a conceptual framework called PIED. This Framework was created following the phases proposed by the method GCF to construct a General Conceptual Framework, presented in this paper too. It is understood that if it is known the elements that characterize impact of a complex decision, the projected of these impacts becomes viable to be defined and decision makers become supported to investigate and analyze the complex decision considering the impact aspect on the emergency domain. To the best of our knowledge, this is the first study in literature that characterizes projected impacts in emergency domain considering the knowledge and experience of decision makers and complex decision structures.

This paper is divided in sections. The related works section presents a review of projected impacts on emergency domain and present some background and important definitions. The next section proposes and discusses a method to create a conceptual framework. Based on the method, the following section named “Conceptual Framework of Projected Impact on Emergency Domain (PIED)” showed the creation of a framework specialized in emergency domain. The last section concludes the paper.

## RELATED WORKS

Impact is defined as a “measure of the tangible and intangible effects (consequences) of one thing's or entity's action or influence upon another” (BusinessDictionary, 2017). Bringing this definition to decision environment, Hammond et al. (2002) consider it and affirm that to achieve smart choices it is necessary to compare the merits of the known alternatives, assessing how well each one satisfies the decision fundamental goal. Discuss and analyze impact decision is a way to understand the consequences of the actions, objectives, decision structure and decision problems. Projected impact is an action performed by decision makers to minimize unexpected consequences after the decision implementation. This action is performed during the decision process. Some authors defend that it is possible to analyses the consequences of a decision implemented through the decision process monitoring, and establish a mitigation action in run time (Hammond et al., 2002). For this strategy, it is necessary to wait the materialization of the impact to introduce solutions for the decision impact on the environment, material resources and humans. On the other hand, there are other works that support an impact analyze beyond an inference and quantitative results. It is possible to find on literature works that discuss decision impact still in the beginning of decision analyses, like on the decision process planning phase (Hammond et al., 2002; Shattuck and Miller, 2006). However, most of researches in this area do not highlight details about how to effectively project impacts in practice, mainly the impacts of complex decisions. Most of them, deal with impacts projection in a subjective way, intrinsic to the decision maker's experience and their mental correlations regarding decision-making. On this work the definition of complex decision is substantiated on Naturalistic Decision Making theory that describe how decision makers make decision in real world complex domains (Orasanu and Connolly, 1993; Klein and Klinger, 1991).

Regarding emergency domain, tools to support projected impacts usually use geographic information systems to combine the relevant data and overlay the impact of the disaster. Regarding this combination, it is possible to identify population, infrastructure and resources affected immediately and also, those affected subsequently by the disaster. Some examples of such tools are: National Atmospheric Release Advisory Center (NARAC) facility at Lawrence Livermore National Laboratory for modeling hazardous atmospheric release (NARAC 2016), Radiological Assessment System for Consequence Analysis, Version 4.3.2 (RASCAL 4.3.2) developed by U.S. Nuclear Regulatory Commission's (NRC's) for studying the atmospheric radiological material release (USNRC 2016), and building fire simulation tools developed at National Institute of Standards and Technology (NIST, 2016).

Jeznach et al. (2016) presents a framework for making decisions about emergency response and remediation actions using hydrodynamic and water quality models to understand the fate and transport of potential contaminants in a reservoir and to develop appropriate emergency response and remedial actions. In the event of an emergency situation, prior detailed modeling efforts and scenario evaluations allow for an understanding of contaminant plume behavior, including maximum concentrations that could occur at the drinking water intake and contaminant travel time to the intake. The modeling study highlights the importance of a rapid operational response by managers to contain a contaminant spill in order to minimize the mass of contaminant that enters the water column, based on modeled reservoir hydrodynamics.

Fisman and Tuite (2014) used a mathematical model considering 2014 West African Ebola epidemic to simulate the quantity of vaccine needed to substantially decrease epidemic size, and also to simulate the impact of

vaccination timing and dosing with a hypothetical vaccine on the future contours of the epidemic. The authors considering different assumptions around timing of vaccine availability to understand the potential impact of vaccination on epidemic trajectory. As result, authors concluded that effective vaccination, used before the epidemic peaks, would be projected to prevent tens of thousands of deaths.

Coles et al. (2016) designed and executed six experiments. In each experiment a particular component of how agencies make partnership decisions in a disaster environment was measured, aiming at develop a model of how such decisions would affect operational efficacy.

The investigation proposed in this paper differs the works cited above through a method to orient a Framework constructions, which provides a systematization of actions. The role of this Framework is to allow the decision makers projected impact of complex decisions inside emergency situations. Through this Framework it will be possible to specialist on decisions to characterize impact in this scenario and visualize the probable consequences of their actions before the decision is made. The proposed method and Framework deal with aspect presented on the environment and on decision maker characteristics. At the end of decisions analyze, the decision maker continue be the one responsible to choose the more indicated alternative of action, considering the options proposed by him.

### A METHOD TO CREATE A CONCEPTUAL FRAMEWORK

To construct a framework, according to Araujo and Borges (2012), it comprises three subactivities: elicitation of requirements from the literature or interview with specialists, design of the framework from the information elicited in the previous sub activity, and elaboration of a method to use the framework. This paper proposes a method to construct a General Conceptual Framework (GCF), where its specialization acts in the emergency domain. This method (Figure 1) is composed by a set of eight phases inspired in Araujo and Borges (2012), and considers the reuse of existing methods and concepts to characterize the domain to be explored. Among the phases, there are: (I) Conceptual Framework planning; (II) Investigation/Adaptation of existent methods; (III) Information research of interest concepts; (IV) Definition of framework categories; (V) definition of framework conceptual structures; (VI) Establishing interaction with stakeholders; (VII) Conceptual Framework construction; (VIII) and Disclosure of the conceptual Framework.

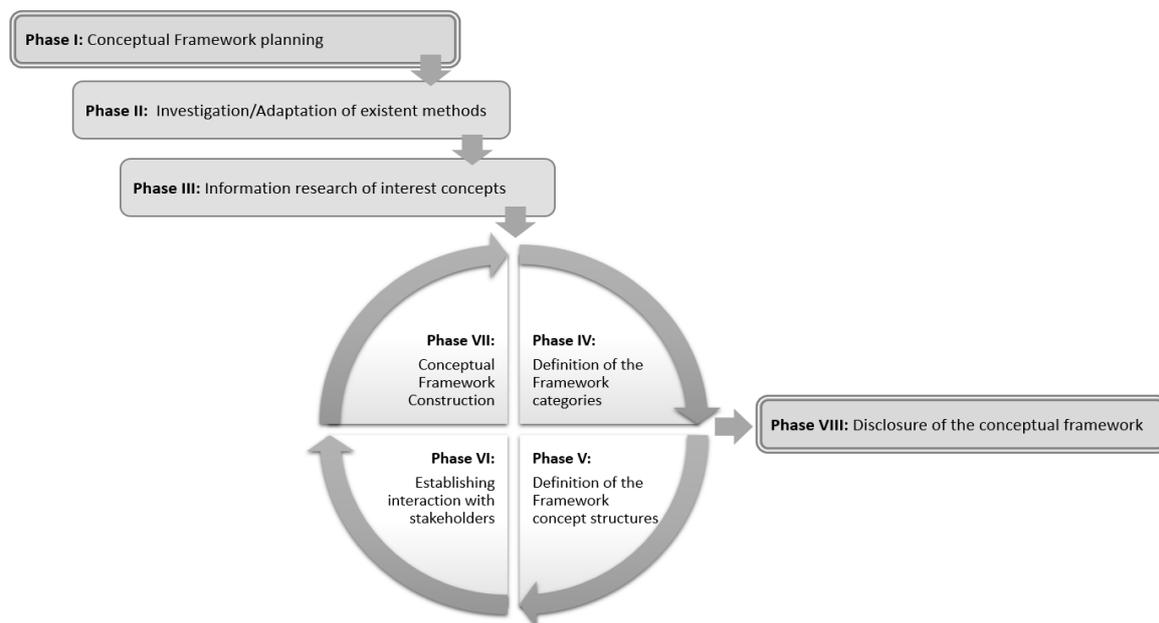


Figure 1. Method to construct a General Conceptual Framework (GCF).

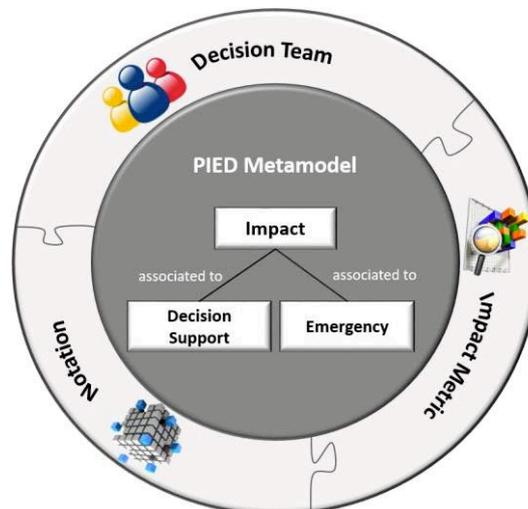
Figure 1 shows the sequences of actions that compose the method, and which should be established for the construction of a Conceptual Framework. In Figure 1, it is possible to observe that the initial phase, which provides the planning of Framework construction actions, highlights the goals to be achieved and the products to be built, including those involved in the construction and information gathering. The next phase is the adaptation of existing Framework construction methods. Thus, the GCF method was adapted from the Araujo and Borges (2012) method with the insertion of new steps and adaptation of already existing steps, other methods can be better adapted according to the result of interest desired. Phase II, however, is optional, it is up to the constructor of the Conceptual Framework to predict it in its actions or to adopt the other phases of the GCF method in the

construction of its conceptual Framework. Phase III includes the elicitation of information on areas of interest that may occur through the literature, practical manuals and experience of those involved in the Framework construction. The fourth phase establishes the categories to be defined to characterize the elements of the Framework, based on the results obtained in the previous phase. Part of this phase is also to refine the survey of the previous phase, focusing on aspects of interest for the categories definition. Using the results of Phases III and IV, the conceptual elements of the Framework (Phase V) are defined and can be expressed in the form of metamodels, ontologies or some other form of conceptual representation.

Building a conceptual framework, consistent with reality, requires a direct interaction with its potential stakeholders. In this way, Phase VI is proposed in the method, where stakeholders are heard about the area of interest of the Framework. At this phase, interviews or questionnaires are planned as a way of eliciting information. Phases IV, V, VI, and VII are cyclic and present results that are dependent on each other. The products generated by these phases are built incrementally and with parallelization in activities. The conclusion of the Conceptual Framework (Phase VII) happens when the actors, involved in its construction, reach a satisfactory representation result of the Framework, according to the goals initially outlined in Phases I and II. Phase VIII is about making the proposed Framework public, so that it can be applied in real solutions and not just as a test. The method proposes a set of phases to support the construction of a Conceptual Framework. It will be up to the person responsible for its execution to define the details of each phase and to implement them. The method output requires a Framework presentation structure to be displayed. The following section presents a practical application of the GCF method for the construction of the Conceptual Framework for impact projection in the emergency domain.

### CONCEPTUAL FRAMEWORK OF PROJECTED IMPACT ON EMERGENCY DOMAIN (PIED)

Based on the GCF method, the construction of the Framework for Projected Impacts on Emergency Domain (PIED) was built (Figure 2). To the Phase I the guidelines to be achieved in the construction of the PIED Framework were established. The main goal is to establish a mechanism to support decision-makers in complex environments. In this way, they can project impacts of actions taken, still in the planning phase of the decision.



**Figure 2. Conceptual Framework of Projected Impact on Emergency Domain (PIED).**

For the construction of the present Framework, the proposed GCF method was used. All its phases were performed, except for Phase II, since the current method was sufficient for the proposed aim. In Phase III, a conceptual survey on the concept Decision was carried out, more specifically were considered the naturalistic decisions, complex and group decisions concepts, beyond the emergency domain. In this survey were considered the definitions of these concepts, their characterizations found in the literature and models to support decision making. The result of this survey generated a set of categories of PIED that was evolved in elements characterizing the Framework, composing the result of Phase IV of the GCF method.

Figure 3 shows the execution of the GCF method's Phase IV to construct the PIED. In this table, there are the categories that express projected impact idea, the categories characterized elements, and the way how the projected impact could be materialized to support decision makers in their tasks. Categories are elements that show the central idea of the framework proposed. The characterized elements show details about the categories. In PIED case, these are the elements that define how complex decision making occur on emergency domain, and what are the possible elements that support projected impact before the implementation of the decision. Support are the

practical action, based on characterized elements, that must be done by decision makers to projected impact on emergency and complex decision. In PIED case, the support considered are the: (i) collaboration between decision makers, volunteers and professionals; (ii) the definition of an impact metric to help decision makers visualize and understand the impact of a decision on the environment and on others decisions; and (iii) the establishment of a notation to represent the projected impact configuration.

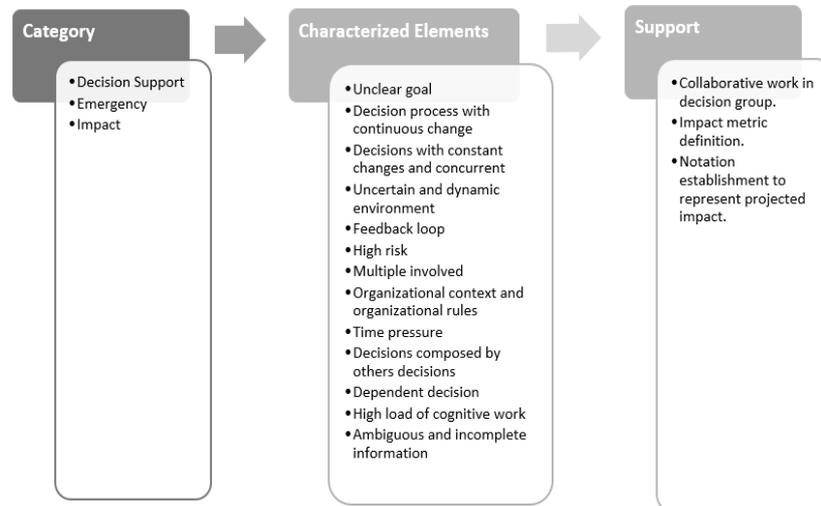


Figure 3. Execution of method GCF’ Phase IV in Framework PIED construction.

In Phase V, the characterizing elements of Figure 3 were evolved in conceptual structures. These structures will compose the materialization of the PIED Framework through the impact projection constructs. Its role is to detail the constructs that, when instantiated, will compose the impact projection model. The main structure of the projection of impacts occurs, through the externalization of: the possible scenarios of a decision to be made; feasible alternative actions in the predefined scenarios; the implications of each alternative; the impact of each alternative in the predicted scenario; and the elements that characterize the decision. These aspects were proposed based on the previous GCF phases results. The phase VI of GCF method compose the detailing of the PIED concepts, considering the specialist view. The last two phases of GCF, the aim is to conclude a representation of the Conceptual Framework and make it known. These goals will be discussed in a future work.

## CONCLUSION

This research had the role of supporting decision makers acting inside emergency domains, in projecting complex decision impacts before its implementation. Since unforeseen events in emergencies can generate uncontrollable consequences, knowing and analyzing a set of potential impacts of the decision, can support the decision maker in the exercise of his activities, reducing his cognitive and functional overload. In this way, this paper contributes with a method to create Conceptual Frameworks (GCF) and the development of an instantiation of this method, named PIED Framework. The PIED framework support decisions makers to analyze complex decisions in emergency domain and project impacts of these decision in the future. As a result of the conducted evaluation, the method and the Framework characterized the impacts projection on emergency environment.

As future work, we can highlight the evolution of the PIED Framework, considering the experts knowledge and their practical on decision making in emergency environment. It is possible to represent the detailing of the PEID concepts by a metamodel, considering the relationship too. This metamodel can be enriched by the actions of impacts discovered by the contact with experts. The aim is to investigate the evidences about the feasibility of the adherence of the proposed framework and its metamodel regarding the actions taken in practice by decision makers.

Another aspect to consider in a future work is the deepening discussion about the indication of collaborative activities to support this kind of projection. Evolutionary iterations of the framework have the potential to generate increasingly good results in terms of its ability to support decision makers. In order to require less dedication of the decision makers in the use of the PIED Framework, a possible path is to build decision-making group orientation processes in the establishment of the projection, and the construction of models and reports in a dynamic. In addition, further research can explore differences in projection of impacts in different areas.

To add value regarding the PIED framework, a web and collaborative application that supports the discussion, analysis and projection of impacts of complex decisions can be developed. In this way, it is possible to support decision-makers, specialists and collaborators who are not physically co-located in discussing and analyzing the impacts of complex decisions in emergency domains dynamically.

## REFERENCES

- Araujo, F. C. S.; Borges, M. R. S. (2012) Support for Systems Development in Mobile Devices used in Emergency Management. In: *CSCWD 2012 - IEEE International Conference on Computer Supported Cooperative Work in Design*, Wuhan.
- Belbin, R. M. (1985) *Management teams, why they succeed or fail*, Butterworth-Heinemann, London.
- Coles, J., Zhang, J., Zhuang J. (2016) Experiments on partnership and decision making in a disaster environment, *International Journal of Disaster Risk Reduction*, Sep 30, 18:181-96.
- Dirr, B., Borges, M., Mendonça, D. (2015) Putting plans on track in unforeseen situations, *Proceedings of the ISCRAM 2015 Conference*, Kristiansand, May 24-27.
- Fisman, D., Tuite, A. (2014) Projected impact of vaccination timing and dose availability on the course of the 2014 west african ebola epidemic, *PLOS Currents Outbreaks*, Nov 21.
- Hammond, J. S., Keeney, R. L., Raiffa, H. (2002) *Smart Choices. A Practical Guide to Making Better Life Decisions*, Broadway Books, New York, USA.
- Hunt, J.D., Bañares-Alcántara, R., Hanbury, D. (2013) A new integrated tool for complex decision making: application to the UK energy sector. *Decision Support System*. 54 (3), 1427–1441.
- Hutchins, S., Kendall, T. (2011) The Role of Cognition in Team Collaboration During Complex Problem Solving. In: Mosier, K.L., Fisher, U.M. (eds). *Informed by Knowledge Expert Performance in Complex Situations*. Psychology Press, Taylor & Francis Group, p. 69-90.
- Impact. BusinessDictionary.com. WebFinance, Inc. <http://www.businessdictionary.com/definition/impact.html> (accessed: January 05, 2017).
- Jeznach, L.C., Jones, C., Matthews, T., Tobiason, J.E., Ahlfeld, D.P. (2016) A framework for modeling contaminant impacts on reservoir water quality, *Journal of Hydrology*, Jun 30, 537:322-33.
- Klein, G.A., Klinger, D. (1991) Naturalistic Decision Making. *Human Systems Iac Gateway*, V.XI, N. 3.
- Klein, G.A., Orasanu, J., Calderwood, R., Zsombok, E. (1993) *Decision Making in action: Models and Methods*. New Jersey: Ablex Publishing Corporation Norwood, P. 138–147.
- NARAC (2016) <https://narac.llnl.gov>, last accessed on January 10, 2016.
- NIST (2016), NIST Fire Dynamics Simulator, <https://pages.nist.gov/fds-smv/>, last accessed on January 10, 2016.
- Ochoa, S., Neyem, A., Pino, J.A., Borges, M.R.S. (2006). Using context to support group decision making in disaster affecting urban areas, *In IFIP International Conference on Decision Support System* (pp. 546-561). Ludic Publishing Ltd.
- Orasanu, J., Connolly, T. (1993) The Reinvention of Decision Making. In: Klein, G.A., Orasanu, J., Calderwood, R., Zsombok, E. (eds), *Decision Making in action: Models and Methods*, New Jersey: Ablex Publishing Corporation Norwood, p. 3-20.
- Shattuck, L.G., Miller, N.L. (2006) Extending Naturalistic Decision Making to Complex Organizations: A Dynamic Model of situated cognition. *Organization Studies*, 27, 989-1009.
- USNRC (2016) <https://www.usnrc-ramp.com/RASCAL%20Overview>, last accessed on January 10, 2016.