

# DESIGN IN COMPLEX ENVIRONMENTS: Application in Emergency Management

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## Abstract

This paper describes ways to identify issues in complex environments using emergency response and recovery as an example. Emergency response and recovery is recognized as a complex problem. The complexity is the result of the number of entities involved and the frequently changing relationships between them. The paper describes a systematic way based on design thinking to analyze systems in complex environments and identify design issues to be addressed. It then shows how such issues can be used to develop joint value propositions that lead to conceptual solutions. The systematic design process begins by identifying manageable themes. It then looks at ways to address identified theme issues by defining joint value propositions and conceptual solutions. The paper draws on data from a number of emergencies to identify issues especially in communication and its proposals. Solutions must be framed not only in the local relationships but also using frameworks such as resilience.

**Keywords:** Complex Systems, Design Thinking, Design Methods, Emergency response

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## 1 Introduction

This paper addresses design in complex environments using emergency management as an example. Design in complex environments can no longer simply be an analytical process to solve a well-defined and precise requirement. The requirement here is often expressed in higher level terms such as “reduce losses in an emergency” or “improve customer retention”. System designers must reduce this requirement to specific requirements, often expressed as a joint value proposition. This paper describes the process used to find such specific problems by identifying themes and theme issues and how to use the issues to create joint value propositions that define development directions.

The paper sees design in complex environments as providing solutions that must be satisfied from a number of perspectives but at the same time satisfy criteria from a number of frameworks as shown in Figure 1. In this paper designers can control perspectives to solve local needs but must satisfy the criteria set by the frameworks. Perspectives here include the social network, activities carried out by different groups, knowledge flows or organizational structure. These are called here the local framework that focuses on stakeholder needs. External frameworks on the other hand look at more abstract notions such as the resilience of the system, the technology infrastructure or responding to unexpected events in complex environments. A simplistic view of design is that the design must create a system where perspectives are structured in a way that satisfies local stakeholder needs and the criteria of a number of frameworks. Here designers look at different perspectives and propose solutions in terms of changes to perspectives. The solutions are created by changes to components in the local framework while being evaluated against the criteria of the external framework. The frameworks in this case are consistent with the idea of making sense often found in business literature. Its goal is to broaden design to not only address a local frame but to assess the design outcome in terms of broader frameworks. Increasingly external frameworks center on complexity and resilience.

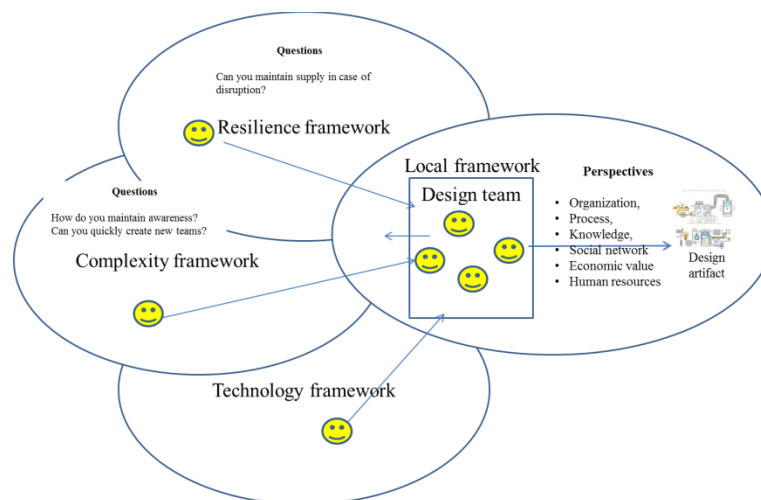


Figure 1 – Design frameworks in complex environments

The design method shown in Figure 1 requires a systematic approach that begins by defining themes and framing them in terms of complexity and resilience. The paper first describes the design process and then illustrates by describing the complex nature of emergency response management as a number of themes. It then focuses on communication and shows how theme issues can be developed and conceptual solutions proposed.

## 2 Designing in complex environments

It is increasingly recognized that design in complex environments should be not susceptible to analytic methods but must proceed in a systematic manner. What is needed is a systematic design approach that identifies problems and then proposes solutions. Increasingly systematic design methods are evolving as exemplified by the Double Diamond method supported by the British Design Council or the dSchool at Stanford University in design thinking. The Double Diamond design process can in some way be seen as a process with delivery points whereas dSchool focuses more on the tools and creative thinking. Martin (2009) stresses the importance of:

- Visualizations that show complex relationships and stimulate creative thinking on potential solutions and focus on in-depth questions usually through brainstorming sessions,
- Incremental development through prototyping,
- Development of themes that define manageable parts of a complex system,
- Defining joint value propositions and conceptual solutions that address the issues and problems.

This paper defines how design thinking has been used to visualize disaster management and recovery and to identify ways to address some of the problems focusing on communication issues. It uses the Double Diamond design process by following :

- The discovery phase to develop an understanding of the system, and identify the stakeholders, relationships between them and their activities,
- The develop phase to clearly define what are the major themes, issues faced in these themes focusing on communication,
- The design phase by describing value propositions identifies from the issues and conceptual business solution that address communication problems.

The theme development is coordinated through interdisciplinary teams. In the paper we describe this process in the context of emergency response and recovery.

## 3 Developing an understanding

One of the most common ways to start is with a storyboard and a rich picture. Figure 2 shows the first step of identifying the systems in disaster recovery. The themes are based on the structure used in NSW in Australia. The basic process is that a number of agencies are part of the NSW emergency management agencies. In the event of an emergency a set of agencies are activated and a response committee known as SEMC created. The committee is led by a senior representative of the lead agency. The lead agency chosen is the one that is the main contributor in addressing the emergency.

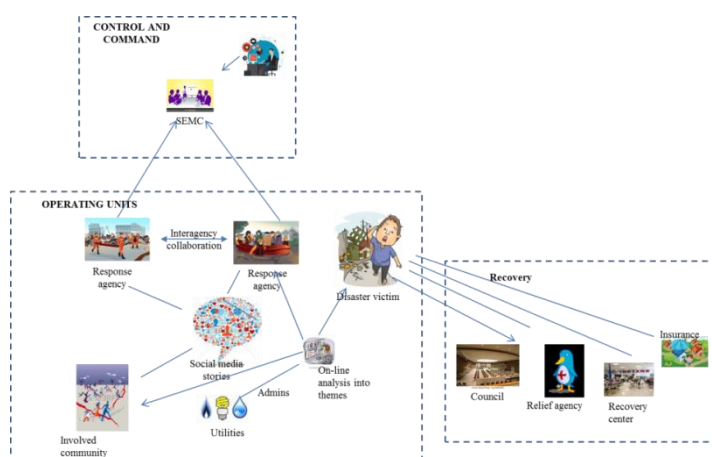
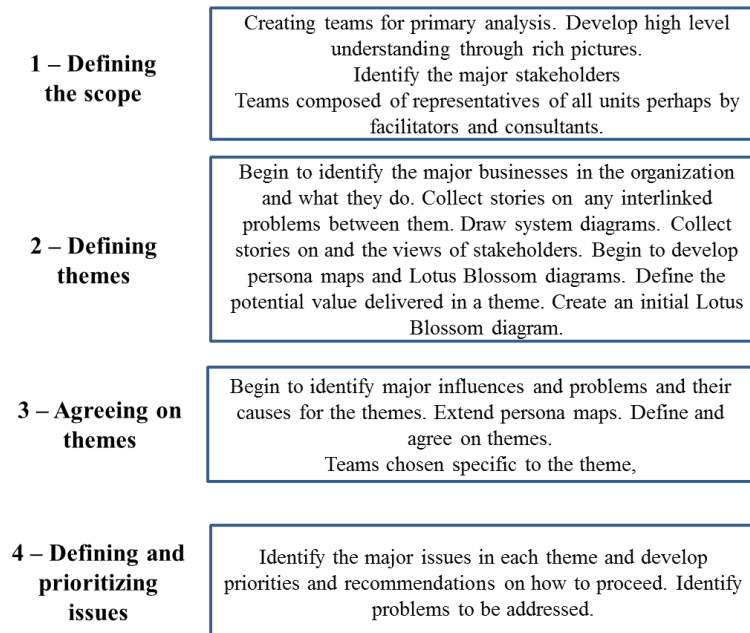


Figure 2 – An early Rich Picture showing stakeholders in the organization

Other visualizations include persona empathy maps and journey maps. Detailed description of these is outside the scope of this paper. Briefly persona empathy maps define the needs and concerns of typical stakeholders; journey maps illustrate the flow of information within a system.

## 4 Identifying themes

Complex systems do not lend themselves easily to analytical solutions. The commonly used approach is to look at themes that can be addressed independently until a set of themes is found that can lead to a solution. To some extent this can be viewed as finding “chunks” of the problem that can be addressed in a systematic way.



*Figure 3 – Choosing Themes*

One important objective of methodologies based on design thinking is to identify themes – or manageable chunks that we can work on. This is seen as important as addressing solutions as small chunks fits in with the gradual solution approach that characterizes design thinking. The interdisciplinary focus in design thinking also means that chunks are not developed independently. The process is shown in Figure 3.

Figure 4 shows the high level theme model emergency management system using a circle diagrams. The center of the representation is the goal of the design, in this case how to organize emergency management. This model has been developed through the author’s participation in Interoperability in Extreme Events Research Group (IEERG) group coordinated through University of Sydney. It included a large number of meetings with the different agencies including agency leaders and two brainstorming sessions.

The main themes in Figure 4 are

- Planning ways to improve emergency management
- Managing response
- Ensuring continuity of infrastructure services
- Managing recovery
- Post disaster analysis
- Developing volunteers
- Developing resilient communities



Figure 4 – Emergency response as a number of themes

In doing this there were a number of discussions, meetings, and brainstorming sessions using storyboards. The result is summarized in Figure 5 where each circle represents one of the themes shown in Figure 4 and is a more detailed analysis of the major themes shown in Figure 4.

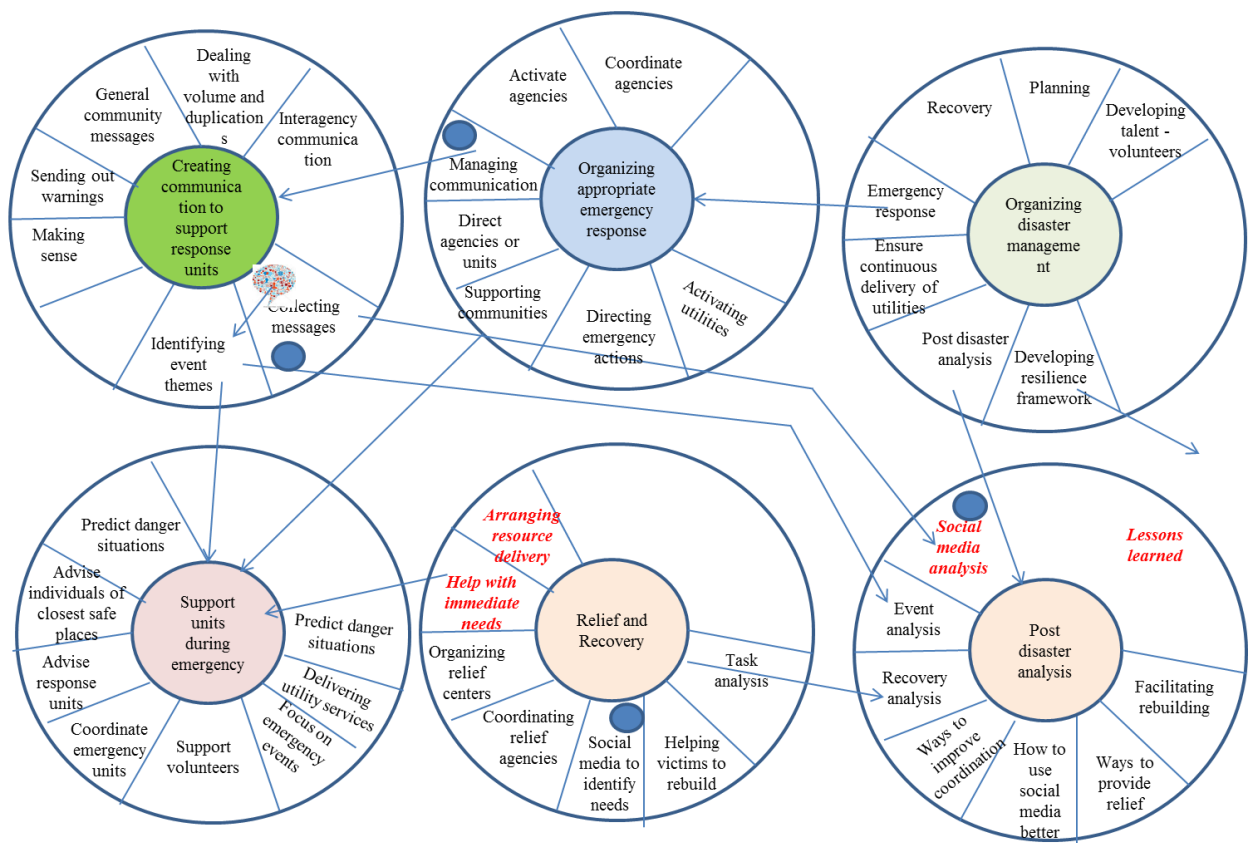


Figure 5 – Seeing the system from the organizational perspectives

It should, however, be noted that creating lower level descriptions is not a hierarchical decomposition, as there are relationships between themes in the different circles. For example communication appears in a number of themes in Figure 5; so does resilience. The remainder of the paper focuses on the theme of “Creating communication to support response units” and at the issues found in this area. It defines the author’s view of the issues rather than any official view. The Figure also indicates the large number of activities in emergency management and the corresponding variety of roles involved in these activities.

## 5 Identifying issues

Theme issues again are mainly discovered through brainstorming using different stakeholder's frames of reference. These in turn lead to questions which in response identify issues if they cannot be answered collectively in a convincing manner.

There are also frameworks from outside the local domain such as complexity or resilience. One is knowledge (Arain, 2015) which addresses the problem from the perspective of making sure that each person has the necessary knowledge to carry out their task. Another is from the social perspective that requires everyone to be aware of the disaster situation. Still there is also the perspective of the resources needed. It is almost obvious that any solution must combine all the perspectives. The relationships between these frameworks are impossible to model analytically in all but the simplest cases. In design processes based on design thinking such trade-offs are resolved through brainstorming.

### 5.1 Focusing on communication issues

Social media here covers mass media such as TV as well as a number of platforms for message exchange. Monares ((2011) describes some of the problems of directing messages through radio channels to operating units, in this case firefighters. We need to distinguish between information about something and information used to guide actions in the field and decisions in the command structure. In this paper sees three classes of strongly connected kinds of communication.

- General communication involving virtually anyone who is interested in an event,
- Communication between operating agencies,
- Control and Command information

Social media now plays an increasingly large role in emergency managements. This role is multifaceted in that it includes communication within a number of themes. Tyshkent (2012) for example describes the importance of Twitter in sending warnings and advice to people effected by any emergency. From the opposite direction information on events is now increasingly supplied by the general public often seen as crowdsourcing (Backfried, et.al, 2012), Cheng 2015) proposes two and sees social media as creating social capital. The complexity here comes from there being an increasingly large number of platforms (Cheng, 2015) used in message exchange and that messages The paper refers to issues raised from a number of reports and research. There is evidence that social media plays a role in improving communication.

- The information needed by the support units in the multiple number of roles,
- The communication with the control and command units.

Research literature describes the use of social benefits of it in the general communication area. However when one studies reports there is more concern when it comes to getting value for control and command purposes.

An example "A lack of communication and engagement also seems to contribute to a lack of awareness and/or understanding from industry. Most research here has been conducted on evaluating the sharing of information. There is now considerable research of how social media results in better awareness of situations. Yates and Paquette for example describes but states that "Little research exists on the design of social media".

The remainder of the paper describes issues found by the author and do not necessarily represent any official viewpoint.

One common aspect of the issues is greater emphasis on data analytics to analyse messages and direct groups of messages to responsible roles. The messages are often crowdsourced and as such provide additional challenges to any automated solution. There may be messages that are intentionally misleading.

THEME: Communication in emergency management

<b>Theme issues (brief description of major issues)</b>	<b>What needs to be addressed?</b>	<b>What value does resolving this theme issue provide to stakeholders</b>	<b>Define the data and knowledge needs to address the issue</b>	<b>What problems must be addressed</b>	<b>What do you see as a main challenge</b>
Issue 1: There is too much “noise” in the messages	Distinguish between genuine and noise messages	Greater reliability on messages to response units	Develop a database of people willing to rent space for visitors	Classifying message senders.	Identifying erroneous or misleading messages.
Issue 2: Consolidating general messages into action focus	Matching messages through their content to identify the need for a decision.			Ways to sort messages by emergency events and direct to responsible roles.	Deciding the role to whom to send the message.
Issue 3: Messages at operational level not focused	Identify information needed by operational roles.	Enables operational roles to make better decisions.	Define role responsibilities and their information needs		

Table 1 – Communication Theme Issues

## 6 Value Propositions and Conceptual Solutions

A joint value proposition in its simplistic form is where we “satisfy a framework criterion by changing a local perspective”. Some value propositions identified in Table 2

Joint value proposition	Theme issues and problem addressed	What is the business innovation	What value will technology provide	What is value to stakeholders	Challenges
We will define different repositories for different stakeholders.	Communication in disaster response		Quicker access to reliable information	Greater trust in social media information received	Ranking contributors
We will reduce noise by using data analytics to monitor and redirecting messages.	Eliminating misleading messages	Identify noise using data analytics	Quicker analysis of messages		Volume of work may be too large
We will separate command and control messages from operational messages			A number of platforms with shared information	Stakeholders get messages focused on their decision needs	

Table 2 – Joint Value Propositions

## 6.1 Developing a Business Solution Model

The issues raised in Table 2 have been addressed in the field. One example is shown in Figure 6, whereas during an emergency, volunteer workers grouped incoming messages to focus on events; in fact the equivalent of identifying themes at the operational level during the emergency to make decisions on actions to take.



Figure 6— An Example from the Blue Mountains

The basis of the business solution model is to:

- Match platforms to the needs of decision makers. The platforms should provide the visualizations that simplify the interpretation of messages and mapping them onto relevant physical objects.
- Provide assistance in interpreting and grouping messages by themes relevant to the platform

An example is given in Figure 6. It comes from the Blue Mountains where volunteers (Blue Mountains Firewatch) monitored messages to sort them by emergency events to identify actions to be taken.

Figure 6 illustrates a possible conceptual model for message management. Here concerned citizens provide message to the system. The message processing here includes:

- includes roles of “message analyst” to process messages and sort them by role,
- classifying citizens to give them different abilities without messages needing to be analysed by the message analyst,
- provide map visualizations to selected citizens,
- provide trusted citizens with abilities to directly post on map visualizations



The prototype solution proposed here is a suggested solution rather than a working prototype that satisfies the current problems.

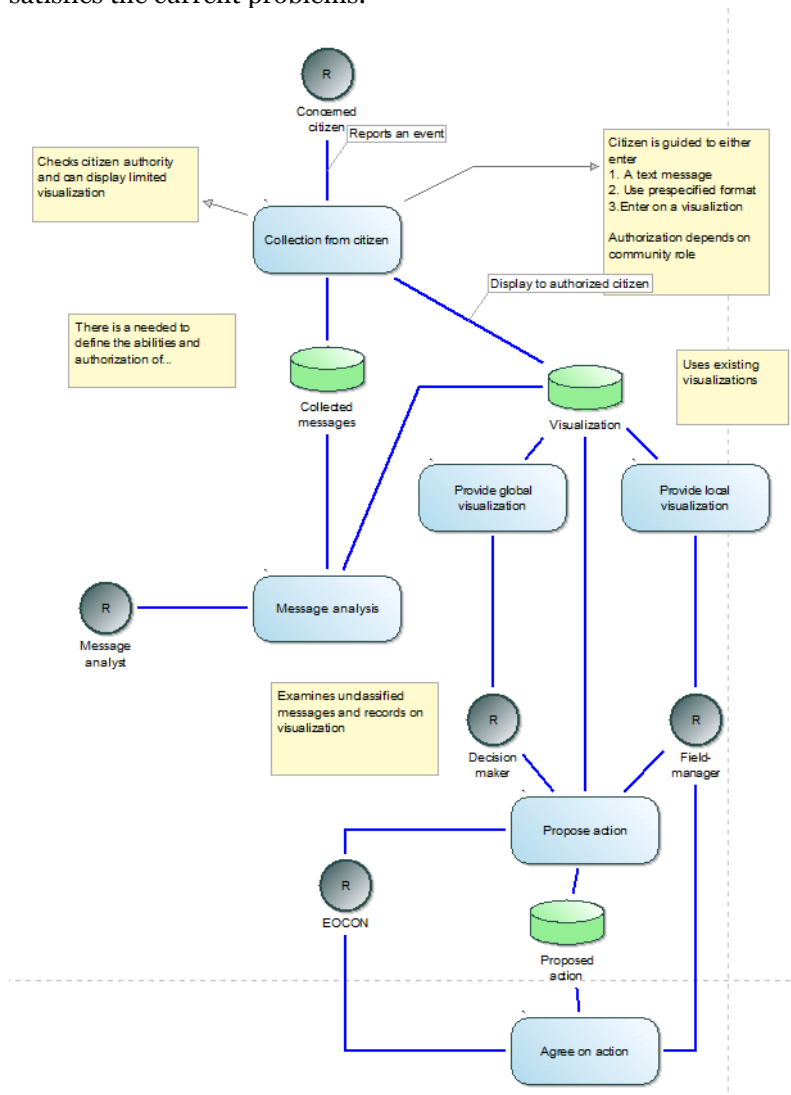


Figure 7 – Monitored Capturing of Information

## 7 Summary and Future Work

This paper described ways to use design thinking tools in design sin complex environments. It defined a systematic design process that begins with understanding the organization followed by breaking the situation into themes and addressing design by focusing on the themes while maintaining the links between the themes. It illustrated the process using emergency management. It focused on communications in this area and identified the need to develop data analytics systems that can quickly analyse messages often in crowdsourced environments to direct them to roles that can act on them.

## 8 Acknowledgements

The research described here benefited from the author's participation in the author's participation in Interoperability in Extreme Events Research Group (IEERG) group coordinated through University of Sydney and in particular Prof. D. Bunker its convenor and the many participants from Universities and the agencies involved in disaster response and recovery.

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