Pontifícia Universidade Católica do Rio de Janeiro

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A Context-aware Model for Decision-making within Multi-expertise Tactical Planning in a Major Incident

TESE DE DOUTORADO

Thesis presented to the Programa de Pós-Graduação em Informática of the Departamento de Informática, PUC-Rio as partial fulfillment of the requirements for the degree of Doutor em Informática

Advisor: Prof. Alberto Barbosa Raposo
Co-Advisor: Profa. Simone Diniz Junqueira Barbosa

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Abstract

Alencar, Marcus Franco Costa de; Raposo, Alberto Barbosa; Barbosa, Simone Diniz Junqueira. **A Context-aware Model for Decision-making within Multi-expertise Tactical Planning in a Major Incident**. Rio de Janeiro, 2015. 112p. DSc Thesis - Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

Activities that involve very complex and unpredictable problems are still relying on human decision-making and manual tools like paper forms. This is still the case for decision-making within tactical planning in a major incident, where the collective knowledge of multi-expertise specialists is essential to make urgent and effective decisions. Specialists tend to reject tools that jeopardize the decision agility required, as it can put human lives at risk and cause major damages to the environment and property. Communications and management are challenges, as these specialists have each their own “expert language”. This thesis proposes a planning model that keeps decisions with specialists and allows them to use their own expressions for tactical planning, but incorporates expressions’ context traceability, authority control over these expressions, and expressions storage for reuse. These features were implemented in a Web tool that aims at empowering decision-making specialists, but tries to preserve the attributes of paper forms. The Web tool was evaluated in oil & gas industry emergency scenarios, and evaluation results indicated that the model’s approach enables important improvements in tactical planning communications and management within this context.

Keywords

Context-aware model, tactical planning, multi-expertise decision making, specialists’ interaction, major incident management

Resumo

Alencar, Marcus Franco Costa de; Raposo, Alberto Barbosa; Barbosa, Simone Diniz Junqueira. **Modelo Ciente de Contexto para Tomada de Decisão no Planejamento Tático Multi-especialidade em um Grande Incidente**. Rio de Janeiro, 2015. 112p. Tese de Doutorado - Departamento de Informática, Pontifícia Universidade Católica do Rio de Janeiro.

As atividades que envolvem problemas muito complexos e imprevisíveis continuam se baseando em tomada de decisão por humanos e ferramentas manuais como formulários. Este ainda é o caso para tomada de decisão no planejamento tático em um grane incidente, onde o conhecimento coletivo de especialistas em múltiplas especialidades é essencial para tomada de decisões urgentes e efetivas. Especialistas tendem a rejeitar ferramentas que comprometem a agilidade de decisão exigida, uma vez que elas podem colocar vidas humanas sob risco e causar grandes danos ao meio ambiente e propriedades. Comunicação e gestão são desafios, considerando que cada especialista possui sua própria “linguagem especializada”. Esta tese propõe um modelo de planejamento que mantém as decisões com os especialistas e permite que eles utilizem suas próprias expressões para planejamento tático, mas faz o rastreamento do contexto de cada expressão, faz o controle da autoridade sobre cada expressão, e armazena as expressões para permitir seu reuso. Essas funcionalidades foram implementadas numa ferramenta Web que visa dar maior poder aos especialistas tomadores de decisão, procurando preservar os atributos dos formulários em papel. A ferramenta Web foi avaliada em cenários de emergência na indústria de óleo e gás, e os resultados das avaliações da ferramenta indicaram que a abordagem do modelo viabiliza importantes melhorias em termos de comunicação e gestão do planejamento tático neste contexto.

Palavras-chave

Modelo ciente de contexto, planejamento tático, tomada de decisão multi-especialidade, interação entre especialistas, gestão de grande incidente

Summary

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1
Introduction

This chapter presents the current scenario for tactical planning in a major incident, the thesis motivation, the research questions and objectives, and the structure of this document.

1.1.
Current Scenario and Motivation

Computational tools continue to evolve rapidly, offering cloud services, new applications, new devices and new interaction modes, gradually incorporating new users and new tasks, participating in a growing number of human activities.

However, some human activities, which deal with very complex, time-constrained and unpredictable problems, are still relying on human decision-making and manual tools, like paper forms. This is the case for decision-making within strategic and tactical planning in a major incident, where higher management approval is required to deploy the required material and human resources, and the combined knowledge of multi-expertise specialists is essential to make the urgent and effective decisions needed. At the incident site, availability of technology is constrained, but much of the strategic and tactical planning for a major incident occurs off-site, where it is not constrained. This is a scenario that deserves deeper investigation.

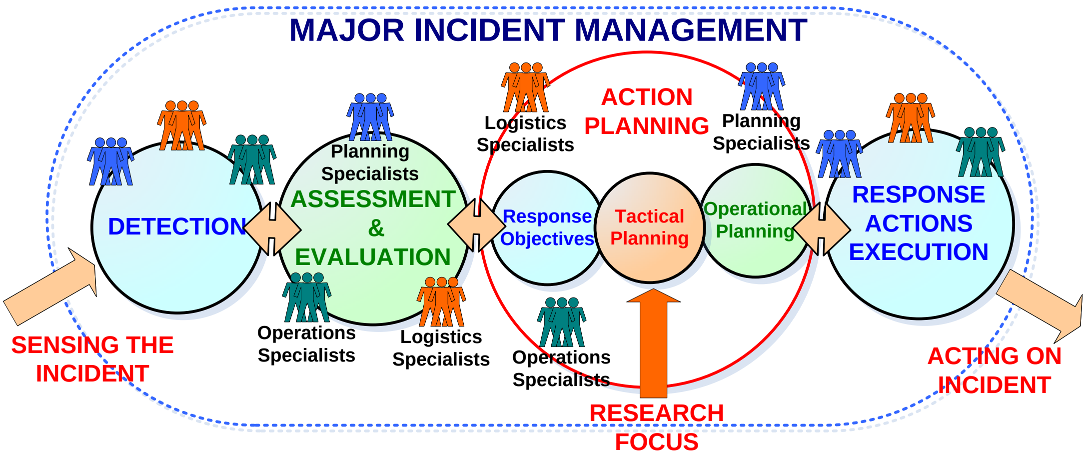


Figure 1. High-level Activities within a Major Incident and Research Focus

Figure 1 was conceived to illustrate the high-level activities required to deal with an incident, and to more clearly position the relative focus of this thesis. The figure was inspired by Norman's stages of user activities (Norman & Draper 1986, p.p. 41-42), which was conceived from a user's perspective, but it was adapted in this thesis to represent a collaborative action response cycle.

"The Physical System" in Norman's action cycle is represented in figure 1 by the incident, and the "User's Goals" by the response objectives. Norman's three execution steps can be mapped in figure 1 to tactical planning (intention), operational planning (action specification) and response actions execution (execution). Norman's three evaluation steps can be mapped in figure 1 to detection (perception), assessment (interpretation) and evaluation (evaluation).

Figure 1 also highlights the multi-expertise nature of the response activities in a major incident, and shows tactical planning as the focus of this research. Minor incidents, on the other hand, can be exclusively dealt by local crew and resources, not requiring explicit strategic and tactical planning, and therefore do not concern this research. Management of a major incident is a complex problem, and it becomes even more complex when involving people and resources from multiple agencies and countries.

In the Oil and Gas industry domain, where this research has its primary focus, there is a tendency to adopt the Incident Command System (ICS) process standard, defined by the Federal Emergency Management Agency (FEMA), aiming at mitigating some of the complexities in managing an incident.

In addition to a standardized process, emergency planning tools have been developed to incorporate specialized operational knowledge and procedures, running simulations and automating the process of producing ad-hoc operational response plans during an emergency. As an example, such an emergency response system (InfoPAE) has been developed, and described by Ferreira Filho et al. (2004) for a Brazilian Oil and Gas company: "The system offers sophisticated action plans, easy access to vital information and tight control over the resources allocated to face an emergency. InfoPAE works with emergency plans, which are structured collections of actions, coupled with information stored in geographical as well as conventional databases."

But at the strategic and tactical planning level, where multi-expertise planning takes place, the use of manually filled ICS paper forms, or a computer system that replicates them, is still widely adopted in Brazil. Their use was observed during a major incident simulation exercise in a Brazilian Oil & Gas company. Figure 2 illustrates a sample ICS-234 paper form, printed from a real system, which describes tactical planning of a fictitious incident created from this major simulation exercise, but with much of its information (actors, equipment, locations and dates) uncharacterized for confidential reasons.

Despite the adoption of a standardized process and incident response planning tools, communication and management in major incidents have still been a major challenge.

WORK ANALYSIS MATRIX		ICS 234
1. Incident Name Simulation A	**2. Operational Period** From: 11/Sep/2014 03:00	#1 v.4 (For Review) To: 12/Sep/2014 03:00
3. Operation's Objectives DESIRED OUTCOME	**4. Optional Strategies** HOW	**5. Tactics/Work Assignments** WHO, WHAT, WHERE, WHEN
1. Preserve Life	Repair Drilling Equipment	Borges OceanDrill Stabilize Drilling Equipment SO-54 Immediate
		OceanDrill Embark Team to Evaluate Repair Drilling Equipment 11/09/2014
		OceanDrill Recompose Drilling Team for Repair Drilling Equipment Immediate
		OceanDrill Evaluate Drilling Equipment Condition and Time to Return to Operations Drilling Equipment Immediate
2. Stop Leakage / Control Well	Capping	Scolari RG Evaluate viability of Well closure without fracturing Campos Basin Immediate
		SIGR Rubens Mobilize all capping resources available Rio Airport Immediate
		ImmFOX-MAC Provide Drawings/information to send a YYB OceanDrill Immediate
		SIGR Rubens Elaborate a Capping Operations Plan Campos Basin 12/09/2014
	Intervention with Drilling Equipment	FOX-MAC/OceanDrill Evaluate Viability of Drilling Equipment to Participate in Well Damping Campos Basin 14/09/2014
	Contention	SIGR Rubens Elaborate Contention Plan OU-CB 20/09/2014
5. Prepared by: *marcus.4biz@gmail.com* *(Incident Commander)*	**Date/Time** 27/01/2015 15:40	**6. Approved by:** **Date/Time**

Figure 2. Sample ICS-234 Form with part of Tactical Planning

During the incident simulation exercise cited above, we identified that planning management and communication within the emergency response organization needed improvements.

The report to the US President on the Gulf of Mexico Oil Spill of the British Petroleum (BP) Macondo Incident (Graham, Reilly, Beinecke, Boesch, Garcia, Murray and Ulmer, 2011) has also identified that management and communication were problematic: “Most, if not all, of the failures at Macondo can be traced back to underlying failures of management and communication.” While part of these failures has occurred pre-incident, some failures of management and communication have occurred during incident response planning.

Research studies have identified more specific communication problems in crisis management and response. Lundberg and Asplund (2011) have identified and addressed problems of situation awareness (problems with communicating long and short term goals, functions, and resources), communication paths (problems finding the right person to contact), form and content of communication (time consuming and ineffective forms of communication) and common ground (different opinions and ideas about basic concepts…). Tactical planning in a major incident has to deal with all these types of communication.

Saoutal, Cahier and Matta (2014) have also identified specific communication problems, in the interpretation of message, interoperability of tools, and information overload. Their study addressed the problem of communication among the multi-disciplinary response groups, sometimes in different organizations. These multi-expertise specialists and groups have each their own expert language and way of doing things, making communication a challenge. This kind of multi-expertise interaction occurs during tactical planning activities in a major incident.

Mishra, Allen and Pearman (2011, 2013, 2014) have addressed decision-making problems in multi-agency, time-constrained, complex and uncertain environments, including response to major incidents, covering many aspects of the problem areas focused by this research. They contend that adequate information sharing and use are essential to improve decision-making in this environment.

This thesis was motivated by the importance and urgency of improving the response to major incidents, particularly in the growing Oil and Gas exploration in risky areas, which has caused many life losses and damages to the environment and property. The motivation is also driven by the intriguing fact that Information and Communication Technology (ICT) has not yet properly addressed communication and management problems in this domain, in spite of its fast-paced growing ability to address communication and management problems in other domains.

1.2.
Research Questions and Objectives

Decision-making in incident response planning involves the complexity of going from high level response objectives down to the specialized operational response actions under time constraints. Figure 3 illustrates that the high level objectives are typically known by the organization, and do not vary significantly from one incident to the other: preserve life, contain source, minimize environment impact and minimize property damage. It also illustrates that lower level operational planning will involve the execution of operational procedures, typically well known by the specialists, although the choice and adequacy of procedures, as well as the amount of resources required, will depend on the incident.

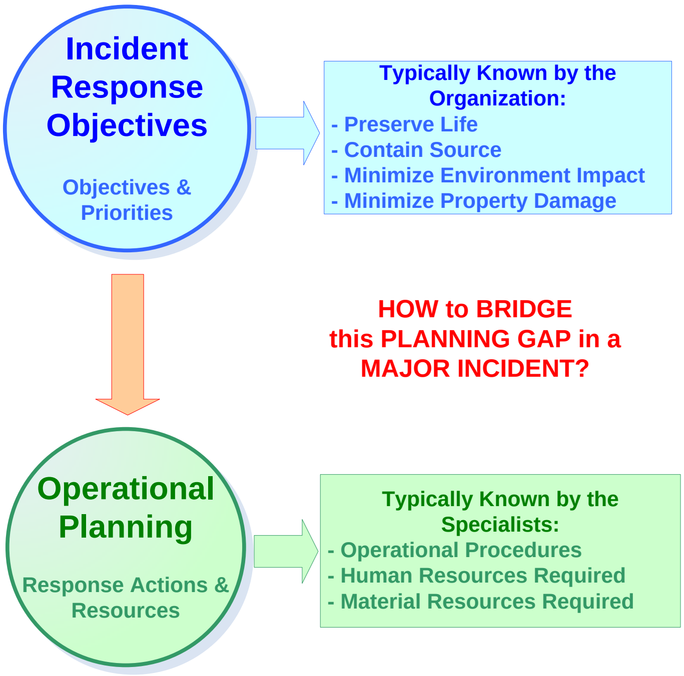


Figure 3. Tactical Planning Gap

Figure 4 addresses the challenge, which is how to bridge the planning gap between high-level objectives and operations, i.e. which strategies, tactics and operations, with what resources, will fulfill the high-level response objectives. In a major incident, this decision making occurs during the tactical planning process, that will establish which multi-expertise solutions (strategies) and respective ad-hoc work assignments (tactics) will translate these response objectives to the proper operational procedures and adequate resources.

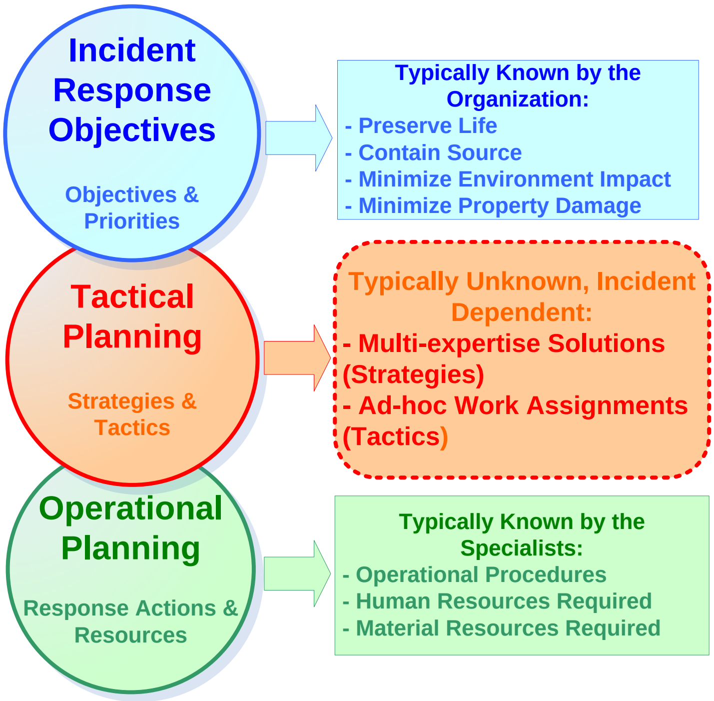


Figure 4. Complex Decision-making in Tactical Planning to Bridge the Gap

As discussed in the previous section, paper forms are still widely used in incident management. They have the virtue of simplicity and high availability, as it is generally easy to produce copies. But the use of paper forms poses the first high-level question of this research: *"How to improve the effectiveness of the process of assigning multi-expertise tactics to properly fulfill the incident response objectives?"* i.e. how to improve the effectiveness of the tactics plan.

Although simple to fill in, paper forms rely entirely on a manual process of filling the form by the appropriate personnel, and being approved by the appropriate personnel, to ensure that the tactics and strategies will fulfil the stated objectives. Communication and management using paper forms in an emergency scenario require very strict discipline from all parties involved, which is not easy to attain.

Automation to mirror paper forms, for example using a Word template, seems to be the first natural step, and it has been already adopted by some Oil & Gas companies. This facilitates form editing and can provide on-line availability of forms, but this is only a replication of the manual process, based on the same human decisions and form filling, so it does not bring a meaningful improvement for the tactical planning process.

On the other hand, during the evolution of this research it became clear that emergency specialists reject tools that add complexity and/or put at risk the decision agility required to respond to an incident, as this could put human lives at risk and cause major damages to the environment and property. Simplicity and agility are very important requirements. This could explain why, in some Oil & Gas companies, automation did not go much further than the use of digital replications of forms.

In such a scenario of rejection of excessive automation, we contend that instead of asking the more obvious question “what could be automated?” a better high-level question, the second one in this research, is: *“what should be automated and what should not?”* as it has been noted that too much automation can sometimes hinder effective incident management.

The two high-level questions described above drive high-level objectives, difficult to assess and evaluate, therefore they will not be stated as research questions, but will provide inputs to the proposed research questions.

The first research question was derived from the problem domain:

Q1: “How to improve communication and management within multi-expertise tactical planning in a major incident?”

The second research question derives from the first and second high-level questions and the discussions above:

Q2: “What types of information and prior knowledge should or should not be incorporated in the Tactical Planning Model to improve quickness and efficiency of multi-expertise Tactical Planning decision-making?”

The third research question derives from the second high-level question and the discussions above:

Q3. “What should be automated and what should not, to obtain benefits from automation of multi-expertise tactical planning, without jeopardizing the simplicity and availability of paper forms?”

The objective of this thesis is to address and respond to these research questions, by proposing a planning model that supports automation of the tactical planning process, and implements this model in a computer tool to perform tactical planning in a major incident. To assess the viability and utility of the proposed tactical planning model, and to gather additional design feedback, the model was instantiated in a Web tool, which was evaluated by experts of two Brazilian Oil & Gas companies.

1.3.
Thesis Structure

This thesis is organized in six chapters. Chapter 1 presents the current scenario for tactical planning in a major incident, the thesis motivation, the research questions and objectives, and the structure of this document.

Chapter 2 presents a review of the literature on the incident management problem domain, and some solutions that address the overall problem in related areas.

Chapter 3 discusses the development of the design requirements and describes the features and behavior of the Context-aware Planning Model, the object of this thesis, intended to improve communication and management in a major incident.

Chapter 4 describes the Web tool that implemented one instantiation of the model and support for tactical planning according to ICS.

Chapter 5 presents the evaluation of the Web tool by emergency response specialists, and an analysis of the results to guide the evolution of the Tactical Planning Model design.

Chapter 6 presents the conclusions of this research and potential future work that emerged from it.

2
Related Work

This chapter presents the literature review and related work in decision making within tactical planning.

2.1.
Literature Review

The increasing importance of major incident management, resulting from the growing number of disasters due to climate change and to oil and gas deep sea exploration, in combination with the complexity of these problems, has brought the attention of the academy to search for innovative and effective solutions, and has made the subject of major incident management a very relevant area for research

Due to its complex nature, very broad areas of research have been explored by researchers. Figure 5 illustrates some examples of this broad research, like detection of incidents through the social Web (Starbird et al. 2012), situation awareness tools (Ferreira 2011) for better assessment of incident situation, information verification (Papoola et al. 2013), to verify the quality of information from social media, operational planning tools (Ferreira Filho et al. 2004) for better planning the specialized operational response, workflow automation tools (Vieira and Casanova 2006), and incident response simulation tools (Mettello et al. 2008).

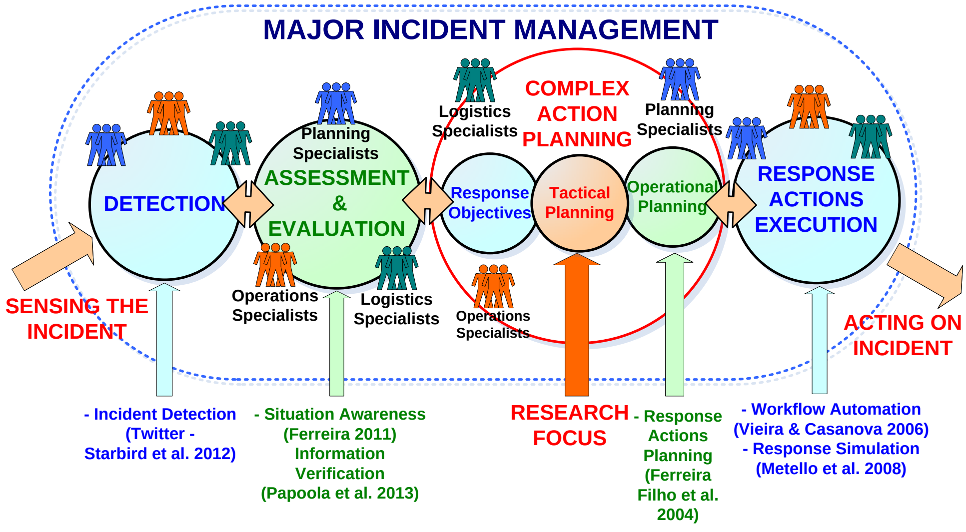


Figure 5. Research Focus and Other Research Areas

These are just a few examples. However, although all of these areas are well covered in proposing tools and solutions, this research found little in terms of tools and solutions for tactical planning. It has identified that most of the research work in this area is still focusing in understanding and mapping the problem situation.

The reason is that tactical planning is still a very big challenge to perform in the real world, so automation is an even bigger challenge. One of the main reasons is that it is seen by some of the emergency responders as unnecessary. Mishra et al. (2011) have investigated tactical planning in a multi-agency major incident, doing survey studies with several tactical commanders, and one of the issues they found was: "The tactical meeting is often considered the best practice in terms of sharing information among multi-agency emergency responders. However, as stated by one of the interviewees, tactical commanders may feel that tactical meetings are simply an extra job."

So tactical planning is viewed as important by top incident managers and good for the team, but it is perceived as unnecessary by some of the tactical commanders that have to do it. As pointed out in the previous chapter, tactical planning covers the decision making process to go from objectives to tactics.

An explicit tactics plan supports collaboration and leans the plan towards more "analytical" decision making. Individual non-explicit tactics plan supports "intuitive" decision making by the commanders. Mishra et al. (2014) discuss in their study the "dual processing debate", whether incident commander decision making tends to be more "intuitive" or more "analytic", which have been labeled as Type 1 and Type 2, respectively (Stanovich et al., 2011). Type 1 decision-making tends to be faster, as it relies on "intuitive knowledge", while Type 2 tends to take longer, in an attempt to make the "optimum decision". Tversky and Kahneman (1974) developed much of the original work that discussed heuristics and biases when making judgements under uncertain situations. Mishra et al. (2014) indicate in their study that context, e.g. time constraints, and individual differences, e. g. expertise, influence what decision making mode is used by the commander. They concluded that time pressure is a relevant contributing factor to the commanders tendency to engage in more "intuitive" decisions (Type 1), relying on their tacit knowledge. They also found in their research that "...Information is often not used to resolve uncertainty in decision making and indeed information is often sought and used after the decision is made to justify the decision." So a non-explicit tactics plan supports this kind of undesirable behavior. This thesis proposes to make the tactics plan explicit, very visible and readily available when dealing with major incidents.

Dolif et al. (2013) suggest in their study that tacit knowledge of experts is the main source of resilience in dealing with critical situations, looking at the positive side of using tacit knowledge for decision making during an emergency. They also found in the same study that: "…Decision-making processes are believed to be situation specific. Thus, taking contextual features in consideration is imperative in understanding the decision." This finding contributes to the context-aware design of the model proposed by this thesis.

Considering that tactical planning will have to interact consistently with response actions planning, this research has also analyzed InfoPAE publications, particularly Ferreira Filho et al. (2004), and has conducted meetings with InfoPAE development team, to understand and identify the boundaries and interaction between tactical planning and response actions planning. The outcome of these meetings was that communication among the team members and management of the plan was considered problematic during major incidents, as identified in the Introduction, so this research has also assessed work in communication and management within an emergency management context.

The inter-disciplinary interaction of specialists that occurs during an emergency has been a challenging problem. Russo et al. (2006) proposed an activity-centered multi-perspective collaboration metamodel to deal with dispersed and inter-disciplinary interactions during disaster management in an Oil & Gas company. Although this Russo's work addresses expert communication to produce the response actions, not the tactics plan, the activity centered concept has inspired this thesis to address and be aware of the whole activity context of an emergency.

Saoutal et al. (2014) produced a study that also addresses multi-disciplinary communication and focuses "… on the communication and information sharing between the most important emergency services, vertically and transversely." They model the inter-dependencies (actions, information, actors and tasks) that result from the inter-disciplinary nature of transversal communication in crisis management. Their model focuses in modelling the response actions, not the tactics plan, but also deals with multi-expert collaboration in an emergency, therefore helps understanding some of the multi-expert collaboration issues.

Chen et al. (2013) identify information sharing as critical for emergency response, and propose a model to address the lack of consistent standardization of emergency management practice. They use activity theory (Kaptelinin and Nardi 2006, Kaptelinin 2013) to guide the development of the data model. They address the communication problem at the operational response level, while this thesis addresses it at the tactical level, but their work is relevant to better understand the lower level tasks and how tactical planning will interact with them.

Turoff et al. (2004) developed a "…framework for the system design and development that addresses the communication and information needs of first responders as well as the decision making needs of command and control personnel". They describe in the paper "…five very specific criteria for the interface design of a group communication system that is extremely appropriate to the emergency response environment: metaphors, roles, notifications, context visibility, and hypertext."

The Web tool interface presented in this thesis has made use of these five criteria:

- use of a hierarchical tree metaphor to represent the Tactics Plan objectives, strategies and tactics hierarchy;
- use of roles to assign authority, independent of user;
- use of alerts and notifications to confirm undoable user action and to report what was done by the system and/or errors;
- provide context visibility of each expression;
- use of hypertext to jump from user id directly to find user contact information.

This section has addressed related research studies of incident communication problems and incident response actions planning. It has identified that tactical planning is an area that presents great challenges for automation, particularly with regards to multi-disciplinary decision making under time pressure.

The next section will address research work that has identified issues for decision making within tactical planning.

2.2. Decision making within Tactical Planning

Mishra et al. (2013, 2014) interviewed in their study a total of 20 tactical commanders to identify information sharing and decision making issues. In their research, "activity theory was used as the overreaching framework for understanding and exploring information management." They discuss findings in tactical decision making, and how the two decision making modes, Type 1 and Type 2, affect decision making. They found that under complex and uncertain environment, decision makers may not seek for more information to make more

Type 2 decisions, but instead they rely on their experience to fill the knowledge gap and make a decision considered more Type 1. They identified that experts make better decisions and this is more pronounced in time critical and complex situations.

Irrespective of which mode is better, the important point is related to time. If the experts had more time available, they would make better decisions, being them based on their tacit knowledge (Type 1) or based on more and better information analysis (Type 2). The model design shall aim for agility and information visibility to support decision making.

In another study, Mishra et al. (2011) address issues in multi-agency major incidents, where members of the response team do not know each other. They also use activity theory for their analysis, and present their findings in three dimensions: social, technological and temporal.

First finding is that “different agencies hold different information due to which tactical commanders need to meet in order to get a full picture of what is happening.” A full picture of the tactics plan is one of the things that all tactical commanders should be aware of. This thesis provides an easily accessible full view of the tactics plan.

In the social dimension, the study found that primacy of one agency is a problem, i.e. when one of the multiple agencies has more information than the others, being sufficient to do the job, they end-up not providing all the information required to the other agencies. The proposed model design will provide visibility of the whole plan to all parties. Another social finding was that terminology/language is an issue in such an environment, as “each emergency organization has its own set of reserved terms which form an organizational discourse...” The issue of interaction stress due to incompatible signification systems will be addressed in the next chapter, and the model will be designed with this issue in mind.

The third dimension was the time critical factor. The time pressure to make a decision was discussed previously, i.e. need for timely and concise information. The model proposed by this thesis was designed to offer timely and easily visible context-aware planning information.

In the technical dimension, the study of Mishra at al. (2011) found issues in availability and simplicity. The model will also be designed with these issues in mind.

Although these researchers have done extensive research in understanding and discussing the problem of decision making within multi-agency tactical planning in a major incident, they have not proposed yet an automated application to deal with the issues, which is the intend of the model being proposed by this thesis.

Kapucu and Garayev (2011) go as far as proposing an organizational framework, not an automated application, as a tool to deal with multi-agency planning during an incident. They also do not have a proposal to support tactical planning with an automated application.

O'Leary (2010) applies activity theory as a theoretical framework for the analysis of DSS (Decision Support Systems) and provides an example on how to apply it. The analysis in this paper helps to understand the importance of contextualizing decision making, leading to context-aware models when implementing automation.

This thesis has embraced the challenge to propose a solution to improve decision making within tactical planning, in the form of a context-aware planning model that will support tactical planning process automation, and will facilitate decision making by the experts. This model will be presented and discussed in the next chapter.

3
The Context-aware Planning Model

This chapter discusses some of the tactical planning alternatives, addresses tactical planning within the scope of the ICS process, describes one current alternative for tactical planning automation, presents the tactical planning issues versus the context-aware planning (CAP) model design approaches, and the proposed CAP model description.

3.1.
Tactical Planning Automation Alternatives

Considering that tactical planning is currently done mostly via paper forms, an attempt to solve management & communication problems would be to automate Tactical Planning.

The first and simpler automation alternative would be to use Word templates that replicate the ICS Forms, including ICS-234, which deals with tactical planning. As discussed at the introduction, this facilitates form editing and can provide on-line availability of forms, improving plan awareness, but it does not bring a meaningful improvement for the tactical planning process.

The second alternative would be a planning application for the desktop. But current planning applications are abandoning this alternative in favor of a more modern and widely available Web tool. This is the case for InfoPAE (http://www.tecgraf.puc-rio.br/areas-de-pesquisa/meio-ambiente-e-seguranca/), the planning system cited at the introduction, which is migrating from desktop planning to Web planning, introducing support to collaborative planning. Therefore, the desktop alternative will not be addressed further.

The third alternative would be a planning application with current Web technologies. This alternative is discussed and described in section 3.3.

Finally, this thesis proposes and presents a fourth alternative, the context-aware planning (CAP) model, which leverages current design alternatives by incorporating unique features that ultimately improve communication and management. CAP model design approach and description are presented in sections 3.4 and 3.5, respectively.

3.2. ICS Process Tactical Planning

The ICS (Incident Command System) process is a subcomponent of NIMS (National Incident Management System), which is maintained by FEMA (Federal Emergency Management Agency) that belongs to the US Department of Homeland Security. ICS has become a widely adopted standard for incident management, so the alternatives discussed in this research, Commercial Web Tool and CAP Model, incorporate support for ICS. Even countries and corporations that do not adopt ICS tend to adopt a similar incident management process.

Appendix A provides a more detailed description of ICS, which defines the organizational structure for incident response and its roles, the planning "P" cycle management, and the standard forms to plan the incident response and exchange information.

Figure 6 illustrates the ICS planning "P". Its leg represents the initial response phase of the incident. For major incidents, right after the initial response the planning process initiates operational periods that cycle around the P, from the objectives meetings up to the execution of the plan, returning to the objectives meeting for the next operational period. Each operational period produces one IAP (Incident Action Plan) which includes one ICS-202 Form (Incident Objectives) and one ICS-234 Form (Tactics Plan).

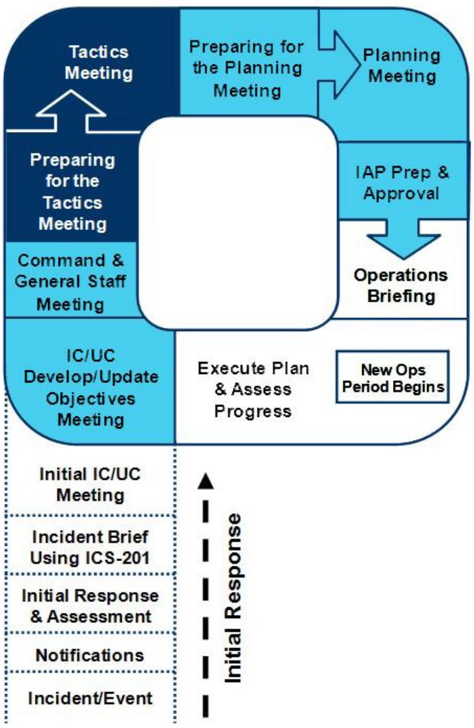


Figure 6. Tactical Planning Phases within ICS Planning "P" (source: FEMA)

In practice, the activities to produce the Tactics Plan occur during the seven phases highlighted in figure 6:

1. Incident Commander/Unified Command Develop/Update Objectives Meeting
2. Command & General Staff Meeting
3. Preparing for the Tactics Meeting
4. Tactics Meeting
5. Preparing for the Planning Meeting
6. Planning Meeting
7. Incident Action Plan (IAP) Preparation & Approval

Although the core of Tactical Planning production activities occurs in phases 3 and 4 (darker in figure 6), “Preparing for the Tactics Meeting” and “Tactics Meeting”, phases 1 and 2 involve discussions on strategies, which will be part of the Tactics Plan, and phases 5 to 7 will involve potential updates to the Tactics Plan, along the detailing of the other plans (human resources, material resources, etc.), until final approval of all plans at phase 7, as part of the IAP.

The two most relevant forms to produce the initial version of the Tactics Plan are ICS-202 and ICS-234.

INCIDENT OBJECTIVES		**ICS 202**
1. Incident Name Simulation A	**2. Operational Period** #1 v.4 (For Review) From: 11/Sep/2014 03:00 To: 12/Sep/2014 03:00	
3. Objective(s) 1. Preserve Life 2. Stop Leakage / Control Well 3. Minimize Environmental Consequences		
4. Operational Period Command Emphasis (Safety Message, Priorities, Key Decisions/Directions) Remove People Remove Drilling Equipment from Well Avoid Drilling Equipment Explosion Resources for Environmental Control Close Production Alert All Organizations Involved Prepare a Note to the Press		
5. Prepared by: *marcus.4biz@gmail.com (Incident Commander)* **Date/Time** 27/01/2015 15:40	**6. Approved by:** **Date/Time**	

Figure 7. Sample ICS-202 – Incident Objectives

ICS-202 form, Incident Objectives, defines the incident objectives and command emphasis for an operational period, as illustrated in figure 7 in the sample of a filled ICS-202 form for a fictitious incident extracted from an actual simulation exercise. Production and approval of ICS-202 form generally occurs at phase 1 and is presented to the team in phase 2.

ICS-234 form, Work Analysis Matrix, defines strategies and tactics to accomplish the incident objectives for an operational period. It essentially captures the Tactics Plan, which is represented through a matrix with a hierarchy of objectives, strategies and tactics, as already illustrated in figure 2 at the introduction chapter (replicated here in Figure 8 to facilitate reading), from the same fictitious incident as in ICS-202.

WORK ANALYSIS MATRIX		**ICS 234**
1. Incident Name Simulation A	**2. Operational Period** From: 11/Sep/2014 03:00 To: 12/Sep/2014 03:00	#1 v.4 (For Review)
3. Operation's Objectives DESIRED OUTCOME	**4. Optional Strategies** HOW	**5. Tactics/Work Assignments** WHO, WHAT, WHERE, WHEN
1. Preserve Life	Repair Drilling Equipment	Borges OceanDrill Stabilize Drilling Equipment SO-54 Immediate
		OceanDrill Embark Team to Evaluate Repair Drilling Equipment 11/09/2014
		OceanDrill Recompose Drilling Team for Repair Drilling Equipment Immediate
		OceanDrill Evaluate Drilling Equipment Condition and Time to Return to Operations Drilling Equipment Immediate
2. Stop Leakage / Control Well	Capping	Scolari RG Evaluate viability of Well closure without fracturing Campos Basin Immediate
		SIGR Rubens Mobilize all capping resources available Rio Airport Immediate
		ImmFOX-MAC Provide Drawings/information to send a YYB OceanDrill Immediate
		SIGR Rubens Elaborate a Capping Operations Plan Campos Basin 12/09/2014
	Intervention with Drilling Equipment	FOX-MAC/OceanDrill Evaluate Viability of Drilling Equipment to Participate in Well Damping Campos Basin 14/09/2014
	Contention	SIGR Rubens Elaborate Contention Plan OU-CB 20/09/2014
5. Prepared by: *marcus.4biz@gmail.com* *(Incident Commander)*	**Date/Time** 27/01/2015 15:40	**6. Approved by:** **Date/Time**

Figure 8. Sample ICS-234 Form with part of Tactical Planning

As it can be seen from the ICS-202 and 234 forms in figures 7 and 8, although objectives are created and defined in ICS-202, they are also present in ICS-234, where the objectives (field 3) are broken down in strategies (field 4), which in turn are broken down in tactics (field 5) to accomplish the strategy. In addition to defining the objectives, ICS-202 also defines the command emphasis, which applies to the whole operational period. Combining ICS-202 and 234 forms, the ICS Tactical Planning hierarchy for an Incident is illustrated in figure 9.

INCIDENT					
OPERATIONAL PERIOD 1					
COMMAND EMPHASIS (ICS-202)					
OBJECTIVES	STRATEGIES (ICS-234)	TACTICS (ICS-234)			
ICS-202 => 234	HOW	WHO	WHAT	WHERE	WHEN
Objective 1	Strategy 1.1	Tactic 1.1.1	Tactic 1.1.1	Tactic 1.1.1	Tactic 1.1.1
		Tactic 1.1.2	Tactic 1.1.2	Tactic 1.1.2	Tactic 1.1.2
		Tactic 1.1.3	Tactic 1.1.3	Tactic 1.1.3	Tactic 1.1.3
	Strategy 1.2	Tactic 1.2.1	Tactic 1.2.1	Tactic 1.2.1	Tactic 1.2.1
		Tactic 1.2.2	Tactic 1.2.2	Tactic 1.2.2	Tactic 1.2.2
	Strategy 1.3	Tactic 1.3.1	Tactic 1.3.1	Tactic 1.3.1	Tactic 1.3.1
		Tactic 1.3.2	Tactic 1.3.2	Tactic 1.3.2	Tactic 1.3.2
		Tactic 1.3.3	Tactic 1.3.3	Tactic 1.3.3	Tactic 1.3.3
Objective 2	Strategy 2.1	Tactic 2.1.1	Tactic 2.1.1	Tactic 2.1.1	Tactic 2.1.1
	Strategy 2.2	Tactic 2.2.1	Tactic 2.2.1	Tactic 2.2.1	Tactic 2.2.1
		Tactic 2.2.2	Tactic 2.2.2	Tactic 2.2.2	Tactic 2.2.2
Objective 3	Strategy 3.1	Tactic 3.1.1	Tactic 3.1.1	Tactic 3.1.1	Tactic 3.1.1
		Tactic 3.1.2	Tactic 3.1.2	Tactic 3.1.2	Tactic 3.1.2
	Strategy 3.2	Tactic 3.2.1	Tactic 3.2.1	Tactic 3.2.1	Tactic 3.2.1
		Tactic 3.2.2	Tactic 3.2.2	Tactic 3.2.2	Tactic 3.2.2
		Tactic 3.2.3	Tactic 3.2.3	Tactic 3.2.3	Tactic 3.2.3
OPERATIONAL PERIOD 2					

Figure 9. ICS Tactical Planning Hierarchy

The Tactics in ICS-234 drive the operational response actions, which is detailed in ICS-215 (Material Resources) and ICS-204 (Human Resources), and produced as part of IAP up to phase 7. But addressing the resources for each tactic, and filling its forms, is outside the scope of the model developed by this research, because this is an area well covered by other researches and systems, e.g. InfoPAE. This thesis only addresses automation of forms ICS-202 (Incident Objectives) and ICS-234 (Work Analysis Matrix).

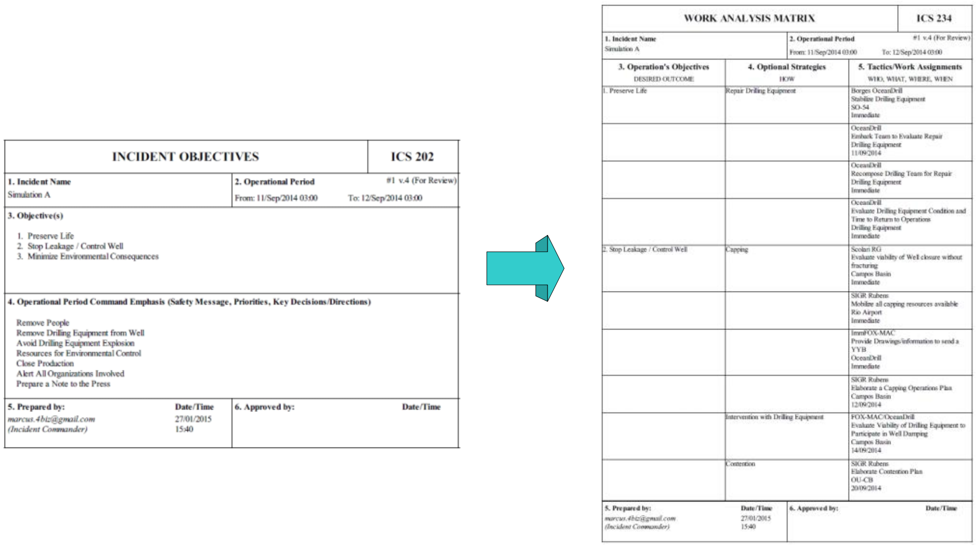
3.3. Commercial Web Tool for Tactical Planning

As discussed in section 3.1, current incident planning systems are adopting Web technologies.

Although there are several ways to employ Web technologies for ICS planning, we will discuss and describe one hypothetical case of a commercial implementation of a Web Tool for Tactical Planning, encompassing only the features for the production and approval of ICS-202 and ICS-234 forms. This hypothetical "Commercial Web Tool" incorporates the more relevant features being considered for the next generation of InfoPAE, which will use Web technologies and fully support the ICS process, not only ICS-202 and ICS-234 forms. But considering that InfoPAE next generation is still under development and has a broader objective, these features do not represent InfoPAE features. They are identified in this research just to provide a reference for a commercial implementation of a planning Web Tool, one that employs currently available technologies and concepts.

The features being assumed for this hypothetical "Commercial Web Tool" are:

- *ICS Tactical Planning Hierarchy:* implements the ICS process Tactical Planning hierarchy. A logical representation of this hierarchy was presented in figure 9 of section 3.2;
- *Automatic ICS Forms Data Linkage:* automatically links information provided in one form to what is required in another form, e.g. incident objectives from ICS-202 are automatically available in ICS-234 to produce the Tactics Plan;
- *ICS Forms/Plans Approval:* supports sequential approval of forms/plans, e.g. enforces the order in which forms/plans have to be created and approved. Figure 10 illustrates the strict sequential approval of ICS-202 (Objectives) before ICS-234 (Tactics Plan). Although this approach warrants Tactical Plan integrity, it requires that ICS-202 is approved before ICS-234 can start creation and update of strategies and tactics, what limits agility;
- *Multiple Views of Tactics Plan:* supports views of the Tactics Plan hierarchy, per responsible for the Tactics in an organizational chart, per location of the Tactics in a georeferenced map and per expected time to completion of each Tactics in a schedule, as illustrated in figure 11;
- *On-line Multi-user Web Access to Forms/Plans:* supports simultaneous access and editing of forms/plans by multiple users, particularly the Tactics Plan (ICS-234), expediting its production and approval.



INCIDENT OBJECTIVES | ICS 202

1. Incident Name
Simulation A

2. Operational Period #1 v.4 (For Review)
From: 11/Sep/2014 03:00 To: 12/Sep/2014 03:00

3. Objective(s)

1. Preserve Life
2. Stop Leakage / Control Well
3. Minimize Environmental Consequences

4. Operational Period Command Emphasis (Safety Message, Priorities, Key Decisions/Directions)

Remove People
Remove Drilling Equipment from Well
Avoid Drilling Equipment Explosion
Resources for Environmental Control
Close Production
Alert All Organizations Involved
Prepare a Note to the Press

5. Prepared by: marcus.4biz@gmail.com (Incident Commander) Date/Time 27/01/2015 15:40

6. Approved by: Date/Time

WORK ANALYSIS MATRIX | ICS 234

1. Incident Name
Simulation A

2. Operational Period #1 v.4 (For Review)
From: 11/Sep/2014 03:00 To: 12/Sep/2014 03:00

3. Operation's Objectives DESIRED OUTCOME	4. Optional Strategies HOW	5. Tactics/Work Assignments WHO, WHAT, WHERE, WHEN
1. Preserve Life	Repair Drilling Equipment	Borges OceanDrill Stabilize Drilling Equipment SO-54 Immediate
		OceanDrill Embark Team to Evaluate Repair Drilling Equipment 11/09/2014
		OceanDrill Recompose Drilling Team for Repair Drilling Equipment Immediate
		OceanDrill Evaluate Drilling Equipment Condition and Time to Return to Operations Drilling Equipment Immediate
2. Stop Leakage / Control Well	Capping	Scolari RG Evaluate viability of Well closure without fracturing Campos Basin Immediate
		SIGR Rubens Mobilize all capping resources available Rio Airport Immediate
		ImmFOX-MAC Provide Drawings/information to send a YYB OceanDrill Immediate
		SIGR Rubens Elaborate a Capping Operations Plan Campos Basin 12/09/2014
	Intervention with Drilling Equipment	FOX-MAC/OceanDrill Evaluate Viability of Drilling Equipment to Participate in Well Dumping Campos Basin 14/09/2014
	Contention	SIGR Rubens Elaborate Contention Plan OU-CB 20/09/2014

5. Prepared by: marcus.4biz@gmail.com (Incident Commander) Date/Time 27/01/2015 15:40

6. Approved by: Date/Time

Figure 10. Sequential Approval of ICS Form 202 (left) before Form 234 (right)

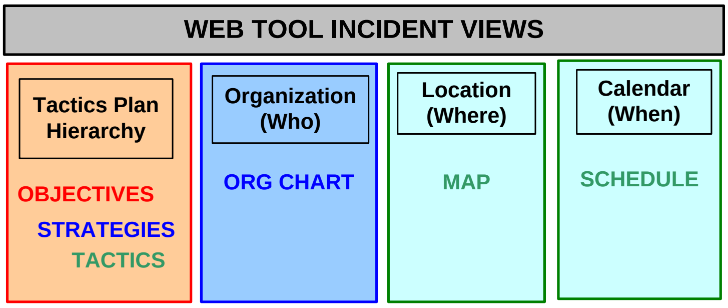


Figure 11. Commercial Web Tool Incident Views

Therefore, upcoming commercial Web Tools are automating the tactical planning process that currently uses paper forms or its digital replica.

This research proposes a model to go beyond what is being implemented by the hypothetical Commercial Web Tool using current approaches. The model aggregates metadata to each planning item instance, and uses this metadata to improve planning.

3.4. The Tactical Planning Issues versus CAP Model Design Approach

As we learned from the previous chapters, there is a need to address management and communication problems regarding decision-making within multi-expertise planning in emergency and disaster management, i.e. major incidents. But management and communication are high-level problems, applicable to almost any domain, and do not identify specific issues, so it deserves further investigation.

Another challenge is the requirement for decision-making to be effective under such a time-constrained and complex environment. Mishra et al. (2011) have done extensive research on information sharing during multi-agency major incidents. They identified that *"… information sharing in such context needs to be undertaken rapidly with concise communication of relevant information."* Ibrahim and Allen (2012) study, on *Information sharing and trust during major incidents*, states that "*The success or failure of the response hinges on the effectiveness of the response during this period as emergency responders aim to respond quickly and efficiently to a very complex situation*."

The decision-making environment is antagonistic: the quicker decisions are made, the less likely to be efficient, and vice-versa, the more work to make it efficient, the slower is the decision.

Mishra et al. (2011) address the importance of information sharing in the context of multi-agency collaboration within major incidents. They have organized the factors that impact information sharing in three groups: social factors, time factors and technological factors. Social factors include: trust, primacy of one agency, classifying information, motivation and language. Time factors include: timely information and concise communication. Technological factors include: availability, simplicity, familiarity, reliability and interoperability.

Deriving from the response requirements and the impacting factors identified above, this research has chosen three attributes focused in improving collaborative tactical planning: agility, visibility and trust. Agility refers to improving user ability to quickly produce the plan, by not only providing features that accelerate production, but also by not introducing features that confuse the user and compromise agility. Visibility refers to making relevant information clearly visible and easily accessible by all users, improving information sharing. Trust refers to providing information that improves user's trust in the planning produced by other users.

The need to improve Agility derives from the need to reduce impact from time factors. The need to improve Trust derives from the need to reduce impact from social factors, particularly trust. The need to improve Visibility derives from the need to reduce impact from both time and social factors, as information visibility can improve information sharing, which can positively impact time and social factors, as described by Mishra et al. (2011). Improvement of the language factor issues was addressed by reducing planning interaction stress, and the adopted approach will be explained in the next section.

The technological factors were dealt by implementing a Web based solution to replace the use of paper forms, aiming to provide a high degree of simplicity, availability, familiarity, reliability and interoperability. The current use of paper forms for incident management provides simplicity, availability and a certain degree of agility resulting from these two attributes. They are still the norm in some Brazilian Oil & Gas Companies.

In summary, this research addresses tactical planning issues which are likely to remain with automation, and targets to improve agility, visibility and trust, without compromising simplicity and availability of paper forms. Within the scope of this research, the three attributes will be defined as:

a. **Agility** of tactics plan production, review and approval, and communications among team members;
b. **Visibility** by the required team members of the planning activities and relevant information for decision-making;
c. **Trust** by the required team members, in the contents and status of the tactics plan during its production, review and approval.

Considering that the ICS process is new to Oil & Gas companies in Brazil, some of the tactical planning issues identified originate from lack of training in ICS. This is expected, and although it is a problem in the short term, it is less of an issue in the long run, as this can be mitigated with proper training in ICS, considering that it has a quite stable set of policies and standards. Therefore, ICS training issues will not be further addressed in this research.

In further analysis of Commercial Web Tool automation features (section 3.3), and learning from participation in incident simulation exercises, from reading ICS manuals, and from academic incident response research, tactical planning issues that will remain were identified and consolidated in five issues, three related to communications and two related to management:

a. Communications: Planning Interaction Stress
b. Communications: Lack of Planning Items Awareness
c. Communications: Planning Knowledge Reuse
d. Management: Tactical Planning Tasks in Sequence
e. Management: Plan/Forms Production and Approval in Sequence

These issues will be described and addressed in the following sections.

3.4.1. Planning Interaction Stress

Incident response planning involves decision-making in a multi-expertise and time-constrained environment. Ibrahim and Allen (2012) refer to Engeström's (2000) activity theory within the context of planning an emergency response for major incidents: “A key theoretical construct in activity theory is that of contradictions, which are tensions within or between elements (e.g. object, rules, subjects, tools) of an activity system. These manifest in the form of deviations from standard scripts, thereby threatening its coherence. According to Engeström although activity systems are driven by a deeply communal motive, they are inherently contradictory. To achieve the goals of the activity, therefore, contradictions have to be resolved.”

These contradictions and tensions during incident planning will be referred to as planning interaction stress, and although they are unavoidable for the specialists to converge to a solution, we contend that they must be avoided when unnecessary.

Mishra et al. (2011) identified in their study that language/terminology is an issue from a social dimension: “Each emergency organization has its own set of reserved terms which form an organizational discourse and often organizational shorthand for communicating. While this may facilitate efficient communication within an organization it may cause problems when communication between organizations needs to occur.” One of the participants in this study said “… there is a clear need for shared ontologies and the reduction of the use of reserved terms when natural language would suffice.” So in fact, each team member in a multi-expertise response may bring his/her own signification system, what causes interaction stress.

Adding to the issue, the growing complexity of computer systems has resulted in increasingly inconsistent user interaction, one in which the user is forced to interact with multiple signification systems, produced by multiple system designers (Alencar, Raposo and Barbosa, 2010), causing additional interaction stress that jeopardizes human activity. De Souza (2005) addresses and discusses the communication between designers and users at interaction time within the scope of semiotic engineering.

Figure 12 illustrates the multi-expertise users’ interaction with a multiple designers system, in this case three different significations systems, at the right, that each user has to interact simultaneously. Consistency of these designer significations systems is important otherwise the user will get confused (Alencar et al. 2010).

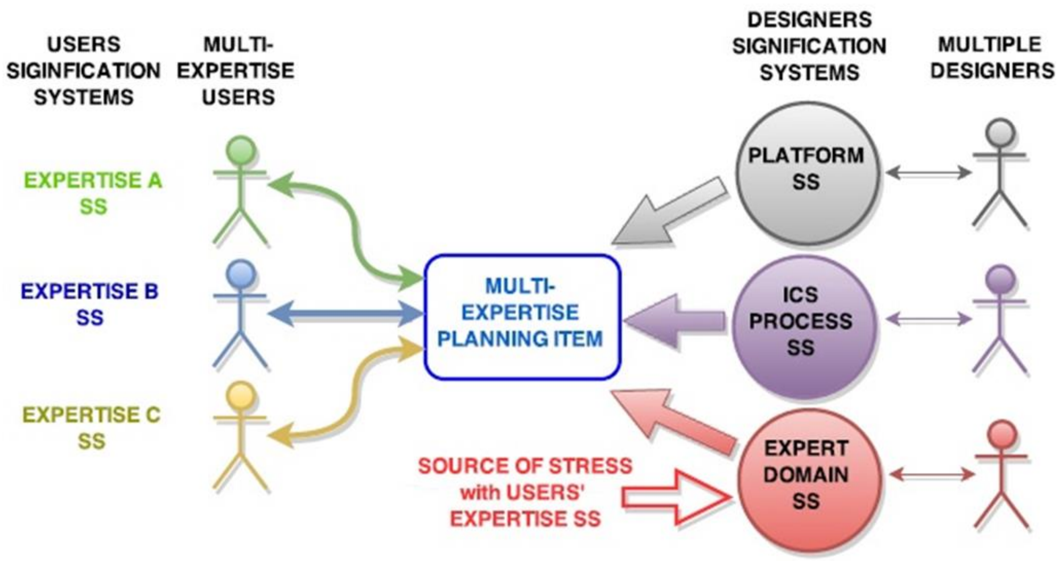


Figure 12. Interaction Stress due to Multiple Signification Systems

However, the multi-disciplinary interaction that occurs during tactical planning among the experts is unavoidable, and the incident resolution needs it to happen, so all that can be done for that matter is training and asking the team members to reduce the use of specialized terms when creating the plans, as suggested in the paragraph above.

The other suggestion from Mishra's study is for participants to use shared ontologies. But in this research we contend that, within such a multi-disciplinary scenario, shared ontologies should only be used for the process domain, which has a stable set of policies and standards, and therefore could be learned with proper training.

A common signification system for multi-expertise team should be as generalist as possible, not incorporating any expertise knowledge, as it would be the source of additional stress with some users, to an already stressful interaction. It would require significant training from users not familiar with it, and because it is not their own, they will not use it after the emergency and will be untrained at the time of another emergency, creating a barrier to use the automated system.

To aggravate this situation, expert knowledge is constantly evolving, so a common signification system that incorporates expert knowledge will require constant user training, something not feasible if it is not that user's area of expertise.

Tools that incorporate specialized significance systems end up restricting meanings assignment and communication by the user. It is up to the designer to capture and establish the common specialized signification system, during system requirements analysis and design. But this is called decontextualization, where institutionally grounded representations, in this case the tool provided to the user, predominate over the user representation. Lave (1996) cites Mehan to explain decontextualization: “When technical language is used and embedded in the institutional trappings of the formal proceedings of a meeting, the grounds for negotiating meaning are removed from under the conversation.” User decontextualization would be the cause of additional planning interaction stress.

Due to the complexity and ad-hoc nature of an incident, trying to impose a limited set of available solutions and/or a standardized communication language among multi-disciplinary specialists could get a negative reaction from them, as it would restrict their actions and/or require training to deal with the added complexity. In meetings with emergency specialists, they were very clear to point out that an incident planning tool should be as simple to use as typing a document in a word processor.

Note that freely filled paper forms incorporate knowledge about the response management process, but they do not incorporate specialized knowledge or restrict the user from using his/her own significance system, and that is one strong reason why they are still in use for much of the planning process. If automation design does incorporate this simplicity as an attribute, then freely paper filled forms, or a digital replication of them, will continue to be the norm for much of the multi-expertise interaction.

So the recommended design approach is that computer tools designed to support interaction among multi-expertise specialists should not implement specialized signification systems, they should focus on signification required to manage the collaboration process, to facilitate interaction and support more **trust** in the plan, because it is under control, and let specialists equally and freely express themselves, without having to deal with unfamiliar signification systems or being restricted from entering their own, what supports planning **agility**. It is important to remove any barrier for specialists to enter their knowledge in the system. Figure 13 illustrates the recommendation not to incorporate a common expert signification system in the automated system, but maintain, and even enhance, automation of the collaboration process, in this case ICS. The model proposed by this thesis is guided by this recommendation.

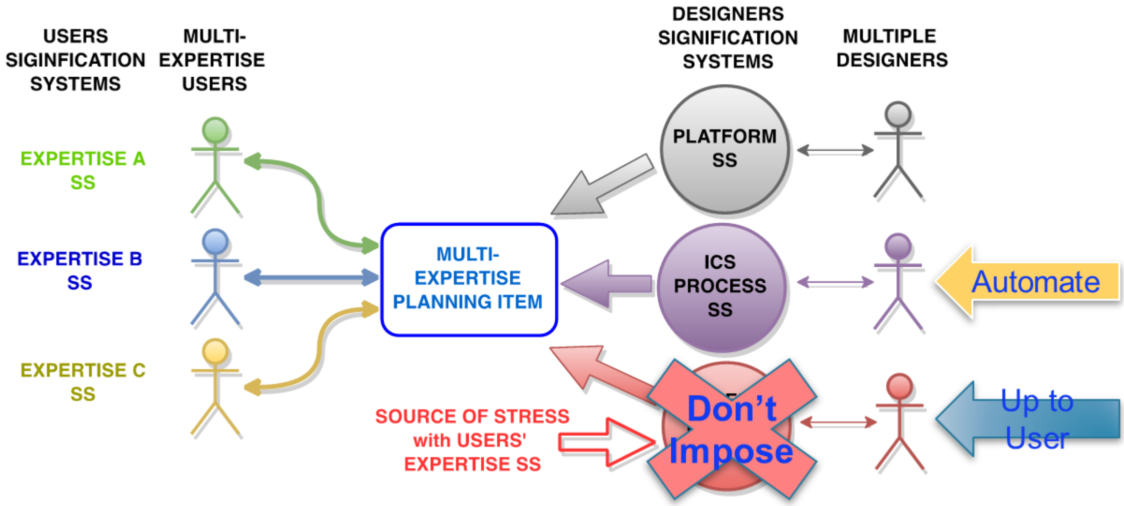


Figure 13. Do not Introduce Additional Stress Focus in Process

It could be argued that letting the specialists enter their own signification systems would also cause stress. While this is partially true, this is the unavoidable interaction stress already present among specialists in this scenario, as explained above, so this is not an additional interaction stress. The signification system will just be stored by the system, without semantic processing, and eventual conflicts will be resolved through interaction between the specialists within the planning activity.

Basically, users should communicate using a generalist language, one that everyone can understand. The system should be agnostic to it, and should not expose the user to signification systems that they are not familiar with, otherwise interaction stress could jeopardize all three desired planning attributes: it will cause loss of decision-making **agility**, due to the time lost trying to understand, loss of **trust** in the system, due to not understanding the system, and even lack of information **visibility**, due to not being capable of perceiving the intended meaning of information he/she is not familiar with.

Another justification to incorporate expert knowledge during the design of the automated system would be for the highly desired ability to reuse previous expert knowledge, in an attempt to improve planning **agility** and **trust**. But if the specialist rejects the tool, tactical planning knowledge will not be captured by the system at all. So the expert knowledge should be limited to expert tools designed to help develop the operational responses, more detailed and hierarchically below the Tactics.

But knowledge reuse is an important demand from specialists to expedite decision-making during an incident, so a different approach will be proposed in section 3.4.3 for knowledge reuse, one that would not introduce relevant interaction stress.

3.4.2.
Lack of Planning Items Awareness

Incident awareness is very important to support effective decision-making during an emergency. But improving incident awareness will not be addressed, because it would have to involve incident-site operational activities, which is out of the scope of this research.

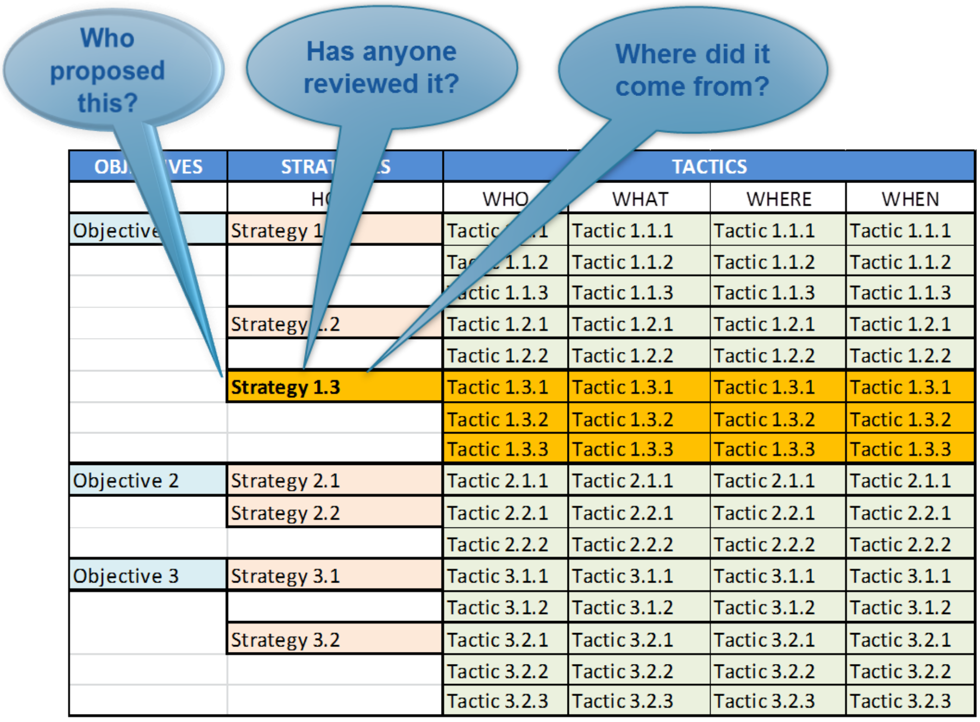
But during a simulation exercise at an Oil & Gas Brazilian Company, where the computer system worked with a digital replica of ICS paper forms, a particular communication and management issue was identified:

- Difficulty to follow-up management of the incident, to understand the flow of activities, and the phase in which the incident is.

This issue relates to lack of planning awareness, which tends to be overseen with regards to the importance of incident awareness, but this is an issue that can and will be addressed by this research for tactical planning.

But lack of planning awareness goes beyond awareness about just the plan. In fact, it has also to do with awareness of the planning items, which in our case can be of the type objectives, strategies or tactics. Figure 14 illustrates questions that team members could have regarding the information entered in the plan for the planning item "strategy 1.3". This kind of information comprises the context of the planning item "strategy 1.3" in figure 14, and helps the recipient of the information to have a better notion of the meaning and relevancy of its content.

The need to consider the context of human activity in the design of computer interaction is not a novel concept, but its importance has grown in recent years. Coutaz, Crowley, Dobson and Garlan (2005) argue on the importance of taking context in consideration, reinforcing the need to have a broader view of the application and its context, i.e. the whole human activity.



OBJ[illegible]VES	STRAT[illegible]S	TACTICS			
	H[illegible]	WHO	WHAT	WHERE	WHEN
Objective[illegible]	Strategy 1[illegible]	Tactic [illegible]1	Tactic 1.1.1	Tactic 1.1.1	Tactic 1.1.1
		Ta[illegible] 1.1.2	Tactic 1.1.2	Tactic 1.1.2	Tactic 1.1.2
		[illegible]actic 1.1.3	Tactic 1.1.3	Tactic 1.1.3	Tactic 1.1.3
	Strategy [illegible].2	Tactic 1.2.1	Tactic 1.2.1	Tactic 1.2.1	Tactic 1.2.1
		Tactic 1.2.2	Tactic 1.2.2	Tactic 1.2.2	Tactic 1.2.2
	Strategy 1.3	Tactic 1.3.1	Tactic 1.3.1	Tactic 1.3.1	Tactic 1.3.1
		Tactic 1.3.2	Tactic 1.3.2	Tactic 1.3.2	Tactic 1.3.2
		Tactic 1.3.3	Tactic 1.3.3	Tactic 1.3.3	Tactic 1.3.3
Objective 2	Strategy 2.1	Tactic 2.1.1	Tactic 2.1.1	Tactic 2.1.1	Tactic 2.1.1
	Strategy 2.2	Tactic 2.2.1	Tactic 2.2.1	Tactic 2.2.1	Tactic 2.2.1
		Tactic 2.2.2	Tactic 2.2.2	Tactic 2.2.2	Tactic 2.2.2
Objective 3	Strategy 3.1	Tactic 3.1.1	Tactic 3.1.1	Tactic 3.1.1	Tactic 3.1.1
		Tactic 3.1.2	Tactic 3.1.2	Tactic 3.1.2	Tactic 3.1.2
	Strategy 3.2	Tactic 3.2.1	Tactic 3.2.1	Tactic 3.2.1	Tactic 3.2.1
		Tactic 3.2.2	Tactic 3.2.2	Tactic 3.2.2	Tactic 3.2.2
		Tactic 3.2.3	Tactic 3.2.3	Tactic 3.2.3	Tactic 3.2.3

Figure 14. Lack of Planning Item Awareness

Activity Theory is well suited to help understand human activity’s interaction context and human attention, including human-computer interaction. It was proposed by Russian psychologist Aleksei Leontiev in the 1930’s, and was further developed in the 1980’s by Scandinavian Yrjö Engeström and other Western researchers.

In recent years, a growing number of researchers have been applying Activity Theory in analyzing issues and developing models to deal with the very complex problem of crisis management. Ibrahim and Allen (2012) and Mishra et al (2011) have done extensive research work on decision-making within planning in a major incident, using the activity theory to identify issues, one of them being planning awareness.

This thesis goes beyond assessing context to support automation analysis and requirements elicitation, it proposes to actually “force” the capture and tracking of planning items metadata (context) in the Tactics Plan, aiming to improve incident management. Some of the planning tools for project management are capturing some metadata, like Trello (https://trello.com/tour), which captures logs of stories, and was used during this thesis for the development of the Web Tool. But it was not designed to be an emergency response planning tool, neither incorporates the features proposed by this thesis. As far as it was investigated during this research, commercial Web Tools for emergency response are not designed with such features.

Planning items instances have been labeled as expressions, as they refer to the content placed by the user in a planning item, which is the “user’s expression of his intent.” Figure 15 illustrates the type of metadata that would be captured and tracked for “Strategy 1.3” expression.

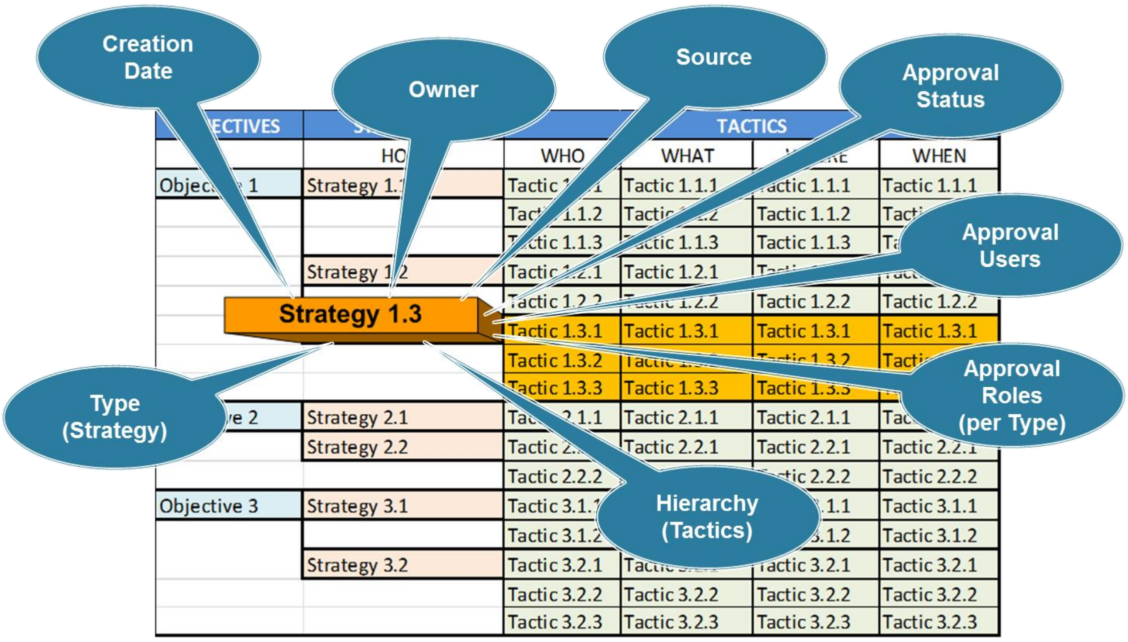


Figure 15. Strategy 1.3 – Metadata for Tactical Planning Item Instance

It is expected that this approach, of providing availability of expression metadata, should improve **visibility**, because it provides the user with easy access to relevant information, **agility**, e.g. knowledge of expression owner could speed up approval decision-making, and **trust** due to use of knowledge of the owner and source to support confidence in the expression, and indirectly in the whole plan. This metadata will also support the other features that will be addressed in the following sections of this document.

3.4.3. Planning Knowledge Reuse

Section 3.4.1 discussed why attempting to reuse pre-loaded expert knowledge would cause interaction stress in a multi-expertise environment, and therefore it was not recommended for reuse within tactical planning.

In many occasions, experts bring their expert knowledge to the emergency in the form of tacit knowledge. Dolif et al. (2013) study results suggest “... that the main source of resilience in dealing with critical situations is the tacit knowledge of experts.”

So this section will propose an approach to reuse tacit knowledge, in the form of tactical planning incident knowledge, i.e. knowledge produced during the incident.

But filtering out irrelevant data is a major problem for knowledge reuse, because irrelevant data can also cause interaction stress.

Calderon et al. (2013, 2014) describe what they were attempting to do in their research: "We wish to enhance interactions between people during crisis, through technology and also to gather information in a way that filters out irrelevant data, by attempting, in a way, to 'harness' the collective intelligence of users, allowing them to make better individual and group decisions …".

So knowledge produced by experts during the incident could in principle bring **agility** and **trust** to tactical planning, if properly filtered for relevancy from the user's perspective.

But how could this be done? No filtering would obviously cause information overload as incident information builds up.

Upcoming Commercial Web Tools could potentially implement three simple filtering mechanisms to reduce overload:

- Suggestion list with only the expressions that match what the user has typed;
- Not listing duplicated expressions;
- List only the expressions of the same type as the one entered, i.e. only strategies for strategy items, only tactics for tactic items, etc.

But users would like a more selective filtering than this, with a suggestion list even more relevant and shorter. Figure 16 illustrates the need for more selective knowledge reuse. Users would like to see only the desired incident knowledge, only the relevant expressions for the context. They would also like to reuse tacit knowledge.

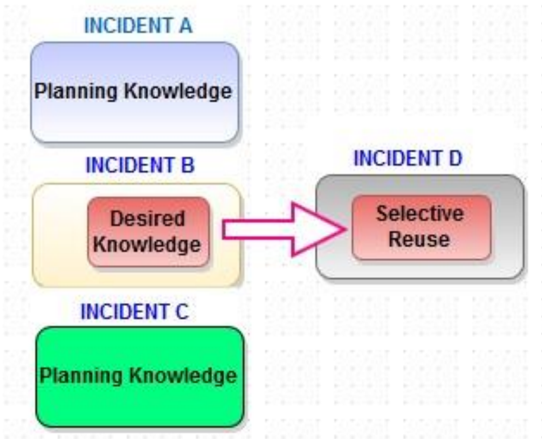


Figure 16. Selective Knowledge Reuse

The approach proposed to solve this issue is to allow the user to set some additional filtering choices that use the tracked metadata proposed in the previous section. Figure 17 illustrates Expertise C user (bottom left) using selected filtering for incident knowledge reuse. In principle, any expression metadata could potentially be used for filtering, but we will address which ones were implemented is section 3.5.2.

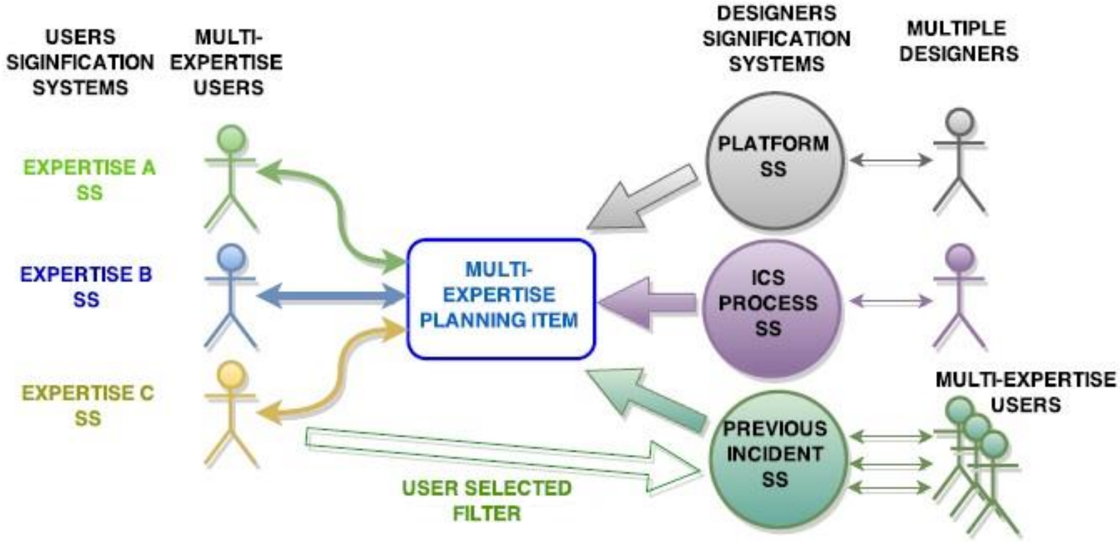


Figure 17. User-driven Selective Reuse from Previous Incidents

Differently from pre-loading a database with expert knowledge, like in Figure 12 of section 3.4.1, this knowledge database is built up by multi-expertise users (bottom right) as they develop the tactics plan, so this database will incorporate tacit knowledge used to respond to the incident. From the point of view of the Expertise C user, these multi-expertise users acted as the designers of the knowledge they are reusing, as they were the ones that previously introduced their own signification systems in the reused incident database.

Tacit knowledge during emergency response involves much more than proposing an objective, strategy or tactics for a planning item, it has to do with the whole set of tactics and strategies to reach an objective, in a certain type of incident, at a certain stage of development, and how they relate to each other. The hierarchy metadata was conceived to support reuse of the children planning items. If, for example, a strategy is reused, the system could automatically bring the tactics of that strategy. This hierarchy is part of tacit knowledge, and could be useful to expedite the production of the tactics plan.

Knowledge reuse could also support expressions from external systems, but without imposing its use to avoid causing stress, and letting the user decide if he/she wants to see it in the suggested expressions list.

It is expected that this approach to knowledge reuse would bring **agility**, because it supports easy and fast input of expressions, **trust** because it reuses expressions that have been used before, and better **visibility** because it makes it easier for the user to find relevant information.

3.4.4. Tactical Planning Tasks in Sequence

Although Tactics Plan life-cycle (creation, review, update and approval) is being implemented in commercial Web Tools, the standard approach is to treat the whole plan as a unit, allowing the creation and initial update tasks in parallel, but requiring the review/update and approval of the whole plan as a unit, with sequential review, update and approval tasks, to warrant the integrity of the plan. Figure 18 illustrates this approach.

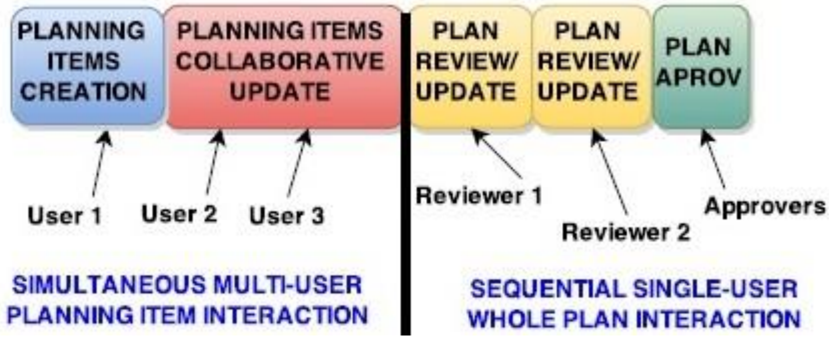


Figure 18. Sequential Update, Review/Update & Approval

But in a major incident the actual life-cycle of planning items (objectives, strategies and tactics) are not the same, and do not follow the whole plan, as illustrated in figure 19, that presents one possible scenario of objectives, strategies and tactics life-cycle. In fact, each planning item instance one has a different level of criticality and will be dealt by a different group of specialists, therefore each one will follow a time pace of its own, some requiring more attention/review and frequent updates, and others not as much. Considering that we are looking for planning agility, it would be very desirable to address each item individually, and get the “easy” ones “out of the way” so that the team attention can focus towards the more critical and difficult planning items to define, instead of having to wait for a review of all the items at the same time, as part of the whole Tactics Plan.

The implementation of planning items metadata, explained in section 3.4.2, opens an opportunity to enhance agility by managing planning items simultaneously.

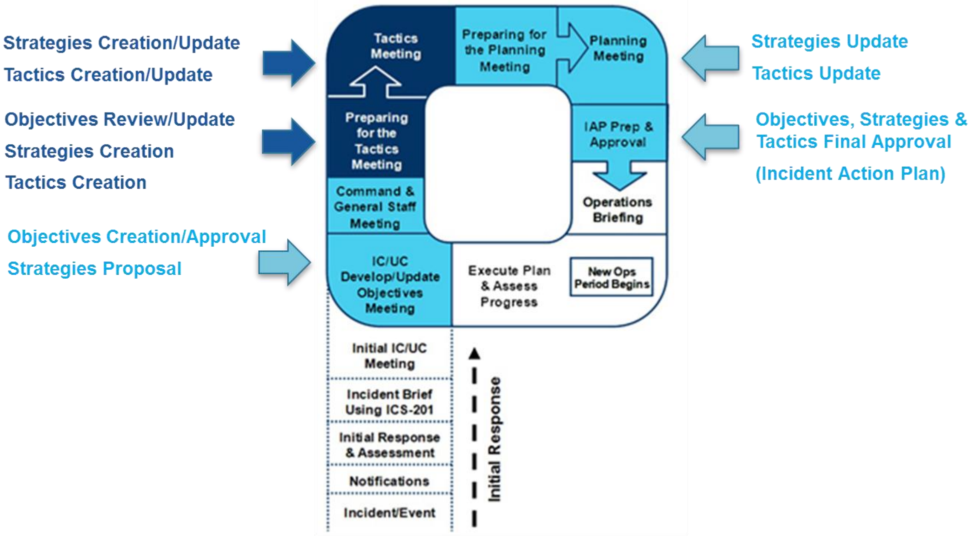
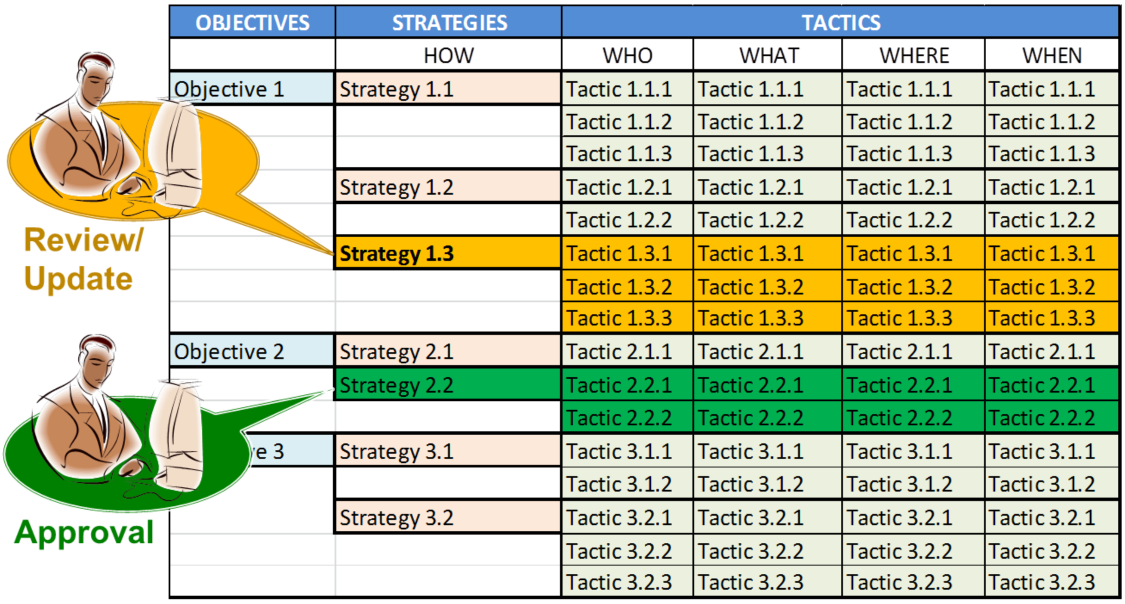


Figure 19. Objectives, Strategies and Tactics Life-cycle along ICS Planning "P"

The proposed approach is to improve **agility** by managing the whole lifecycle (creation, review, update and approval) of each planning item individually and asynchronously from each other, instead of dealing with the plan as a whole, providing support for simultaneous work of multiple specialists on multiple planning items of the same Tactics Plan, each one in a different planning item. Figure 20 illustrates the possibility of simultaneous review/update and approval of separate planning items.

Having more than one specialist working simultaneously on the same planning item would be possible, but this would cause confusion that would compromise decision agility, therefore it not recommended.



OBJECTIVES	STRATEGIES	TACTICS			
	HOW	WHO	WHAT	WHERE	WHEN
Objective 1	Strategy 1.1	Tactic 1.1.1	Tactic 1.1.1	Tactic 1.1.1	Tactic 1.1.1
		Tactic 1.1.2	Tactic 1.1.2	Tactic 1.1.2	Tactic 1.1.2
		Tactic 1.1.3	Tactic 1.1.3	Tactic 1.1.3	Tactic 1.1.3
	Strategy 1.2	Tactic 1.2.1	Tactic 1.2.1	Tactic 1.2.1	Tactic 1.2.1
		Tactic 1.2.2	Tactic 1.2.2	Tactic 1.2.2	Tactic 1.2.2
	Strategy 1.3	Tactic 1.3.1	Tactic 1.3.1	Tactic 1.3.1	Tactic 1.3.1
		Tactic 1.3.2	Tactic 1.3.2	Tactic 1.3.2	Tactic 1.3.2
		Tactic 1.3.3	Tactic 1.3.3	Tactic 1.3.3	Tactic 1.3.3
Objective 2	Strategy 2.1	Tactic 2.1.1	Tactic 2.1.1	Tactic 2.1.1	Tactic 2.1.1
	Strategy 2.2	Tactic 2.2.1	Tactic 2.2.1	Tactic 2.2.1	Tactic 2.2.1
		Tactic 2.2.2	Tactic 2.2.2	Tactic 2.2.2	Tactic 2.2.2
e 3	Strategy 3.1	Tactic 3.1.1	Tactic 3.1.1	Tactic 3.1.1	Tactic 3.1.1
		Tactic 3.1.2	Tactic 3.1.2	Tactic 3.1.2	Tactic 3.1.2
	Strategy 3.2	Tactic 3.2.1	Tactic 3.2.1	Tactic 3.2.1	Tactic 3.2.1
		Tactic 3.2.2	Tactic 3.2.2	Tactic 3.2.2	Tactic 3.2.2
		Tactic 3.2.3	Tactic 3.2.3	Tactic 3.2.3	Tactic 3.2.3

Figure 20. Simultaneous Planning Items Interaction

Features will be implemented to warrant the integrity of the expressions, e.g. no duplicate expressions, hierarchy completion (objective, strategy and tactic), all expressions approved, etc. The combination of this integrity check with planning item status **visibility** will support **trust** in the whole tactics plan, in spite of the asynchronous updates.

3.4.5.
Plans/Forms Production and Approval in Sequence

Incident management involves the production of several plans, documented in standard forms. Many of these plans/forms are developed in a hierarchical and interdependent way, where information in one plan/form is hierarchically linked to the previous plan/form.

So the simplest way to implement automation of plans/forms production and approval is to do it in strictly sequential order, as illustrated in figure 21. This would be the case for ICS-202, ICS-234 and ICS-215/204.

Figure 21. Ideal Sequential Production & Approval of Forms

With this approach it is much easier to ensure the integrity of plans, as there is no risk of updates to the “parent plan” when working in a “child plan”.

The problem is that this is not a realistic scenario in a time-constrained incident response environment, as the unpredictability of the response plans may lead to “parent plans” being updated while “children plans” are still being developed within a response cycle. Figure 19 illustrated one possible scenario for the life-cycle of the planning items. Considering that objectives are actually created, updated and approved as part of ICS-202, in practice the life-cycle of ICS-202 and ICS-234 will superimpose with each other.

Specialists will start preparing the lower level plans (ICS-215/204) as soon as possible, irrespective of approval of the higher level plans, and will do whatever they have to, whenever they can. If the automated system does not support their urgency need, they will proceed responding to the incident without using it, which is not a desirable situation.

So the requirement for full approval of a plan to move to the next plan is not realistic. Figure 22 illustrates the more realistic scenario for plans approval. Therefore, addressing this need is critical for the success of an automated tactical planning system.

This thesis proposes a plan approval scheme that supports some parallel planning work, in line with the more realistic scenario, but restricts parallelism based on planning tasks, to preserve plan integrity. The design will be detailed in the next section.

Figure 22. More Realistic Parallel Production & Approval of Forms

It is expected that this approach will improve planning **agility** by allowing parallel work on ICS-202 and ICS-234, without compromising the integrity of the plans.

3.5. CAP Model Design Description

In the previous section, five tactical planning issues, which will likely persist after current automation, were discussed and design approaches were proposed to address them.

This research proposes a tactical planning model with three features that will incorporate the proposed design approaches:

- Expression Context Traceability
- Selective Expression Reuse
- Expression Authority Control

This research will refer to this model as Context-Aware Planning (CAP) model, due to its planning awareness abilities.

All of these three features will incorporate knowledge about the process, a recommendation that came out of the analysis of the first issue, Planning Interaction Stress.

Expression Context Traceability will address the second issue, lack of planning item awareness, and it will incorporate metadata in the model to provide the basis for the other two features to work.

Selective Expression Reuse will address the first issue, Planning Interaction Stress, and the third issue, Planning Knowledge Reuse, by providing selective access to an incident planning knowledge database, but not implementing an expertise knowledge database.

Expression Authority Control will address the fourth issue, Tactical Planning Tasks in Sequence, and the fifth issue, Plans/Forms Production and Approval in Sequence, by implementing strict control of the life-cycles of the planning items and the Tactics Plan.

Table 1 illustrates the mapping of the three CAP model features versus the five addressed issues and respective recommendations.

CAP MODEL FEATURES	TACTICAL PLANNING ISSUES				
	1. Interaction Stress	2. Planning Awareness	3. Knowledge Reuse	4. Tasks in Sequence	5. Plans in Sequence
Expression Context Traceability	X	X			
Selective Expression Reuse	X		X		
Expression Authority Control	X			X	X

Table 1. Mapping of CAP Model Features to Tactical Planning Issues

These CAP model features could be applied in principle to any type of planning tool, but in this research we will focus in instantiating them in a model for tactical planning consistent with ICS standards.

The following sections will present the three CAP model features.

3.5.1. Expression Context Traceability

This CAP model feature involves capturing and tracking each expression entered in the plan. It captures not only the expression, but also context (metadata instances) of each expression, to provide expression planning context-awareness.

Figure 23 illustrates the ICS tactical planning hierarchy implemented by the model and the context-aware planning item instances (expressions), designed to support this feature.

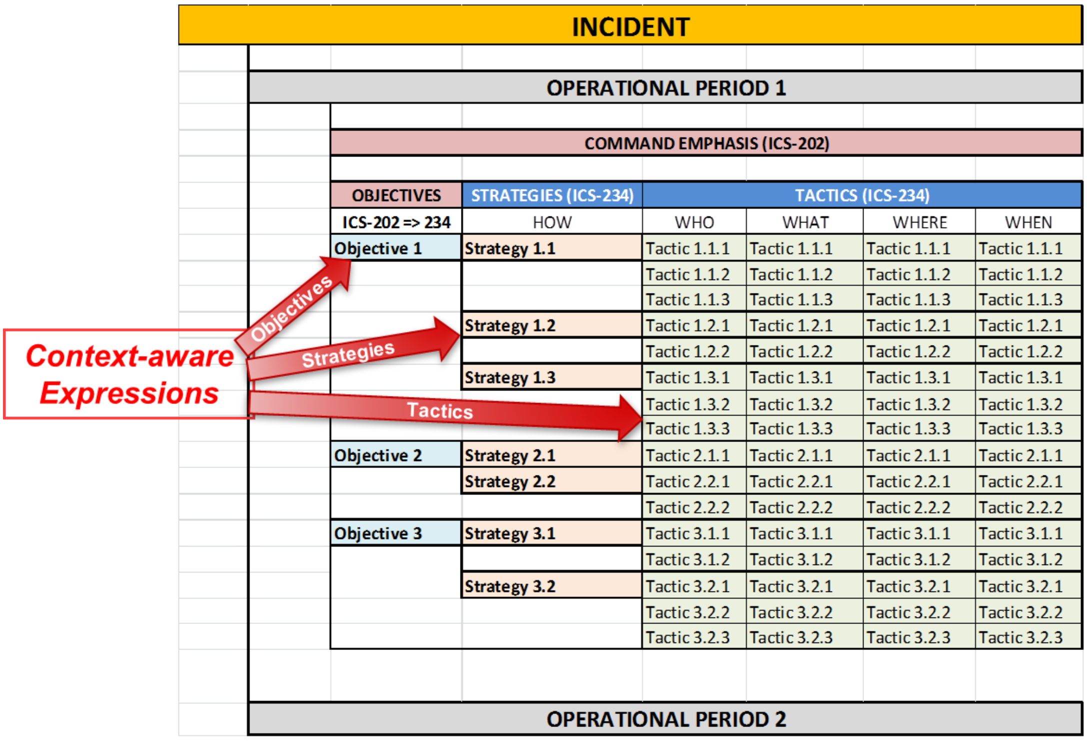


Figure 23. Context-aware Expressions within ICS Tactical Planning Hierarchy

Figure 24 illustrates the type of metadata captured for an Expression in the sample case of Strategy 1.3 of figure 13:

- Incident name: incident that Strategy 1.3 belongs to;
- Expression Creation/Update Date: in this case of Strategy 1.3;
- Expression Owner: User Id of who created/updated Strategy 1.3 instance;
- Expression Source: origin of the data: None, incident Name or User Id, as it will be explained later;
- Expression Approval Status: in this case Status of Strategy 1.3;
- Expression Approval Users: users that approved Strategy 1.3;
- Expression Approval Roles: in this case Roles for Strategy Approval;
- Expression Hierarchy: in this case Tactics that belong to Strategy 1.3;
- Expression Type: in this case Strategy.

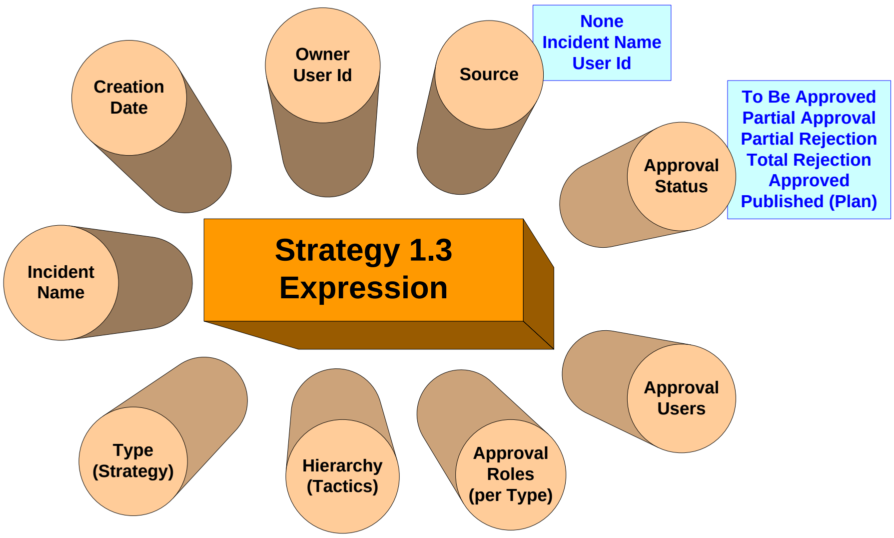


Figure 24. Expression Context Traceability

Source metadata of an expression will follow these rules:

a. If an expression is totally typed by the user, Source will be None;

b. In the case of reuse, if Source of the reused expression has None or an Owner Id, assign the Owner User Id of the reused expression;

c. In the case of reuse, if Source of the reused expression has an Incident Name, assign this Incident Name;

d. When an expression is approved and published as part of a Tactics Plan, Source will become the Incident Name of the published plan, i.e. the "incident will appropriate itself" of all the expressions approved and published during the response.

The availability of metadata per expression allows the CAP model to support external **visibility** of planning context to the multi-expertise users, providing planning awareness that can also mitigate interaction stress. For example, the ability for the approver chief to find out in real-time who produced the expression and to contact the person immediately provides **agility** in understanding and reviewing, and it can lead to **trust**.

This CAP model feature can also aggregate meaning, for example, in the case that the chief already trusts the person who created the expression, then he/she could approve the expression immediately without further investigation, resulting in gain of **agility** due to **trust**.

The metadata described above is also used to support the other two CAP model features that address the issues. As it will be detailed in the next section, the Selective Expression Reuse feature will use the Incident, Owner and Date metadata to perform selective reuse. The Expression Authority Control feature will use and update the Approval Status and Users metadata, and will use the Approval Roles and the Hierarchy metadata to warrant the integrity of the expressions and the plan.

3.5.2. Selective Expression Reuse

The usefulness of reuse will depend on its ability to filter out irrelevant data, avoiding information overload and harnessing the collective knowledge of users, allowing them to make better decisions within tactical planning. The Selective Expression Reuse CAP model feature attempts to implement such filtering.

As a basic requirement, the feature implements automatic filtering by:

- Listing only the expressions that match what the user has typed;
- Not listing duplicated expressions;
- Listing only the expressions that are of the same Type as the one entered, i.e. only strategies for strategy items, only tactics for tactic items, etc.

But the feature also supports expression reuse filtering according to user preferences, by making use of some of the expression metadata proposed by this thesis to provide a smaller and more relevant list of suggested expressions to the user, improving agility and trust.

User selected expression filtering was implemented in the Web Tool using these three context metadata (see figure 25):

- Incident name: reuse only of planning item instances from a specific incident;
- Owner User Id: reuse only of planning item instances from a certain user;
- Creation/Update Date: reuse only of planning items within a time range.

Some of the other metadata could also be used for additional filtering. For example, one metadata that is available and was not implemented by the Web Tool is Approval Status. Its use could provide the user with an even shorter and more relevant suggested expressions list, with just the published expressions, not including the expressions that are still going through an approval process. If that is a filter that the users need, it could be easily implemented in the future.

The Hierarchy metadata is not used for expression filtering, it represents Tactics that belong to the Strategy instance to be reused, so Tactics can be reused whenever its parent Strategy is reused. Figure 25 illustrates the five expressions context metadata that are involved to implement this feature.

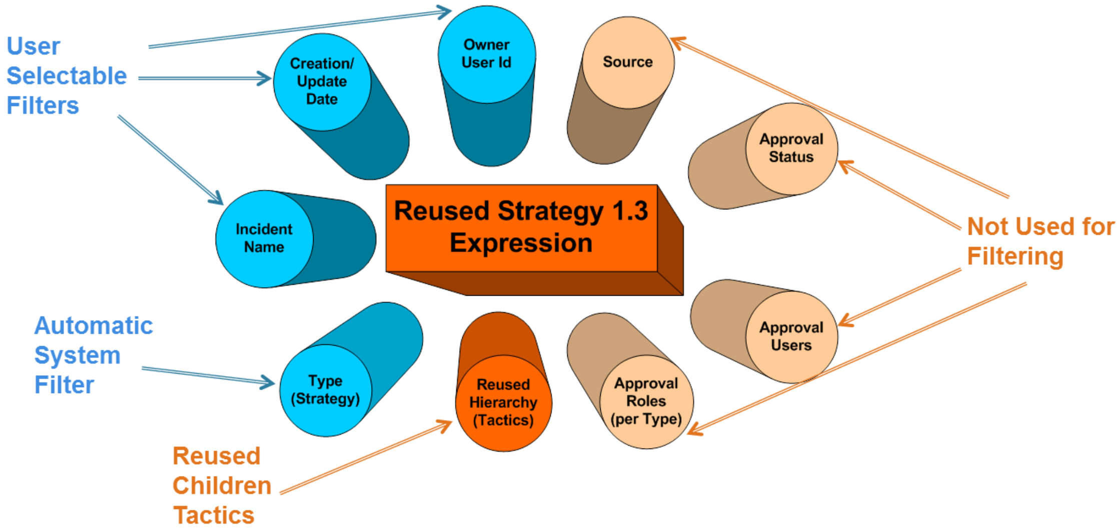


Figure 25. Context Metadata used in Selective Expression Reuse

Expression reuse has to be clearly intended by the user. Reuse only happens if an expression instance is selected from the suggested list. If the expression is totally typed by the user, not selected from the list, there will be no reuse, and it will be considered a new expression, with its own context metadata, even if identical to existing expressions in the database.

Hierarchy reuse has required the definition of specific rules:

a. The user will have the option to activate or deactivate Hierarchy reuse, to avoid information overload, so the three alternatives below are only applicable if Hierarchy reuse is activated;

b. If the reused Strategy is being input in a new planning item, it automatically brings the children Tactics of the reused Strategy, but flags these children as automatically generated;

c. If the Strategy is being updated with a reused Strategy, but it has no children Tactics, it automatically brings the children Tactics of the reused Strategy, but flags these children as automatically generated;

d. If the Strategy is being updated with a reused Strategy, but it has children Tactics, the user must be warned that current children tactics will be lost, and if agreed, it automatically replaces all current children Tactics with the children Tactics of the reused Strategy, and flags these children as automatically generated.

The use of the additional filtering proposed by this CAP model feature will support a much more focused and relevant reuse, reducing interaction stress, and providing better information **visibility**, greater **agility** for the user to find what he/she wants, and also **trust** in the reused information, because he/she will be aware of where it came from.

3.5.3.
Expression Authority Control

This CAP model feature was created to support simultaneous collaborative work of the multi-expertise specialists when producing a version of the Tactics Plan (ICS-234). This feature leverages on the Expression Context Traceability feature for managing the approval cycle of each expression individually.

Figure 26 illustrates the approach proposed by this thesis to handle creation/update, review/update and approval of each tactical planning item in ICS-234, aiming to provide more **agility** to tactical planning, as it can take advantage of simultaneous work of several specialists on the same plan. In particular, Figure 24 illustrates the tasks being performed in parallel on an Objective, its child Strategy and grandchild Tactic. This scenario assumes that Objective review and approval is performed by the Incident Commander, but Strategy and Tactic review and approval are performed by the Planning Chief. This explains why Strategy review and approval happen simultaneously with Objective review and approval, but not with Tactic review and approval, because the same person would have to do it.

Figure 26. Approach for Expressions Creation/Update/Review/Approval

This CAP model feature requires the incorporation of the following functionalities and rules:

a. Roles versus User Independence

ICS assigns authority to Roles, not users. Therefore, CAP model treats Users and Roles separately. The rules are:

- Each User corresponds to one person, with a unique User Id;
- Each User can have several Roles;
- User versus Role assignment can be modified anytime to support the flexibility required by an incident;
- Authority to interact with the model entities is solely defined by the Role.

b. Roles versus Authority Assignment

CAP model implements a feature that maps role versus authority to perform planning tasks. In fact, this mapping is flexible and could be modified at any time.

But for the purpose of evaluating its performance in a real case scenario, the model has implemented the top ICS roles and some supporting roles.

Figure 27 illustrates the top ICS command structure. So the model has considered the roles and authority of the Incident Commander, Operations Chief, Planning Chief and Logistics Chief. The Finance/Admin Section Chief was not implemented due to his/her limited involvement in planning the expert responses.

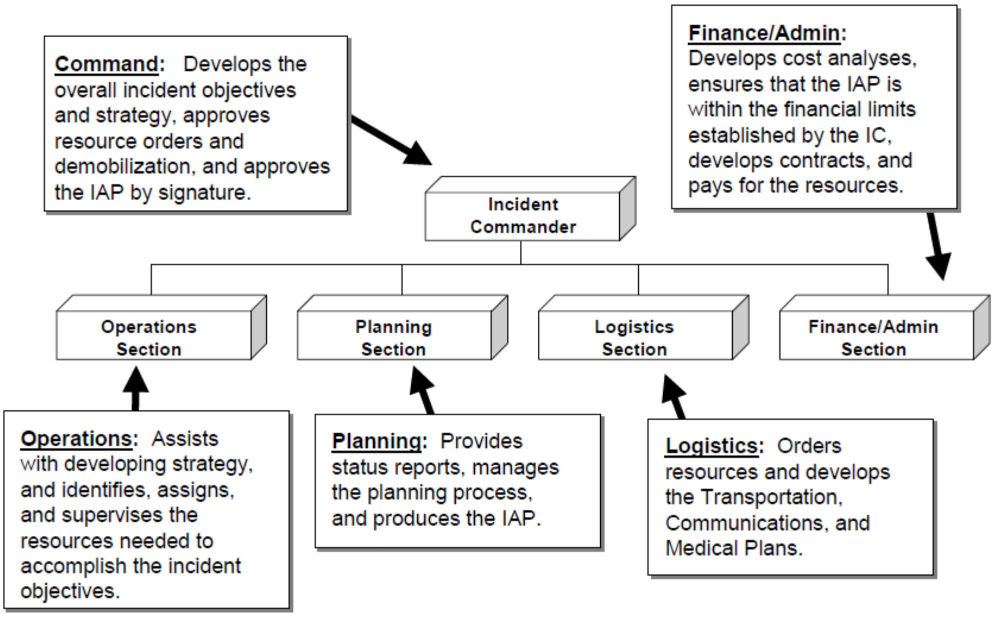


Figure 27. Top of the ICS Command Structure and its Roles (source: FEMA)

Complementing the top team, the implementation of the model has included supporting roles, what was suggested by one specialist: Deputy Commander, Operations Assistant, Operations Specialist, Planning Assistant, Planning Specialist, Logistics Assistant and Logistics Specialist. These other roles have distinct authorities from the top command, so this way it was possible to evaluate the CAP Web tool for user interaction with different levels of authority.

Table 2 defines the authority of these roles to create/update, delete and approve each type of expression. This authority table was derived from the ICS process manuals. The exact authorities per role may vary depending on the ICS process implementation choices made by each corporation.

EXPRESSION TYPE	CREATION & UPDATE	DELETE	APPROVAL
OBJECTIVE	All Roles	Incident Commander, Planning Chief, Deputy Commander or Planning Assistant	Incident Commander
COMMAND EMPHASIS	All Roles	Not Available	Incident Commander
STRATEGY	Incident Commander, Planning Chief, Operations Chief, Logistics Chief, Deputy Commander, Planning Assistant, Operations Assistant or Logistics Assistant	Incident Commander, Planning Chief, Operations Chief, Logistics Chief, Deputy Commander, Planning Assistant, Operations Assistant or Logistics Assistant	Planning Chief and Operations Chief
TACTICS (Who, What, Where, When, Response)	Same as Strategy plus Planning Specialist, Operations Specialist or Logistics Specialist	Same as Strategy plus Planning Specialist, Operations Specialist or Logistics Specialist	Planning Chief and Operations Chief

Table 2. Expression Type versus Authority Rule

c. Expression Context Metadata Update Behavior

When an expression is updated, context metadata that may be updated is:

- Update Date;
- New Owner User Id that did the update;
- Possible change in Source (see 3.5.1);
- Possible change in Approval Status (see item e for details).

When an expression is reviewed and approved or rejected, context metadata that may be updated is:

- Change in Approval Status (see item e for details);

- Capture of the Approval User.

d. Children and Grandchildren Approval Status Reset

To preserve planning integrity, updates to a parent planning item are flown down to the children and grandchildren items.

If the expression is a Strategy, any update to it will cause its children Tactics to go to the “To Be Approved” status, and any approval status will be lost. If the expression is an Objective, its children Strategies and grandchildren Tactics will also go to “To Be Approved” status.

e. Expression Approval Status Tracking

Figure 28 illustrates at its left the Expression Approval Status Flow, describing the actions that trigger the change in approval status of each individual expression of the type Objective, Strategy or Tactics. Basically, any update to an expression invalidates any prior approval, requiring it to go through all the approval process again. Any rejection will require the expression to be updated, and will also start the approval process again. Although the implementation of this feature aims to save time, it can’t compromise plan integrity, otherwise it would jeopardize trust in the plan. At its right-hand side, figure 28 illustrates the published plan status, where all plan expressions are frozen into one tactics plan for the operational period. When the plan is published, the source of each expression is updated with the incident name, so that from this point on all the expressions used to produce the plan will “belong” to the plan, facilitating its reuse by incident. If a published plan needs to be modified, the CAP model could support the plan revoke functionality, reversing final plan approval. This latter functionality was not implemented in the CAP Web Tool.

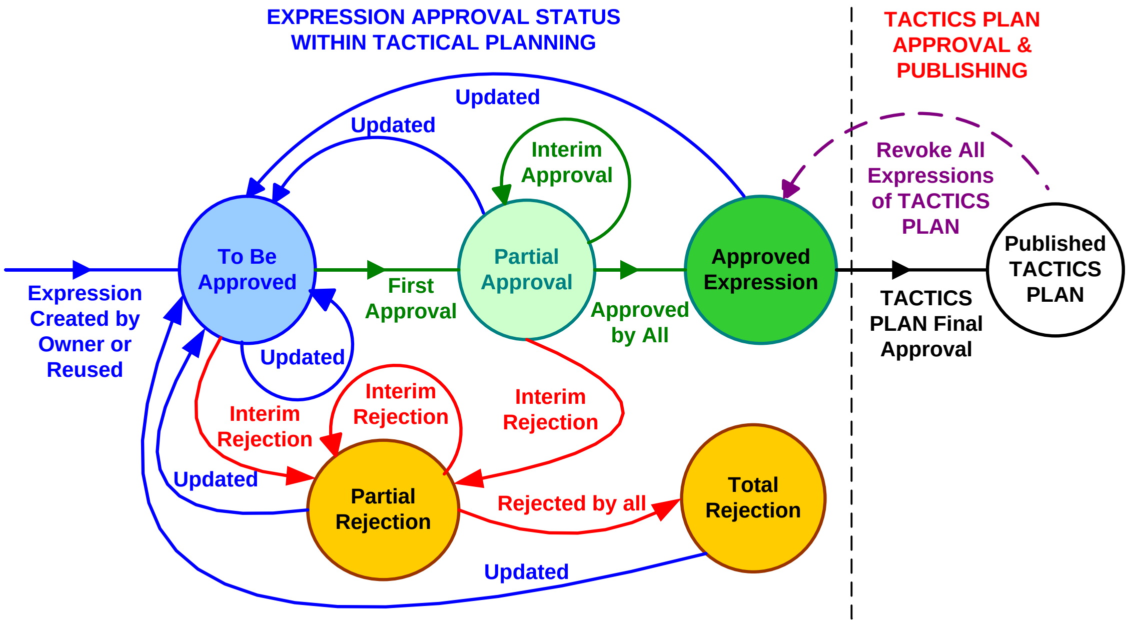


Figure 28. Expressions Approval Status Flow and Tactics Plan Publishing

Some of the reused tactic and strategy expressions might not have been directly selected from a list by the user, but have been automatically generated from the reused parent Objective or Strategy, when hierarchy brings back the children strategies or tactics. In this case, those strategies and tactics will go to a state that flags to the users that they were automatically generated, instead of entered or selected by the user, therefore they deserve special attention when reviewing and approving them.

f. Tactics Plan Integrity Check

This CAP model feature allows work in the Tactics Plan (ICS-234), before ICS-202 is approved, which is not the typical implementation. Figure 29 illustrates the proposed approach.

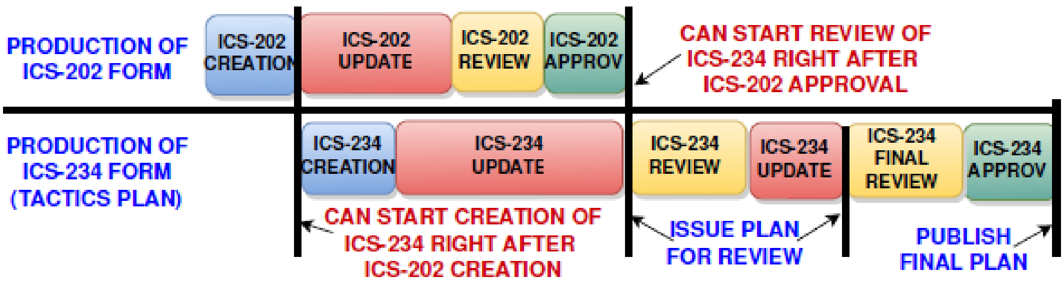


Figure 29. Proposed Parallel Production & Approval of ICS-202 and 234 Forms

The production of each plan is broken per type of task, and parallel production of tasks is done as long as performing one task in one plan is not incompatible with performing another task in the other plan, such that plan integrity is not compromised.

Analyses of the tasks (create, update, review and approve) concluded that:

- ICS-234 can start creation as soon as ICS-202 is created, with its current objectives and command emphasis;
- ICS-234 can only be reviewed after ICS-202 is approved, otherwise updates to ICS-202 before approval could invalidate review of ICS-234.

It is expected that this approach for plan approval will bring some **agility** to tactical planning, because there is a potential for time reduction equivalent to the time spent to update, review and approve ICS-202.

But in addition to gaining time from potential parallel work in multiple plans, this feature was primarily created to warrant the integrity of the Tactics Plan in light of the nature of expressions approval, where each expression (objective, strategy or tactic) has an approval life-cycle of its own, asynchronous with its parent plan, the Tactics Plan (ICS-234).

A mechanism with checkpoints and rules was created to support the integrity of the Tactics Plan at “Issue for Review” and “Publish Final Plan” checkpoints. Two sets of rules were defined for these two checkpoints, although the rules could vary dependent on corporate policies. The more important aspect is that there should be rules bounding the freedom of expression updates within its parent plan, otherwise its integrity could be compromised.

A Tactics Plan version is “Issued for Review” only if:

- Issued by Planning Chief, Planning Assistant, Operations Chief or Operations Assistant;
- All Objectives are approved;
- Every Objective has some Strategy;
- Every Strategy has some Tactic (Tactics require at least Who and What);
- There should be no duplicated Strategies in the same Objective;
- There should be no duplicated Tactics in the same Strategy.

A Tactics Plan version is accepted to “Publish Final Plan” only if:

- Issued by Incident Commander or Commander Assistant;
- All checks done for Issue for Review, plus;
- Current Version of the Plan was not modified after Issued for Review;
- Plan for all previous Operational Periods have been approved and published;

- All expressions must be approved;
- Tactics Where and When must be filled.

The next chapter will describe the Web Tool prototype that was developed to demonstrate the viability and utility of implementing the features described previously.

4
The CAP Web Tool – A CAP Model Instantiation

The CAP Web Tool follows the CAP model, adapted to a Web platform. It also incorporates additional functionality to support typical ICS process automation. It was developed to support the evaluation of the CAP model features. The CAP Web Tool implements:

- The three unique CAP model features proposed by this research study;
- The terminology, workflow and functionalities of the ICS process relevant to support the ICS tactical planning phases, encompassing the production of ICS-202 and ICS-234 forms;
- A User Interface for a Web platform that supports the functionalities required for ICS tactical planning.

During the development of the CAP Web tool, a prototype was demonstrated to emergency specialists in three occasions, from three different Oil & Gas Companies, to gather feedback on the implementation of the CAP Web Tool User Interface and the planning features. Appendix C details the feedback received in these three occasions.

4.1.
Implementation Design Choices

This section discusses the main implementation design choices during the development of the prototype Web Tool.

a. For ICS Process Support

Although the focus of the CAP model is to automate the production of the tactics plan within ICS-234, it was also necessary to implement the functionality to create a new incident in the system, as well as to manage the production of ICS-202, because that is where the Objectives and the Command Emphasis are currently created, updated, reviewed and approved, and they are essential to guide tactical planning.

But considering that the model implementation supports work in ICS-234 before ICS-202 approval, the Web Tool implemented the ability to view and approve Objectives and Command Emphasis from within ICS-234 interface, although creation and updates are kept as only possible from within ICS-202 interface.

Considering that ICS communications among team members is all based on pre-defined forms, and formal approval requires signatures in paper forms, it was necessary to implement the ability to output he plans in ICS formatted PDF versions of the ICS-202 and ICS-234 forms, so that a printed version is easily produced. Three types of PDF versions of the plans were implemented: Draft, For Review and Final Plan. These will be discussed in more detail in item **d** of this section.

b. For Expression Context Visibility

In principle, user visibility of any metadata could be implemented, and in many forms, but sometimes too much visibility causes information overload. The challenge is to provide only the information needed for each usage context. Metadata visibility was provided in two manners:

i. Tactics Plan Matrix View

This view emulates the ICS 234 form, showing the Work Analysis Matrix with objectives, strategies and tactics expressions (see figure 2). The following expressions metadata are visible to users in this view:

- Incident name
- Expression Hierarchy, via position in matrix
- Expression Type, via position in matrix
- Expression Text
- Expression Approval Status, via use of a color code

ii. Expression Metadata Window View

The user just clicks on an expression of the “Tactics Plan Matrix” to see the “Expression Metadata Window” (see figure 30). The following expressions metadata are visible to users in this view:

- Expression Type
- Expression Text
- Expression Owner
- Expression Source
- Expression Approval Status
- Expression Approval Roles
- Expression Approval Users

Figure 30. Expression Metadata Window

Some metadata is available in both manners, some in just one. But note that Expression Creation/Update Date is the only “invisible” metadata, not available to the users either way. The intent was to avoid information overload, and the tool evaluations performed so far did not indicate that this information was missing. This information is available from the CAP model, so it would be easy to add to the metadata window, and is currently used by the other two features, so this could be an implementation oversight if users find out later that it is relevant for some usage scenarios.

The need for additional features emerged during the tool development, coming in some cases from meetings with specialists, as described in appendix C:

- Emerged in testing: after identifying the owner of an expression, search the database for user contact Information;
- Emerged from specialist: assign criticality levels (high, medium, low) to tactics;

- Emerged from specialist: need to create link to the operational responses, what led to the inclusion of a response item in every tactics, implementing context-awareness as well.

c. For Selective Expression Reuse

The implementation focused in demonstrating the CAP model concept. Only the following metadata were implemented:

- Incident Name, from this incident only;
- Owner User Id, from this user only;
- Creation/Update Date, used for searching for the most recent only.

Although the CAP model theoretically supports reuse of Objectives with automatic reuse of its children Strategy expressions and grandchildren Tactic expressions, the CAP Web Tool only implemented the reuse of Strategies with automatic reuse of its children Tactic expressions.

One additional feature that emerged during tool development was the ability to filter identical expressions, because as reuse grows, the amount of identical instances of reused expressions grows accordingly. So first the identical expressions are consolidated into one, to shorten the suggestion list. But when automatically reusing tactics of a selected strategy, it is important to determine exactly what instance will be reused, because children tactics might be very different. To support the user in this dilemma, the CAP Web Tool places a sign beside the expression to indicate that there is more than one instance of that same expression, and automatically offers additional filtering by incident first, and by date second.

d. For Expression Authority Control

The separation between user and roles defined by the CAP model in section 3.5.3 was implemented.

For the metadata Owner, who is also the system user, the user's e-mail was the User Id implemented, as it becomes also available as contact information.

ICS defines that a person, defined by its User Id, may have more than one role. The Web tool implemented up to three roles per user, configurable by the user within the tool. The implemented roles and their authority were already described in section 3.5.3.

As explained in item **a** of this section, the Web Tool outputs three types of ICS formatted PDF versions of plans: Draft, For Review and Final Plan.

Issuing a Draft plan was implemented with no restriction, as any user can do it anytime during the production of the plan, but it does not increment the Tactics Plan version number, it does not archive the PDF output in the system for later retrieval, and it prints a "Draft" watermark all over the printed form, such that it is very clear that it is a "work in progress" version, not to be used for formal review and approval, just for personal use.

The role authority required and the rules to issue For Review and the Final Plan were already discussed in section 3.5.3.

When ICS-234 is issued For Review, the Web Tool generates a PDF version of the form, stores it for later retrieval, and increments the current version number by one, i.e. the previous version is "frozen" in PDF format. The PDF form incorporates the User Id and his/her role in the "Prepared by" area.

When ICS-234 is published as the Final Plan for the operational period, the Web Tool generates the final PDF version of the form, and stores it for later retrieval. But it keeps the same version number adding the label "Final". This was implemented this way because the system requires that the final version be the same as the last issued For Review version in a paper form, to warrant the integrity of the published plan. The PDF form incorporates the User Id and his/her role in the "Prepared by" area and the approver User Id and role in the "Approved by" area. Once published, this operational period plan is "frozen", as it will be sent for execution.

The need for additional features emerged during tool development:

- Emerged from developer testing with test cases: Feature for Approval and Deletion in groups, allowing the user to approve or delete a large number of selected expressions of a time, instead having to do it one by one;
- Emerged from specialist during prototype demonstrations: Approval flag, alerting the user that he has to review and approve a particular expression as per his/her current authority.

4.2. CAP Web Tool Prototype Implementation

A CAP Web Tool prototype was developed to incorporate the CAP model features, and support evaluation of the viability and utility of these features by emergency specialists. In this section we identify the web technologies used and present the user interface implemented to support the features and the tactical planning tasks.

4.2.1. CAP Web Tool Platform

One of the attributes of paper forms is the level of availability they can provide, as it is generally quite easy to make additional copies of blank forms.

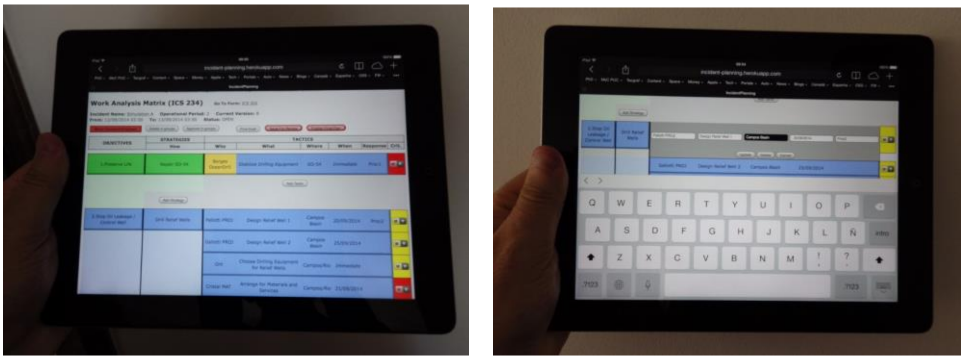
So in many instances it is not viable to achieve the level of availability provided by paper forms. This is the case at the incident site, where the availability of technology continues to be fragile, as the ICT (Information and Communication Technology) infrastructure might be one of the victims of the incident.

But our context is tactical planning for major incidents, so it more likely that this planning will take place off-site, where ICT infrastructure should not be a problem, and immune from the incident.

But still, mobility for the team is crucial, as some specialists may provide their support from other sites, so the ability to run in as many platforms as possible was very important to preserve the availability attributes of paper forms, otherwise experts would not use the tool when in a site away from the emergency room.

So the first decision was to deploy the tool in the Web for widespread Internet access via a web browser. But in addition to running in a PC browser, the Web Tool was also designed with tablets in mind. For example, no “mouse over” functionality was employed. An iPad was used to test this implementation, and it performed the planning functions satisfactorily, although the actual evaluation used PC notebooks.

Deploying in the Web and tablets supports a high level of availability and mobility, although no formal analysis was done to compare it with paper forms. What can be said is that this approach offers better availability than desktop planning applications that need to go through installation in PCs. Figures 31a and 31b illustrate the CAP Web Tool running in a Tablet, with the user performing Tactics Plan visualization (31a) and editing (31b).



Figures 31a & 31b. CAP Web Tool in a Tablet: Visualization (a) & Editing (b) of the Tactics Plan (ICS-234)

4.2.2. CAP Web Tool Technologies

Current Web technologies were used to implement the Web Tool prototype.

a. Deployment

- Heroku: cloud platform to deploy the Web application. (www.heroku.com)

b. Server side

- Ruby: web tool programming language;
- Rails: web application server;
- PostgreSQL: DBMS;
- Devise: user authentication solution;
- WickedPDF: converts HTML generated by the application to PDF.

c. Client side

Typical standard Web technologies:

- HTML (Hyper Text Markup Language);
- CSS (Cascading Style Sheet);
- JavaScript;
- AJAX (Asynchronous JavaScript and XML).

4.2.3. CAP Web Tool User Interface

This subsection describes the User Interface for the main features of the Web Tool.

a. Incident Creation and Objectives Definition

The CAP model features were designed to produce the Tactics Plan in ICS-234. But before it can be produced, an Incident needs to be created and the Incident Objectives need to be defined in ICS-202, although they do not need to be approved for the tactical planning activity to start.

The Web Tool implemented the functionalities to create an incident, its operational periods, and to define its objectives in ICS-202.

Incident Planning System

Incidents List My Profile Tool Config Search Users Logout malencar@tecgraf.puc-rio.br

LOGIN SUCCESSFUL.

Incidents List

Name	Status	Creation Date	Accessible by	
Teste N	OPEN	02/Feb/2015 03:18	Tecgraf	Delete
Teste	OPEN	15/Jan/2015 18:59	Public	Delete
Tecgraf teste	OPEN	05/Dec/2014 10:24	Tecgraf	Delete
Simulation A	OPEN	11/Sep/2014 14:46	Public	Delete
First Incident	OPEN	09/Sep/2014 17:24	Public	Delete

Create new Incident

Figure 32. Incidents List Page

Figure 32 illustrates the list of existing incidents in the Web Tool available for a particular user. This page also allows the user to create a new incident.

Figure 33 illustrates the list of operational periods of a particular incident, in this case Simulation A. The page also allows the user to initiate the creation of a new operational period.

Incident Operational Periods

Incident Name: Simulation A **Initial Time:** 11/09/2014 03:00

Period	From	To	Period Status	ICS 202	Objectives Status	ICS 234	Current Version	
1	11/09/2014 03:00	12/09/2014 03:00	OPEN	Incident Objectives	TO BE APPROVED	Work Analysis Matrix	4	Past Versions
2	12/09/2014 03:00	13/09/2014 03:00	OPEN	Incident Objectives	TO BE APPROVED	Work Analysis Matrix	8	Past Versions
3	13/09/2014 03:00	14/09/2014 03:00	OPEN	Incident Objectives	TO BE APPROVED	Work Analysis Matrix	1	Past Versions
4	14/09/2014 03:00	15/09/2014 03:00	OPEN	Incident Objectives	TO BE APPROVED	Work Analysis Matrix	1	Past Versions

New Operational Period Delete last period

Figure 33. List of Operational Periods of an Incident

The creation of an operational period is done at ICS-202 page, illustrated in figure 34, together with the definition of the incident objectives and the command emphasis for that operational period.

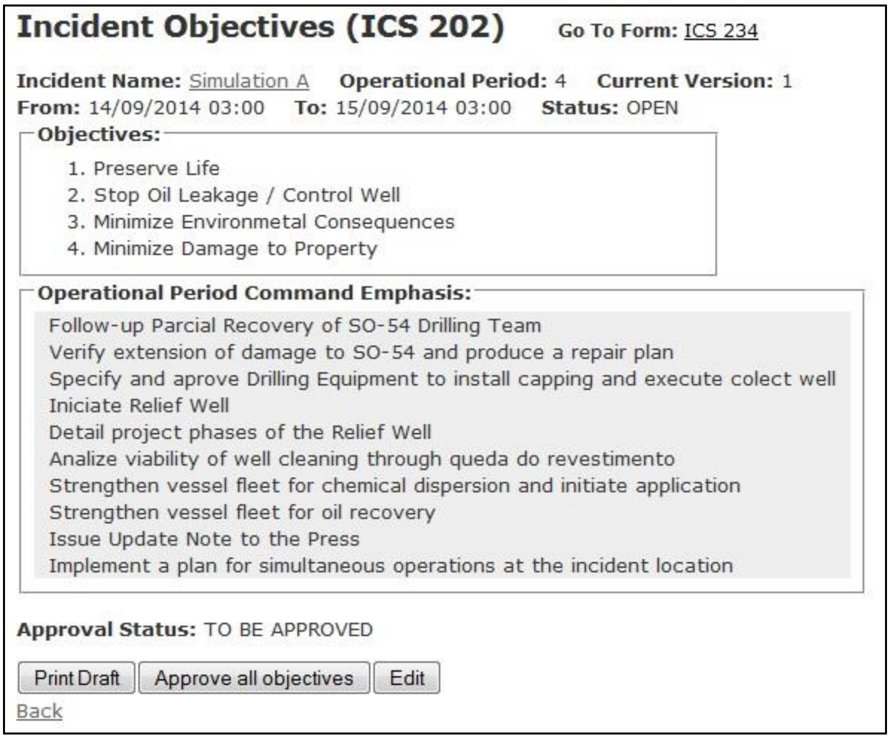


Figure 34. Incident Objectives Page – ICS 202 Form compatible

Once ICS-202 is created, work can start in the Tactics Plan (ICS-234), that will open with a page like in figure 35, with all objectives to be approved, and no strategies or tactics.

Figure 35. Tactics Plan Page - Newly created ICS-234 from Incident Objectives

In the following items it will be described how the three CAP model features were implemented in the Web Tool User Interface to produce the Tactics Plan through ICS-234.

b. Expression Context Traceability User Interface

The “Expression Context Traceability” feature captures and tracks any update to the expressions and its metadata, and makes them available to the user through the Web Tool user interface.

Figure 36 illustrates work in progress on the Tactics Plan (ICS 234), showing the hierarchy of objectives, strategies and tactics expressions in its own color coded status.

The user interface allows users to quickly perceive what part of the plan is done and what part is still being worked on. Color blind users can access the expression metadata window (see figure 37), which is available to all users with one click at the expression, getting the approval status information plus other expression metadata: owner, source, approval roles and approval users.

With this feature the users can perceive in real-time the updates to the Tactics Plan and take action if necessary. The owner user id in the metadata windows is a link to the user contact information, so if anyone needs to contact the person who created the expression, for some clarification, his/her contact information is readily accessible.

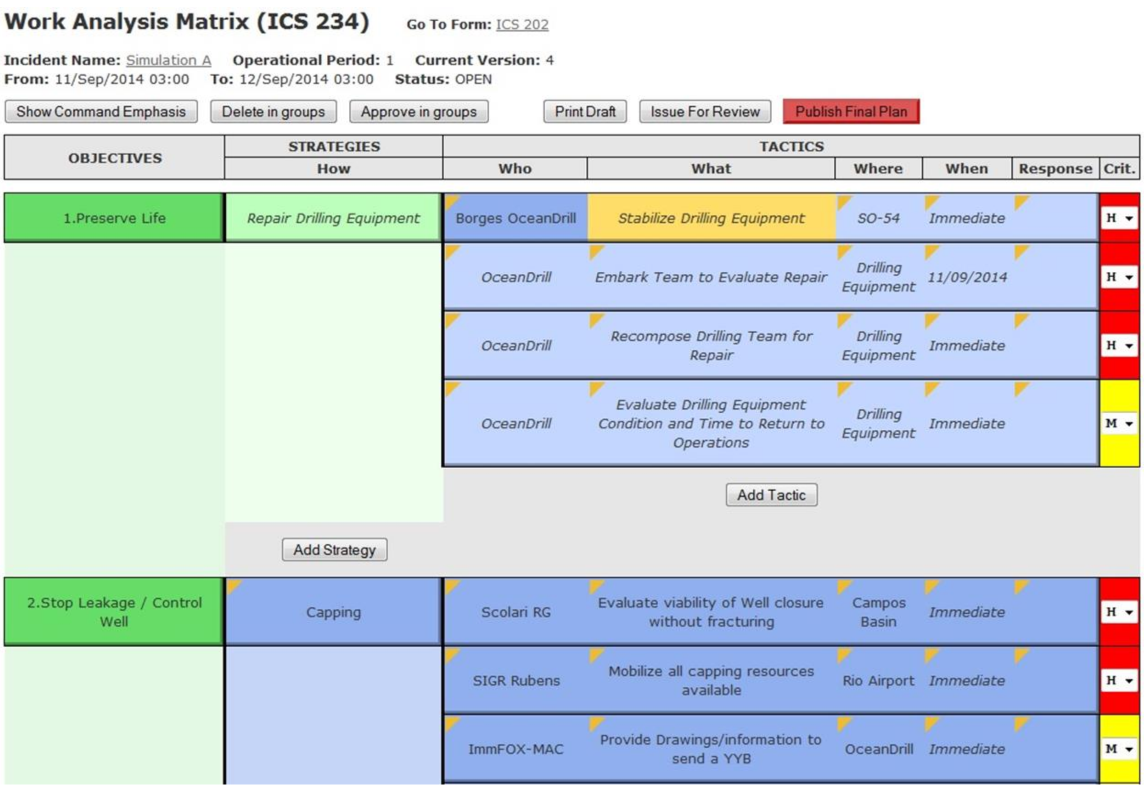


Figure 36. Work in Progress on the Tactics Plan showing Expressions Status

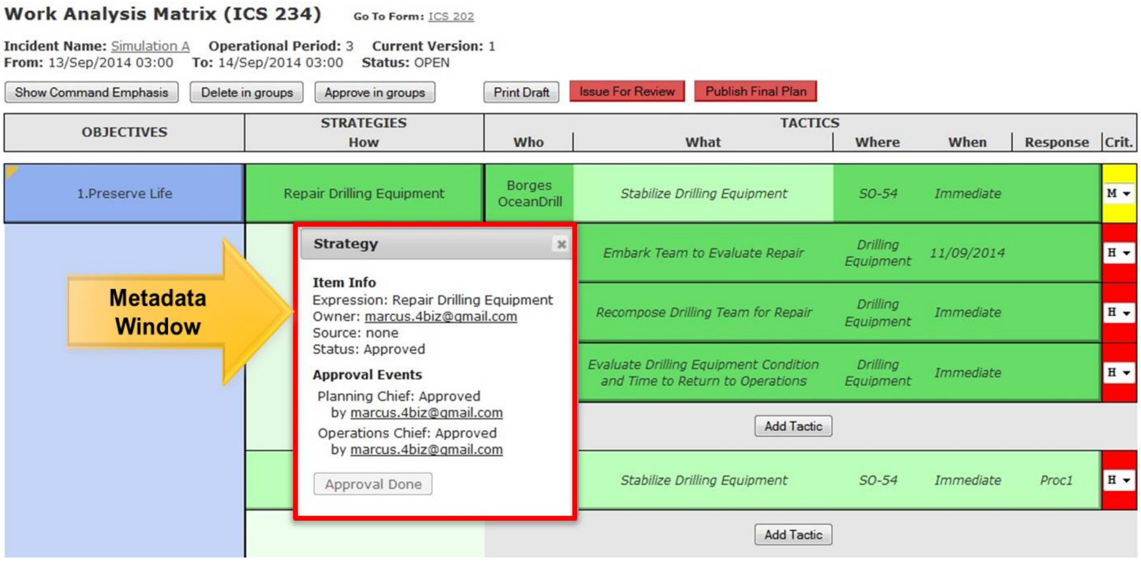


Figure 37. Expression Metadata Window

So this feature provides improved tactical planning awareness, by aggregating more information to each expression of the plan, by making this information easily visible, and by facilitating communication among team members.

c. Selective Expression Reuse User Interface

The “Selective Expression Reuse” feature supports selective filtering of previous incident expressions.

Before interacting with the Tactics Plan the user should configure his/her reuse filter selection for that Tactics Plan.

Figure 38 illustrates the user interface of the page to do this configuration. The Web Tool allows the user to enable or disable this function, for users that may think that a suggestion list is intrusive. He/she can also enable/disable hierarchy reuse, i.e. automatic reuse of tactics from the selected reused strategy. This is also to satisfy users that prefer not having to deal with automatically generated tactics.

Figure 38. Tool Configuration Page

Finally, for users that want to use the feature, they can select up to three filtering mechanisms: by user, by incident or by date. In this figure the filter is selected for “Simulation A” expressions only.

Figure 39 illustrates the Web Tool filtering in action, with a suggestion list of expressions that matches expressions that matched the filter and what the user is typing. Naturally, the list gets shorter as the user types additional characters. In this figure, typing “Ev” by the user shows a suggestion list with 3 expression entries that match “Ev” and belong to “Simulation A“ .

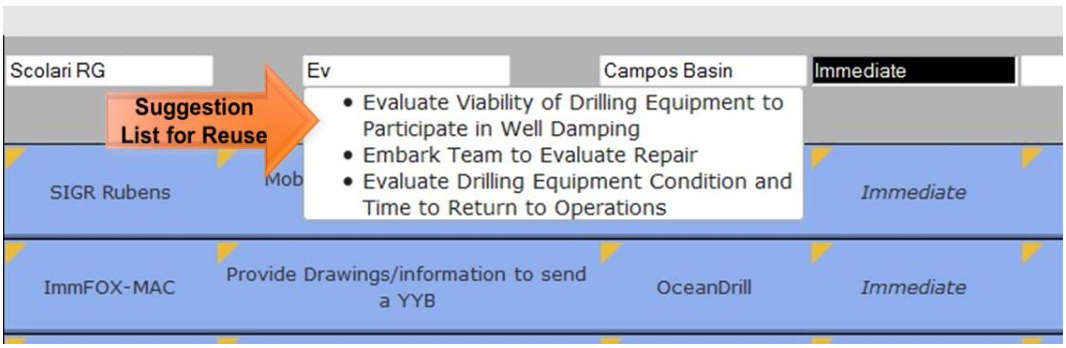


Figure 39. Expression Reuse from Library in Web Tool

So this feature provides the user with a more relevant and shorter suggestion list than reusing the created expressions without any filtering. The feature uses a simple filtering mechanism that the user can easily relate to. This is only possible due to the capture of “expression metadata”.

d. Expression Authority Control User Interface

The “Expression Authority Control” feature runs in the background, allowing the users to perform only actions authorized by their roles, and providing alerts when the user attempts to perform an action that is not allowed, considering the status of the plan and/or its planning items.

To be able to interact with the plans, the user needs an assigned role. Figure 40 illustrates the page “My Profile”, where the user can enter his/her contact information and configure his/her roles, up to three. A password is needed to change this configuration.

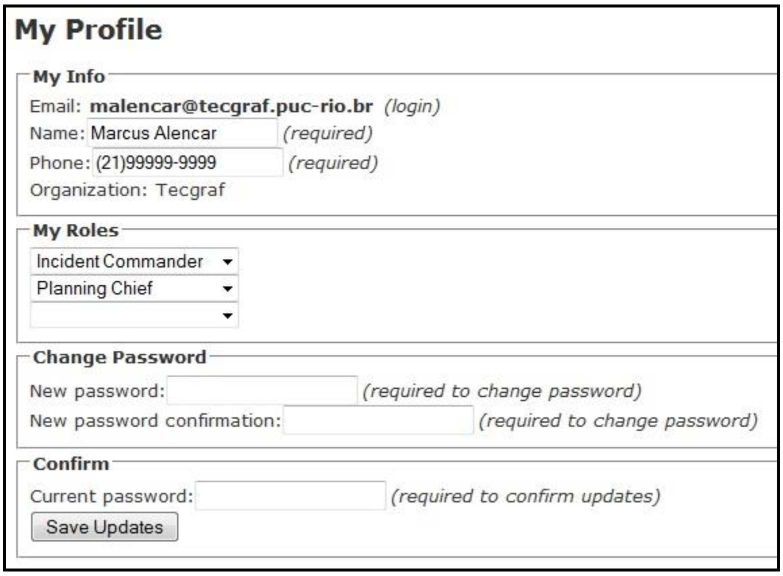


Figure 40. My Profile Page for Role Configuration

Then the user will inherit the authority of the assigned roles, and the interface will provide feedback of what he/she can do. Figure 41 illustrates two metadata windows that inform the user that he/she has already approved strategy “Repair Drilling Equipment”, but still has to approve or disapprove the Tactics Who “Embark Team to Evaluate Repair”. The interface also communicates to the user, through the approval flags in the figure, what planning items are still due for his/her approval.

Figure 41. Approval Authority Control

As the plan is updated with new expressions and approved by multiple users simultaneously, the interface provides planning awareness, by providing visual feedback of each expression's approval status. Figure 42 illustrates expressions in five different states, to be approved, automatic reuse (also to be approved), partial approval, approved and rejected. The interface also communicates if an expression was reused through using an italic font. It is important to signal to the user if an expression was fully typed by a user, reused from a list, or automatically reused as children tactics. Review and approval has to be extra careful with the later.

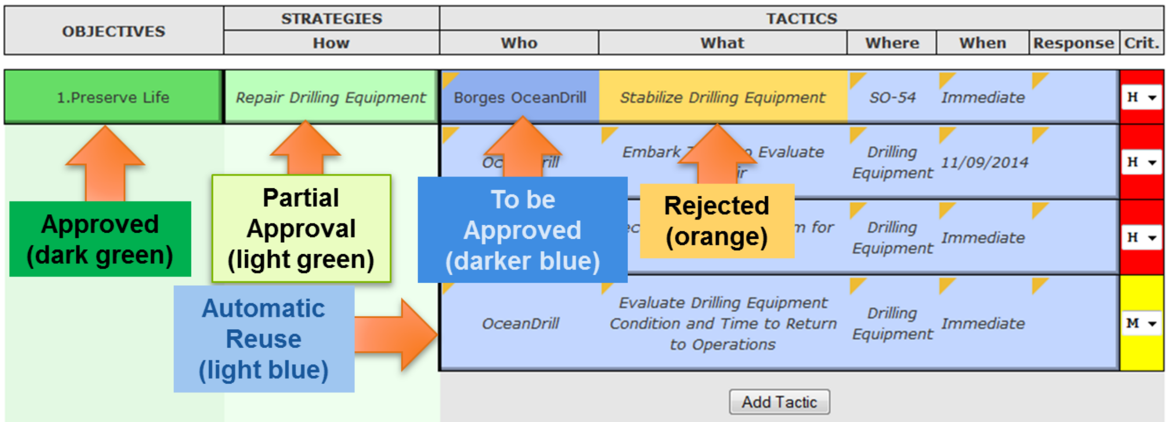


Figure 42. Expression Approval Status Visual Feedback

Finally, to issue the Tactics Plan, it is necessary to warrant its integrity. Figure 43 illustrates the alerts issued when trying to publish a final Tactics Plan with many expressions not consistent to allow it to happen. The Web Tool issues

Plan Approval Alerts at the plan level, and produces alerts for each expression that demands action to comply, marking these expressions with a red rectangle.

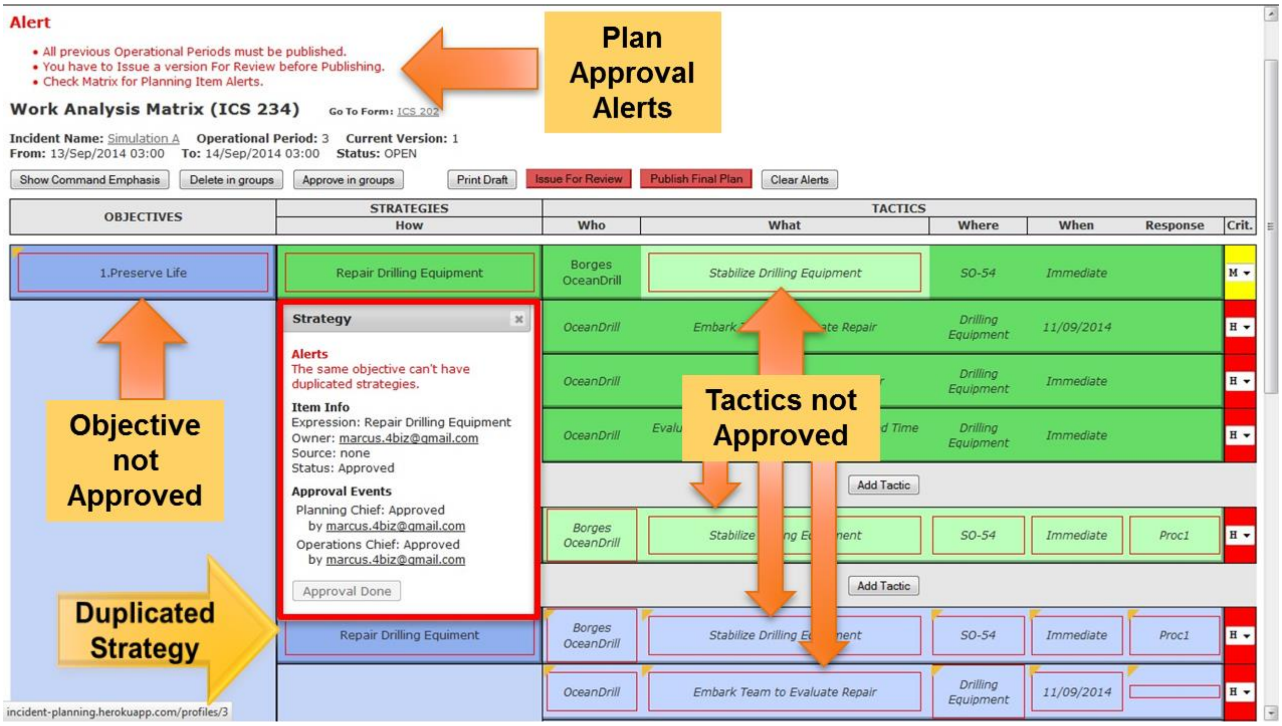


Figure 43. Publish Final Plan Alerts

So this feature provides control of the life cycle of expressions, to allow simultaneous work of multiple users on various parts of the Tactics Plan, and warrants the integrity of the Tactics Plan when it needs to be issued, like for publishing it.

This section presented how the Web Tool implemented the User Interface to support the CAP model features. The next chapter will present the Web Tool evaluation.

5
CAP Web Tool Evaluation & CAP Model Design Assessment

This chapter describes the Overall Evaluation Process, the Web Tool Evaluation plan and its results, and the CAP model design assessment and feedback, which resulted from analysis of Web Tool evaluation results.

5.1.
Overall Evaluation Process

Beyond testing the implemented features along Web Tool development, the evaluation process for CAP model/Web Tool involved three approaches:

- Evaluation along the development, replicating the planning process through the use of ICS-202 and ICS-234 forms generated during an actual incident simulation exercise of Oil and Gas Company C. They provided good insight into the typical forms and its contents, helping to verify if the Web Tool was adequately designed to support them;
- Evaluation along the development, through Web Tool demos to specialists to obtain their feedback on the features, as described in appendix C;
- Evaluation of the final version of the Web Tool prototype, through user observation when using the Web Tool to produce the tactics plan for a simulated incident scenario, complemented by post-use questionnaire and interview. This Web Tool evaluation was performed in two Oil and Gas Companies, as it will be described in the next section.

5.2.
Web Tool Evaluation Plan

The initial intent was to develop a pre-defined emergency scenario to be used in all evaluations of the Web Tool, avoiding the scenario to become an evaluation variable.

But when the actual specialists were contacted to perform the evaluation, it became clear that this was not a good approach because:

- The scenario would be discussed and pre-defined with the participation of the designer/developer of the Web Tool, so even unintentionally the Web Tool could be “tuned” to perform well in this scenario;
- The scenario would potentially incorporate signification systems unfamiliar for some of the evaluation participants, becoming a source of unnecessary stress, disrupting the evaluation results.

What made more sense was to use emergency scenarios developed internally by each of the companies for training, as they are already produced with the signification systems familiar to its employees.

Oil and Gas Companies A and B (OGC-A and OGC-B, respectively) participated in this evaluation and each provided two different scenarios but with some similarity, so that the reuse feature could be evaluated in the second scenario. Section B.1 of Appendix B describes in detail the four scenarios used for the evaluation.

Currently, OGC-A uses ICS forms in Word templates for incident managing, and OGC-B uses their own standard forms.

Considering that tactical planning is a collaborative activity, and the CAP model intends to address communication problems, each company allocated two Oil & Gas EHS (Environmental Health and Safety) specialists for the evaluation. One company provided EHS specialists with more than 10 years of experience, and the other provided specialists with 2 to 5 years of experience.

Web Tool evaluation at each company involved the following phases:

a. **Introduction:** the evaluator explained the evaluation purpose, participants signed the agreement to participate, and filled in the profile form (in appendix B.4);
b. **Demonstration:** the evaluator made a demonstration the Web Tool;
c. **Practice:** participants used the Web Tool to get basic familiarization;
d. **Scenario Usage 1:** the two participants used the Web Tool to develop ICS-202 and ICS-234 (Tactics Plan) for simulated incident 1. One specialist was configured in the Web Tool as the Incident Commander and the Operations Chief, and the other as the Planning Chief.
e. **Scenario Usage 2:** same for simulated incident 2.
f. **Post-use Questionnaires**: participants answered a questionnaire with 25 questions (in appendix B.5).
g. **Semi-structured Interview:** participants were interviewed by the evaluator (form in appendix B.6) to provide additional information about

"out of pattern" answers, and information to assess if designs of the CAP model and the Web Tool have met their objectives.

Other Oil and Gas companies were contacted to provide additional feedback, but they were not able to allocate specialists for an evaluation within the timeframe of this thesis. Going through all these evaluation phases took approximately four hours of these specialists, who are in high demand in their respective companies, so it is not surprising that other companies could not participate.

5.3. Web Tool Evaluation Results – Questionnaire

Appendix B.2 (questionnaire results) contains all the 25 questions of the questionnaire and their answers, by all four participants. The questions were divided in two sets.

The first set of 8 questions was extracted from the basic TAM (Technology Acceptance Methodology) questionnaire in Turner et al. (2010), conceived to assess the perception of acceptance of new technology, in this case the Web Tool. They are subdivided in two subsets, 4 refer to the perceived Usefulness and 4 refer to the perceived Ease of Use of the Web Tool.

The second set of 17 questions was divided in two subsets, 3 questions were proposed to assess if the problem of communication and management was being addressed the Web Tool, i.e. the incident management activity had improved, and 14 questions were proposed to assess the perception if the CAP model features had the desired attributes of agility, visibility and trust, as intended.

Table 3 presents the average grade per question for the first set, Web Tool acceptance perception. The average grade for Usefulness was 6.4, and the average grade for Ease of Use was 6.8, what is a very high average considering that 7 is the maximum grade.

Web Tool Acceptance Perception (Scale 1 to 7)	Average
1. Using the Web Tool would improve my performance in doing my job.	6.5
2. Using the Web Tool at work would improve my productivity.	6.25
3. Using the Web Tool would enhance my effectiveness in my job.	6.25
4. I would find the Web Tool useful in my job.	6.5
5. Learning to operate the Web Tool would be easy for me.	7
6. I would find it easy to get the Web Tool to do what I want it to do.	6
7. It would be easy for me to become skillful in the use of the Web Tool.	7
8. I would find the Web Tool easy to use.	7

Table 3. Web Tool Acceptance Perception Results

Question 6 was the one with the lowest average grade, 6. Although still high, the explanation for this low average came from one participant that gave it grade 4. In the interview, he/she explained that his/her rational was that the tool imposed some process guidelines, therefore he/she could not do whatever he/she wanted it to do. So the low grade means the tool was working as it was supposed to, and in this case not letting the user do whatever he/she wants is a good thing.

As discussed in chapter 3, the design approach of the CAP model is to enforce the ICS process, and therefore "force" the users to follow the ICS process rules. On the other hand, the design approach is that the system should not enforce or suggest the incorporation of expert knowledge in the expressions, because they should be understood by everyone, but the system will also not enforce this rule, in the sense that the user will be free to input any knowledge he feels like, even expert knowledge.

Table 4 presents the average grade per question for activity improvement perception. The average grade for these three questions was 6.2, what is a high average.

Activity Improvement Perception (Scale 1 to 7)	Average
9. Use of this tool would improve communication among participants during an emergency	6.5
10. Use of this tool would improve decision-making by the specialists in an emergency	6
11. Use of this tool would improve tactical planning management in an emergency	6

Table 4. Activity Improvement Perception Results

Table 5 presents the average grade per question for CAP model features attribute perception. The average grade for Context Traceability was 6.2, for Selective Reuse 6.8, and for Authority Control 6.3.

Question 14 was the one with the lowest average grade, 5.5. Although a good grade, in the interview one of the participants explained that in his/her point of view the tool helps managing the tactical planning activities, but it is the knowledge of specialists that is decisive to perform this management. It is not the tool that will manage. This is an interesting comment and in line with the perception that specialists do not like that the tools interfere with their decision making process. The CAP model was designed to support an auxiliary tool for the specialists, not to replace their decision making process, so this participant point of view is in line with the CAP model design approach.

Features Attribute Perception (Scale 1 to 7)	Context Traceability	Selective Reuse	Authority Control
12. Traceability and visibility of context of creation, update and approval of each expression would facilitate communication among participants	7		
13. Traceability and visibility of context of creation, update and approval of each expression would facilitate decision-making by the specialists	6		
14. Traceability and visibility of context of creation, update and approval of each expression would facilitate tactical planning management by the specialists	5.5		
15. Traceability and visibility of context of creation, update and approval of each expression would improve agility of production of the tactics plan	6		
16. Traceability and visibility of context of creation, update and approval of each expression would improve visibility of participants about production of the tactics plan	6.25		
17. Traceability and visibility of context of creation, update and approval of each expression would improve trust of participants in the production of the tactics plan	6.25		
18. Authority Control over each expression would improve agility of production of the Tactics Plan			6.25
19. Authority Control over each expression would improve visibility of participants about the production of the tactics plan			6.25
20. Authority Control over each expression would improve trust in the production of the tactics plan			6.25
21. The possibility to reuse expressions would improve agility of the production of the tactics plan		7	
22. The possibility to reuse expressions would improve visibility of participants about the production of the tactics plan		6.75	
23. The possibility to reuse expressions would improve trust in the production of the tactics plan		6.5	
24. The possibility to filter the reuse of expressions according to relevancy determined by the user would improve agility of the production of the tactics plan		7	
25. The possibility to filter the reuse of expressions according to relevancy determined by the user would improve trust in the production of the tactics plan		6.75	

Table 5. Features Attribute Perception Results

All participants were very enthusiastic about the tool, looking forward to use it in the future, even asking for a release date. The selective reuse feature deserves special mention, as it was the best perceived feature, 6.8 out of 7, causing very high enthusiasm from users, which led to suggestions on how to improve the selective reuse feature even further, what it will be addressed in the next section, comments and interviews.

5.4. Web Tool Evaluation Results – Comments and Interviews

Appendix B.3 contains the information collected from comments and interviews from OGC-A and OGC-B evaluations, respectively. This information is consolidated in the next items. Consolidation was done per company, by gathering comments in the questionnaire and in the interviews that refer to the same subject, and consolidating them in one single entry, independent of participant and number of occurrences. The text in each entry is a conglomerate of annotations from the participant and the evaluator, therefore it is not written in a formal way. They were left this way to help understand the original meaning of these annotations and make a better judgment when classifying them in the table. The objective was to get a common qualitative perspective of the Web Tool from each company, grouped by Strong Points and Points for Improvement.

a. Consolidated OGC-A Comments and Interviews

Strong Points of the Web Tool:

- Expressions reuse very good, reuse of tactics in strategy hierarchy
- System quickness
- Control of approvals flow, electronic approval facilitates flow
- Possibility to verify author of expressions, facilitates contact
- Remote follow-up of Tactics Plan by high ranking executives in real-time, liberating the team
- Tool is easy to use, gives freedom, very simple, didactic, friendly
- Incident history is important for auditing and lessons learned
- Through the tool it is possible to gain agility in tactical meetings, align members with the plan
- Tool agility improves decision-making
- Visibility provided by the tool to participants is unquestionable

- Interface layout easy to understand
- This is what is needed in a stress situation, a tool to guide and help

Points for Improvement of the Web Tool:

- Ability to send e-mail notifications to the members of the emergency team.
- Create an observer user for high ranking members.

b. Summary of OGC-B Comments and Interviews

Strong Points of the Web Tool:

- Reutilization of past scenarios would bring more agility to elaborate new scenarios.
- The tool is very friendly with regards to the layout and utilization, tool usage is “light”.
- With the suggestions we have made, I think it will be able to be used as a fundamental tool for the operationalization of the emergency situation.

Points for Improvement of the Web Tool:

- Would like to be able to completely import a previous scenario/incident to use in another one.
- Would like to adjust scenarios already created.
- Frozen operational plan in practice will need to be unfrozen during the operational period for adjustments.
- Would like the possibility to get real-time feedback of what is happening in practice at the incident.

The Strong Points results presented above will be analyzed in section 5.5, CAP model evaluation assessment, and the Points for Improvement results will be analyzed in section 5.6, CAP model design feedback.

5.5. Analysis of Results – CAP Model Design Assessment

This section maps the strong points of the evaluation results, identified in the previous section, to one of the three CAP model features, or to the Web Tool, if the strong point was considered not to be due to the CAP model. Each of the strong points was also mapped to the attribute, or attributes, it is referring to. Simplicity is a strong attribute of paper forms, and was also identified as a required attribute in section 3.4, one that shall not be lost in automation. The CAP model and CAP Web Tool designs have had the objective all along to preserve the simplicity of paper forms as much as possible, e. g. by using a similar page layout and supporting free text entry by the user. So Simplicity was also included as an attribute of the table to be assessed.

Table 6 presents the two mappings of the strong points to the three CAP model features or the CAP Web Tool, in the case that no feature is involved, and to four attributes.

Strong Points	Context Traceability	Selective Reuse	Authority Control	Web Tool	Simplicity	Agility	Visibility	Trust
1- Expressions reuse very good, reuse of tactics in strategy hierarchy		x				x		
2- System quickness				x		x		
3- Control of approvals flow, electronic approval facilitates flow			x		x	x		x
4- Possibility to verify author of expressions, facilitates contact	x						x	x
5- Remote follow-up of Tactics Plan by high ranking executives in real-time,				x		x	x	x
6- Tool is easy to use, gives freedom, very simple, didactic, friendly				x	x			
7- Incident history is important for auditing and lessons learned	x							x
8- Through the tool it is possible to gain agility in tactical meetings, align members with the plan				x		x		
9- Tool agility improves decision-making				x		x		x
10- Visibility provided by the tool to participants is unquestionable	x						x	
11- Interface layout easy to understand				x			x	
12- This is what is needed in a stress situation, a tool to guide and help				x		x		
13- Reutilization of past scenarios would bring more agility to elaborate new scenarios.		x				x		
14- The tool is very friendly with regards to the layout and utilization, tool usage is “light”.				x	x	x		

Table 6. Web Tool Strong Points versus Features and Attributes

In some cases, the assignment of the attributes to the strong points is not obvious, as it involves the interpretation of the evaluator, who did the interviews and was present during all phases of the evaluation process. So these assignments are explained here for each Strong Point:

- Item 1: the perceived advantage of reuse was the time gained, i.e. Agility;
- Item 2: system quickness, i.e. Agility;
- Item 3: approval facilitates flow, in the sense of Agility, not having to waste time with it, and Trust, not having to worry if it is effective;

- Item 4: possibility to verify author, i.e. Trust, facilitates contact, information Visibility;
- Item 5: provides Visibility and Trust in the plan to executives, and liberates the team, providing free time which can be used for incident response, i.e. Agility;
- Item 6: easy to use, simple, i.e. Simplicity;
- Item 7: incident history is important for auditing, i.e. Trust
- Item 8: gain agility in meeting, i.e. Agility;
- Item 9: agility improves decision making, i.e. Agility and Trust for decision making;
- Item 10: visibility provided, i.e. Visibility;
- Item 11: interface layout, i.e. Visibility;
- Item 12: tool to guide and help, i.e. Agility;
- Item 13: bring mode agility, i.e. Agility;
- Item 14: tool is very friendly, i.e. Simplicity, tool usage is “light”, i.e. Agility;

Table 7 consolidates the mapping of strong points in Table 6 to a Matrix of Features versus Attributes, where the specific CAP model features were separated from the remainder of Web Tool features, and mapped to the perceived attributes.

Features	Simplicity	Agility	Visibility	Trust
Context Traceability			X	X
Selective Reuse		X		
Authority Control	X	X		X
Web Tool	X	X	X	X

Table 7. Features versus Perceived Attributes

This analysis demonstrates that the CAP model features have been perceived as capable to introduce improvements to tactical planning in terms of agility, visibility and trust, as intended. It also demonstrates that the Web Tool design was perceived to have all four attributes, including simplicity.

5.6. Analysis of Results – CAP Model Design Feedback

This section maps, in Table 8, the points for improvement of the Web Tool evaluation results in section 5.4, to one of the three CAP model features, or to:

- New to Model, meaning that this improvement’s implementation is a non-existing feature of the model, either because it is not covered (new) or because it would be used outside the current tactical planning scope of the model;

- Web Tool, meaning that this improvement' implementation would be addressed by the Web tool, not affecting the model;
- External System, meaning that this improvement would be implemented in an external system.

The level of complexity to implement each of these new improvements was estimated as Low, Medium or High at table 8, and explained here for each item:

- Item 1: this would be relatively simple to implement using existing system features, but it is out of the intended scope of CAP model features;
- Item 2: different roles are already part of the model, so it has only to be instantiated in the Web Tool through simple to do configuration;
- Item 3: the model includes reuse up to objectives, but it could be rethought to include up to the incident level. Estimated medium complexity;
- Item 4: this was not considered in the model initially. It could be added but the estimated complexity is high. An interesting challenge as future work;
- Item 5: this was also not considered in the model, and the same applies as the previous item;
- Item 6: this was also not considered in the model, and it was perceived as an improvement desired by most organizations. But it depends on interaction with external systems, so implementation would be a big challenge. Also interesting as future work.

Points for Improvement	CAP MODEL				EXTRA-MODEL	
	Context Traceability	Selective Reuse	Authority Control	New to Model	Web Tool	External System
1- Ability to send e-mail notifications to the members of the emergency team					Low	
2- Create an observer user for high ranking members			Low			
3- Would like to be able to completely import a previous scenario/incident to use in another one.		Medium				
4- Would like to adjust scenarios already created.				High		
5- Frozen operational plan in practice will need to be unfrozen during the operational period for adjustments.				High		
6- Would like the possibility to get real-time feedback of what is happening in practice at the incident.				High		High

Table 8. Points for Improvements Mapping

Therefore, we conclude that the only CAP model design feedback that is within the intended scope of the CAP model is item 3, the ability to reuse a whole incident. The other items are either already covered in the model, and only need to be implemented in the Web Tool (item 2), or are outside the current scope of the CAP model.

This chapter presented the Web Tool evaluation process and an analysis of the results, including its evaluation by specialists when performing tactical planning with “realistic” simulated scenarios at two Oil and Gas Companies, and handled by the Web Tool without previous “tuning”, presenting a very positive acceptance by its users, who recognized its features and suggested a few points for improvement, mostly outside the intended scope of the CAP model, providing preliminary evidence that the CAP model has the correct design approach to improve tactical planning.

6
Conclusions and Future Work

This thesis has addressed further research in communication and management problems within major incident management, identifying specific issues. These issues were translated into three novel features of a context-aware planning model, which aggregates metadata to expressions (planning item instances) to support the features, which are:

- expression context traceability, provides planning awareness;
- selective expression reuse, allows reuse of incident knowledge;
- expression authority control, controls life-cycle of each expression, independent of the tactics plan.

These features were implemented in a prototype CAP Web Tool for evaluation by emergency management specialists. Two Brazilian Oil and Gas Companies participated in this evaluation. Another two Brazilian Oil and Gas Companies saw a presentation and a demo of the Web Tool prototype and provided design feedback.

Evaluation results provided preliminary evidence that the Web Tool improves tactical planning agility, visibility and trust, preserving simplicity, as intended. Evaluation also highlighted the benefits of incident knowledge reuse, a CAP model feature praised by all specialists that evaluated or saw a demo of the Web Tool, leading to suggestions of potential uses of this feature well beyond what it was conceived for.

This research has also addressed the three following research questions:

- Q1: “How to improve communication and management within multi-expertise tactical planning in a major incident?”

  Resp.: To deal with this problem this thesis proposes the CAP model with planning agility, visibility and trust attributes. The viability of this model was indicated by the implementation of the Web Tool, and its usefulness was indicated by the good results achieved in its evaluation with domain experts.
- Q2: “What type of information and prior knowledge should and what should not be incorporated in the Tactical Planning Model to improve

quickness and efficiency of multi-expertise Tactical Planning decision-making?”

Resp.: Section 3.4 addresses this question, by proposing design approaches that address tactical planning issues. Particularly, the recommendation is not to pre-load the system with specialized knowledge for use in the tactics plan, because this may cause interaction stress due to the multi-expertise nature of participants. Instead, the recommendation is to store incident knowledge as it is created during an incident, and support its reuse in a following incident.

- Q3. “What should be automated and what should not, to obtain benefits from automation of multi-expertise tactical planning, without jeopardizing the simplicity and availability of paper forms?”

  Resp.: This question is also addressed by section 3.4. Particularly, the recommendation is to automate the process, in this case ICS, so that the tool will guide the expert users in following the process accordingly, but not automate the expert decision making, i.e. the expert response, because that is where the experts shine at their best.

The main contribution of this thesis was to develop the CAP model, a planning model that addresses communication and management issues in emergency scenarios with novel design approaches for:

- **User interaction**, focusing in automating the process only, not the expert decision-making, and letting the user freely enter his/her own expressions, instead of imposing a “common language” or “expert domain language”, neither incorporating expert domain knowledge to the model;
- **User awareness**, focusing in improving planning awareness to enhance collaboration, versus just incident awareness, the most common approach;
- **Knowledge reuse**, focusing in selective reuse of previous incident knowledge, produced by users during an incident, versus reuse of expert domain knowledge introduced by system designers;
- **Collaborative planning**, supporting simultaneous multi-user planning by individually controlling the approval life cycle of each planning item, instead of whole plans.

This research has also identified future work in developing the CAP model beyond what it was conceived for:

- Instantiate the model in another multi-expertise collaborative planning domain, other than ICS, and verify if the CAP model attributes for decision making are still useful and valid;
- Extend the model to not only capture but also develop tacit knowledge, by allowing experts to adjust the tactics plan to a simulated incident, and reuse this plan for a future incident with similar characteristics;
- Add logging to expressions and metadata, and then apply social web search techniques to extract trends and "lessons learned" type of knowledge. It should be noted that the use of these techniques would require the collection of a very large amount of data from usage of the CAP Web Tool during many incidents.

In addition to new research work, the CAP model could evolve, incorporating new features to support new planning capabilities like:

- Possibility to interact and exchange information with external systems, like systems for operational response and resource planning, for incident situation awareness, for organizational structure management, and for geo-referenced installations/platforms/equipment management;
- Alternatively, the CAP model could be integrated into an existing incident management system to provide its complementary features;
- Possibility to reuse an entire incident at once, not just tactics from a reused strategy;
- Incorporate workflow features to support the execution and management of the several parallel activities.

7
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Appendix A – The Incident Command System

The Incident Command System (ICS) process was originally developed during the 70's in California, USA, for management of efforts against catastrophic forest fires. ICS is a subcomponent of NIMS (National Incident Management System), which is maintained by FEMA (Federal Emergency Management Agency) that belongs to the US Department of Homeland Security. Bigley and Roberts (2001) study discusses the reliability of the ICS.

ICS has been adopted worldwide as the standard system for management of disasters and emergencies, in particular in the field of oil and gas. Genwest (2005) produced an ICS manual for the Oil and Gas Industry.

The content in this appendix is based on the ICS review material (FEMA 2008). Figure A.1 illustrates the top of the incident command structure and its roles and figure A.2 illustrates the functional details of this structure.

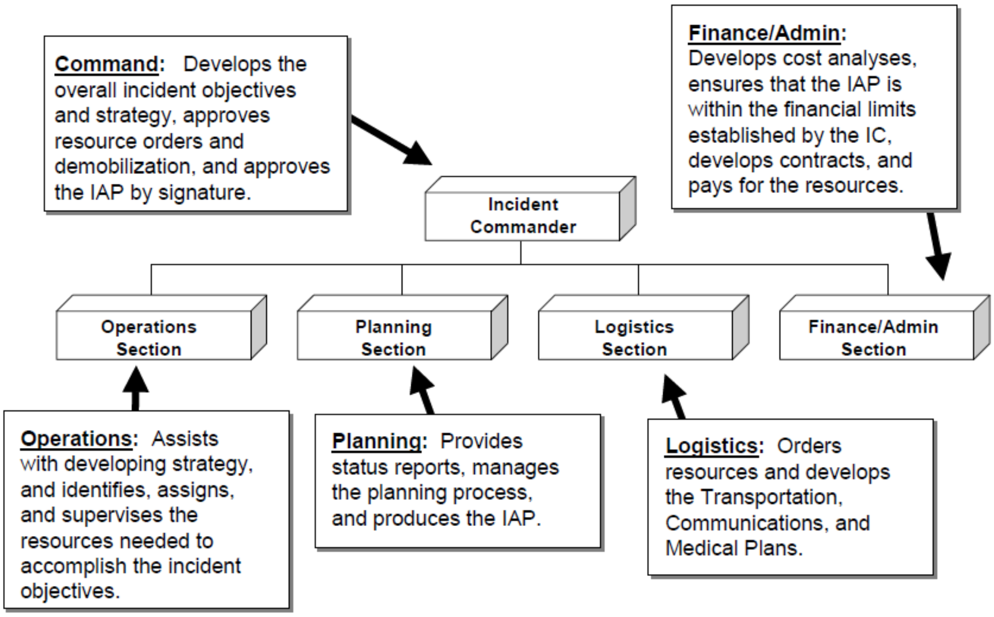

Figure A.1. Top of the command structure and its roles (source: FEMA)

These diverse groups participate in the management of the incident according to the operational planning cycle shown in figure A.3, called Planning "P", due to the shape of the diagram. As it can be seen on this figure, planning has an initial part, called "initial response", after which it enters into an operational cycle of responses, called "Operational Periods", until management of the incident considers it is properly finalized.

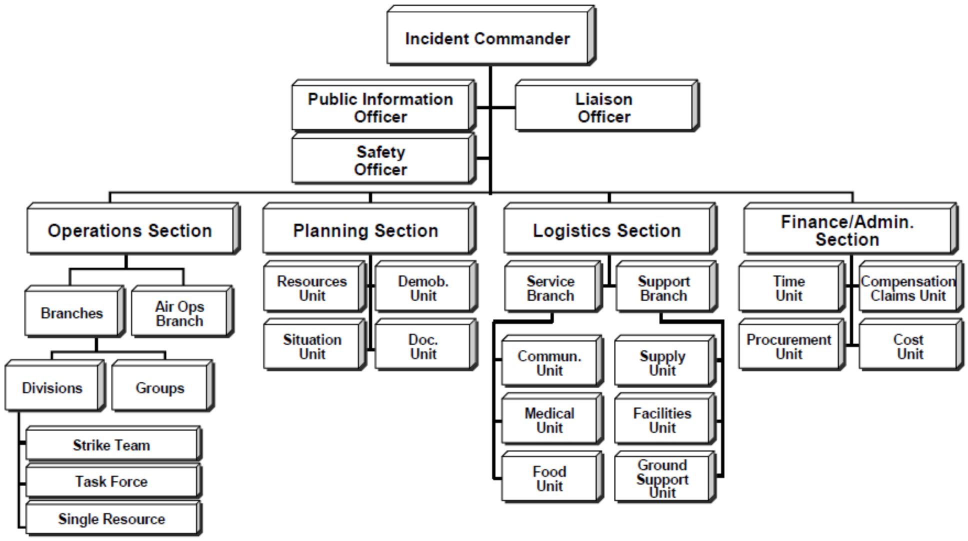

Figure A.2. Organizational structure of incident command (source: FEMA)

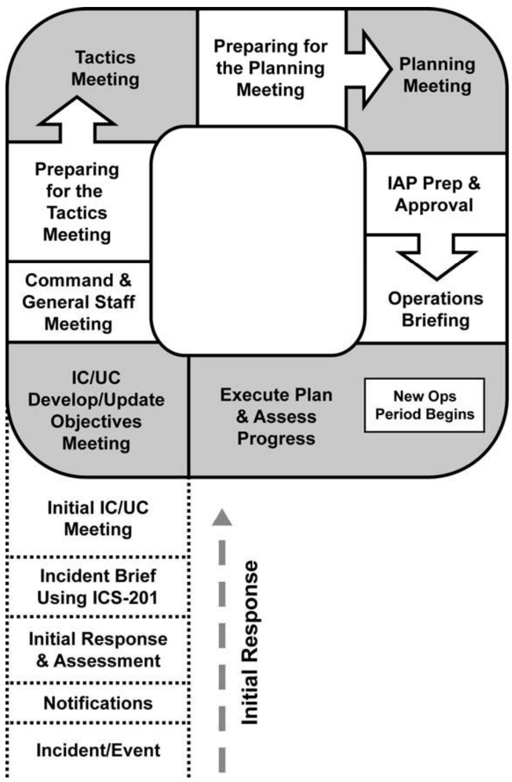

Figure A.3. Planning "P" Operational Planning Cycle (source: FEMA)

ICS defines the process during the execution of the operational periods, and also defines the forms that must be filled.

On the initial phase, the form ICS-201, called “incident briefing”, is filled. This form characterizes the incident and describes the resources that were immediately allocated to deal with the incident.

Once the operational cycle is initiated, a meeting is held among the high command of the incident to update the incident objectives of the incident with regards to the current situation of the incident. At this point, form ICS-202 is filled. This form defines the incident objectives, the command emphasis (e.g. priorities) and makes these goals clear.

During the operational periods the various groups involved engage operational and planning meetings, in which they discuss the incident and produce forms documenting the actions that should be taken and the necessary resources, aiming to manage the incident according to ICS. The Incident Action Plan (IAP) is the set of forms and documents that defines these actions and resources.

One of the forms that is produced by the operations section, and that is a part of IAP, is form ICS-234, the “Work Analysis Matrix”, which is produced in advance for discussion during the tactics meeting, identified in figure A.3.

Appendix B – Scenarios, Evaluation Results and Questionnaires

B.1 Emergency Scenarios

I. Oil and Gas Company A (Originally in Portuguese)

INCIDENT 1: Collision between the support boat and the maritime unit of wells drilling.

During the performance of the Formation Test of Well-ES1, the support boat EA-12 was approaching Sea Hawk platform for food transfer, when it lost control and crashed with the sound. The collision force affected one of the lateral tanks at starboard of the bat, causing diesel oil spill to the sea.

The machine Officer of the support boat identified the damaged area and the source of leakage, which was isolated, stopping oil leakage to the sea.

The procedure to transfer Fuel Oil to other non-damaged tanks has been concluded, indicating that about 80 m3 of diesel oil leaked to the ocean.

The stability of the units was investigated and there are no signs that larger structural damage that may compromise safety of the installation.

In this event there was one case of a seriously wounded person, for whom the MEDEVAC structure was requested.

INCIDENT 2: Loss of the anchoring system of the maritime unit of wells drilling

The passage of a cold front has caused the rupture of 3 (three) cables of the anchoring system of the Blue platform, which was performing Formation Test in well Poço-ES1.

The platform lost stability and had to be disconnected and taken to a safe distance from the well, causing leakage of the oil contained in the test column. It is estimated that 15-20 m3 of crude oil have leaked to the sea. The stability of the units was investigated and there is no indication of major structural damages that could compromise safety of the installation.

II. Oil and Gas Company B (Originally in Portuguese)

INCIDENT 1:

I – Identification of the installation that originated the incident

Name of the installation: Platform B1-ES

( ) In no conditions to provide information

II – Date and Hour of Observation

Date: 15/12/2014

Hour**:** 8:29 h

III – Estimated Date and Hour of the Incident

Date: 15/12/2012

Hour: 5:00 h

( ) In no conditions to provide information

IV – Oil or another substance that is harmful or dangerous when leaked

Type of Oil and º API or Product: Crude Oil, ºAPI 20

Estimated Volume (m3): 150 m³

( ) In no conditions to provide information

V – Current Situation of Leakage

(**X**) Paralyzed;

( ) Not Paralyzed;

( ) In no conditions to provide information

VI – Brief description of the Incident:

There was oil leakage to the ocean through the producing riser in well XYZ-ES1.

VII – Probable cause of the Incident:

The incident occurred probably due to fatigue of the flow-line/riser material (between the buoy and ANM).

VIII – Number of Wounded: none

( ) In no conditions to provide information

IX – Initial Actions

(X) Emergency Plan In Execution

( ) Other tasks done:

The following response actions were taken in response to the event:

1) Pump BCS in the interior of the well was paralyzed at 8:32 h and closed at 8:33 h;

2) The brigade wall called at 8:33 h;

3) Cleaning team and the on call nurse were called at 8:33 h.

X – Other information deemed appropriate:

Wind direction and velocity: 034° / 0.1 knots.

Sea current direction and velocity: 026° / 1.3 knots.

INCIDENT 2:

I – Identification of the installation that originated the incident

Name of the installation: Platform B1-ES

( ) In no conditions to provide information

II – Date and Hour of Observation

Date: 15/12/2014

Hour**:** 9:20 h

III – Estimated Date and Hour of the Incident

Date: 15/12/2012

Hour: 9:20 h

( ) In no conditions to provide information

IV – Oil or another substance that is harmful or dangerous when leaked

Type of Oil and º API or Product: Crude Oil, ºAPI 21

Estimated Volume (m3): 130 m³

( ) In no conditions to provide information

V – Current Situation of Leakage

(**X**) Paralized;

( ) Not Paralyzed;

( ) In no conditions to provide information

VI – Brief description of the Incident:

There was oil leakage to the ocean due to the rupture of the transfer hosepipe during the offloading operation to the Reliever Tank Ship.

VII – Probable cause of the Incident:

Suspicion of material fatigue.

VIII – Number of Wounded: none

( ) In no conditions to provide information

IX – Initial Actions

(X) Emergency Plan In Execution

( ) Other tasks done:

The following actions were taken in response to the incident::

09:23 – Pump for charging the inert gas system was paralyzed;

09:25 – Mooring Master was alerted to close the valve of the reliever manifold;

09:26 – OIM requested the SOPEP teams, brigade, safety and nurse to be on call.

X – Other information deemed appropriate:

Wind direction and velocity: NE / 19 knots.

Sea current direction and velocity: SW / 1.1 knots.

B.2 Questionnaire Results

I. Acceptance Perception (TAM)

Web Tool Acceptance Perception Questions (Scale 1 to 7)	A1	A2	B1	B2
1. Using the Web Tool would improve my performance in doing my job.	7	7	6	6
2. Using the Web Tool at work would improve my productivity.	7	7	5	6
3. Using the Web Tool would enhance my effectiveness in my job.	7	7	5	6
4. I would find the Web Tool useful in my job.	7	7	6	6
5. Learning to operate the Web Tool would be easy for me.	7	7	7	7
6. I would find it easy to get the Web Tool to do what I want it to do.	7	7	4	6
7. It would be easy for me to become skillful in the use of the Web Tool.	7	7	7	7
8. I would find the Web Tool easy to use.	7	7	7	7

II. Attributes Perception

Attributes Perception Questions (Scale 1 to 7)	A1	A2	B1	B2
9. Use of this tool would improve communication among participants during an emergency	7	7	6	6
10. Use of this tool would improve decision-making by the specialists in an emergency	7	5	6	6
11. Use of this tool would improve tactical planning management in an emergency	7	5	6	6
12. Traceability and visibility of context of creation, update and approval of each expression would facilitate communication among participants	7	7	7	7
13. Traceability and visibility of context of creation, update and approval of each expression would facilitate decision-making by the specialists	7	5	6	6
14. Traceability and visibility of context of creation, update and approval of each expression would facilitate tactical planning management by the specialists	7	5	5	5
15. Traceability and visibility of context of creation, update and approval of each expression would improve agility of production of the tactics plan	7	5	6	6
16. Traceability and visibility of context of creation, update and approval of each expression would improve visibility of participants about production of the tactics plan	7	7	5	6
17. Traceability and visibility of context of creation, update and approval of each expression would improve trust of participants in the production of the tactics plan	7	7	5	6
18. Authority Control over each expression would improve agility of production of the Tactics Plan	7	7	5	6
19. Authority Control over each expression would improve visibility of participants about the production of the tactics plan	7	7	5	6
20. Authority Control over each expression would improve trust in the production of the tactics plan	7	7	5	6
21. The possibility to reuse expressions would improve agility of the production of the tactics plan	7	7	7	7
22. The possibility to reuse expressions would improve visibility of participants about the production of the tactics plan	7	7	6	7
23. The possibility to reuse expressions would improve trust in the production of the tactics plan	7	7	5	7
24. The possibility to filter the reuse of expressions according to relevancy determined by the user would improve agility of the production of the tactics plan	7	7	7	7
25. The possibility to filter the reuse of expressions according to relevancy determined by the user would improve trust in the production of the tactics plan	7	7	6	7

B.3 Comments and Interviews Results

I. Oil and Gas Company A

Participant A1

Strong Points

Comment in Questionnaire: Expressions Reuse

Interview: reuse is very good, also for hierarchy reuse and alert of automatic Tactics

Comment in Questionnaire: System Quickness

Comment in Questionnaire: Approvals Flow

Comment in Questionnaire: Possibility to verify who created expressions

Interview: facilitates contact with this person

Comment in Questionnaire: Follow-up of the Tactics Plan by high ranking executives in real-time

Interview: do not need to call emergency team all the time, liberates team

Comment in Questionnaire: Tool is Easy to use

Interview: Not difficult to use

Comment in Questionnaire: Tool Freedom

Interview: Incident history is important for auditing and lessons learned

Points for Improvement

Comment in Questionnaire: Ability to send e-mail notifications to the members of the emergency team [I: notify a person assigned to the task not accessible at the time or from outside the team structure

Comment in Questionnaire: Create Observer User for high ranking members

Participant A2

Strong Points

Comment in Questionnaire: Through the tool it is possible to gain agility in tactical meetings, members become aligned and in agreement with objectives, strategies and tactics in real-time

Interview: agility improves decision-making

Interview: visibility provided by the tool to participants is unquestionable

Interview: creates a permanent record

Interview: Reuse helps very much

Interview: Interface layout easy to understand

Interview: very simple, didactic, friendly

Interview: this is what is needed in a stress situation, a tool to guide and help

Interview: electronic approval facilitates flow.

Points for Improvement

Interview: no suggestion, did not see any fragility

Points of Note

Interview: decision-making relies heavily on the team experience, tool does not suffice.

II. Oil and Gas Company B

Participant B1

Strong Points

Comment in Questionnaire: Reutilization of past scenarios would bring more agility to elaborate new scenarios.

Interview: why low grade to question 6? Tool has its guideline, it does not let me do anything I would want.

Points for Improvement

Comment in Questionnaire: Would like to adjust scenarios already created.

Interview: Would like to be able to completely import a previous scenario to use in another one.

Interview: Frozen Plan in practice will need to be unfrozen during the operational period for adjustments.

Participant B2

Strong Points

Comment in Questionnaire: The tool is very friendly with regards to the layout and utilization. With the suggestions we have made, I think it will be able to be used as a fundamental tool for the operationalization of the emergency situation.

Interview: tool usage is “light”.

Points for Improvement

Interview: would like to be able to reuse whole Scenarios/incidents.

Interview: possibility to get real-time feedback of what is happening in practice.

B.4 Participant Profile Questionnaire (Originally in Portuguese)

Name: __________________ Company: _____________ Date: ____ / ___ / 2014

1. Personal Data

Age: ______ Gender (M or F): ____

What is your expertise? _______________________________________

2. Experience with Management of Emergency Incidents

2.1. How many years of experience do you have with management of emergency incidents?

( ) – up to 1 year
( ) – from 1 to 2 years
( ) – from 2 to 5 years
( ) – from 5 to 10 years
( ) – more than 10 years
( ) – No experience

2.2. What would be your role in the management of an emergency?

____

2.3. Have you already participated in any emergency?

( ) – No
( ) – If yes, how many? _________
( ) – Another answer ________________________

2.4. Have you already used any tool for emergency planning?

( ) – No
( ) – Paper forms, different standard than ICS
( ) – Paper forms in ICS standard
( ) – Word template forms in ICS standard
( ) – ICS compliant application. Which one? _______________________
( ) – Another answer ________________________

B.5 Post-usage Evaluation Questionnaire (Originally in Portuguese)

Participant: ______________________________ Date: ____ / ___ / 2014

Please respond to the following questionnaire regarding your interaction with the Web Tool.

There are no correct or wrong answers, what matters is your opinion about this experience.

Mark an X inside the box at the scale that represents your degree of agreement with the statement.

A. Overall Perception of Web Tool

1. Using the Web Tool would improve my performance in doing my job.

	1	2	3	4	5	6	7		
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree	or N/A ___

2. Using the Web Tool at work would improve my productivity.

	1	2	3	4	5	6	7		
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree	or N/A ___

3. Using the Web Tool would enhance my effectiveness in my job.

	1	2	3	4	5	6	7		
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree	or N/A ___

4. I would find the Web Tool useful in my job.

	1	2	3	4	5	6	7		
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree	or N/A ___

5. Learning to operate the Web Tool would be easy for me.

	1	2	3	4	5	6	7		
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree	or N/A ___

6. I would find it easy to get the Web Tool to do what I want it to do.

	1	2	3	4	5	6	7		
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree	or N/A ___

7. It would be easy for me to become skillful in the use of the Web Tool.

	1	2	3	4	5	6	7		
Strongly Disagree	☐	☐	☐	☐	☐	☐	☐	Strongly Agree	or N/A ___

8. I would find the Web Tool easy to use.

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

B. Perception of Web Tool Attributes

Comparatively with the current process for managing the tactics plan in an emergency:

9. Use of this tool would improve communication among participants during an emergency.

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

10. Use of this tool would improve decision-making by the specialists in an emergency.

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

11. Use of this tool would improve tactical planning management in an emergency.

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

12. Traceability and visibility of context of creation, update and approval of each expression would facilitate communication among participants.

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

13. Traceability and visibility of context of creation, update and approval of each expression would facilitate decision-making by the specialists.

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

14. Traceability and visibility of context of creation, update and approval of each expression would facilitate tactical planning management by the specialists.

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

15. Traceability and visibility of context of creation, update and approval of each expression would improve agility of production of the tactics plan

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

16. Traceability and visibility of context of creation, update and approval of each expression would improve visibility of participants about production of the tactics plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

17. Traceability and visibility of context of creation, update and approval of each expression would improve trust of participants in the production of the tactics plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

18. Authority Control over each expression would improve agility of production of the Tactics Plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

19. Authority Control over each expression would improve visibility of participants about the production of the tactics plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

20. Authority Control over each expression would improve trust in the production of the tactics plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

21. The possibility to reuse expressions would improve agility of the production of the tactics plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

22. The possibility to reuse expressions would improve visibility of participants about the production of the tactics plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

23. The possibility to reuse expressions would improve trust in the production of the tactics plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

24. The possibility to filter the reuse of expressions according to relevancy determined by the user would improve agility of the production of the tactics plan.

Strongly Disagree ☐☐☐☐☐☐☐ Strongly Agree or N/A ___
1 2 3 4 5 6 7

25. The possibility to filter the reuse of expressions according to relevancy determined by the user would improve trust in the production of the tactics plan.

Strongly Disagree [ ][ ][ ][ ][ ][ ][ ] Strongly Agree or N/A ___
1 2 3 4 5 6 7

C. Comments

26. Would you have anything else to comment about your experience with the Web Tool?

For example:

- General impressions about the tool utilization.
- Positive experiences using the tool, characteristics that have helped a lot.
- Negative experiences using the tool, characteristics that were missing or did not help.
- Suggestions of how to improve the tool towards a real emergency scenario.

___

___

B.6 Post-usage Participant Interview (Originally in Portuguese)

Participant:___________________________ Company: ________

Date: _____ / ___ / 2014 Evaluator: Marcus Alencar

Topics that should be addressed:

1) Ask the participant to elaborate on the points of the last question of the questionnaire.

2) Ask the participant to clarify the reason for any negative answers in the questionnaire, in case it has not been previously addressed.

3) Did the participant find the interface clear? Or did he have any difficulties?

4) Did the participant have any question during the interaction that the system was not able to solve?

5) Ask the participant to elaborate on suggestions to improve these aspects.

Observations that must be done during the test to include questions on the following interview:

Since the scenario of the task is exploratory, it is important to try to differentiate what is a simple exploration of the interface from what is a break in the communication – taking notes of these moments and subsequently asking the participant if the answer is not clear.

____

____

Appendix C – Specialists Feedback

Overall, four Oil & Gas Companies were involved in providing feedback to improve Web Tool/CAP model, some during development and others during evaluation.

For confidentiality reasons, these companies will be called simply OGC-A, OGC-B, OGC-C and OGC-D. OGC-A provided feedback during development and evaluation. OGC-B during evaluation only. OGC-C and OGC-D during development only.

Feedback during evaluation will be presented in chapter 5. This appendix describes the feedback during the development phase.

One feature that all Oil & Gas Companies would like is to link Tactical Planning in ICS-234 with critical resources planning in ICS-215 and 204. After all, the final version of the Tactics Plan has to account for resource availability.

But considering that it was not feasible to integrate the development of an existing commercial product with a proof of concept prototype, the Web Tool, the approach was to append a “Response” field to every Tactic in the Web Tool, and allow the specialists to use it to manually type the tactic link to the forms and procedures that address its response resources.

Another feature that is highly desirable for an automated ICS-234 system is to link the Who and the Where in the Tactic with external systems that handle the corporate organizational structure and the geo-referenced equipment/platform locations, respectively. But this must be done with extreme caution, because using the suggested input should be an option, not an obligation, as there are many cases in an emergency where these “valid” options will not fit with the desired response. For example, the Who could be an external company that is not yet loaded in the organizational structure database. Alternatively, it could be the joint responsibility of two groups, one external consultant and one internal team, like SeaCrest/WellTeam. Therefore, the system must have the flexibility to accept the ad-hoc nature of a major incident.

Several other features were suggested in specific meetings with specialists where the Web Tool was demoed:

In a meeting with OGC-A, the specialist comments about the demo of a close to final Web Tool prototype were:

- Could the Web Tool be faster when deleting planning items, instead of deleting one at a time? Note: In fact, the Web Tool was already capable of deleting and approving in groups. This feature was demonstrated at the meeting and the specialist was satisfied;
- Could the Web Tool issue a report by Who is responsible for which tactics and what tactics are the responsibility of one specific Who? Note: Not yet, but the implementation of this feature would be simple because the information is already available in the database, so it only has to be properly queried and displayed;
- Could the Web Tool show which planning items are still waiting for his/her approval? Note: this feature was implemented in the final Web Tool prototype as an approval flag inside the expression cell;
- Could the Web Tool look for a Who at the Organizational Structure? Note: It can't do it at the moment but it was conceived to be able to do it in the future;
- Could the Web Tool send a message to people in a list about events during the production of the plan, like for example warn about the issue of a new version of the plan? It is not implemented, but it would not be difficult to implement;
- Could the Web Tool generate logs of planning actions (who did it, what, when?) for future auditing purposes? No, but it was conceived to do it. The metadata could provide a richer log implementation;
- Could the Web Tool identify and checkmark the strategies and tactics that went wrong during and incident, so that they are not used anymore? No, this is a novel idea, but it would happen off-line after the incident. One has to be careful on how to implement because what went wrong in one incident could be correct at the next one.

In a meeting with OGC-C, the specialist comments about a demo of an early Web Tool prototype were:

- The interface should only use ICS terms, familiar to the trained user. Tool specific terms should not be visible to the User, like the term "expression" which was appearing at the interface, very specific to this tool (Note: correct observation as it would cause interaction stress. Expression was changed to Item, much more generic, and

Cycle was changed to Operational Period, in line with ICS convention);

- Pages should show exactly the name and number of the corresponding form, ICS-202 and 234. (Note: correct observation, inconsistent nomenclature causes stress. Form names were updated and the form numbers were displayed);
- The Commander and Chiefs are not likely to use the Tool, but their assistants would use instead, so the Assistant Role Authority should reflect this. (Note taken, the Deputy and Assistant Roles were created and included in the Roles versus Authority Table);
- Commander and Chiefs will continue to formally sign the paper forms, because it is a process requirement. So the Tool needs to print the form to be signed by the proper authority. (Note: the Tool was updated to produce PDF form versions Draft, For Review and Final Approval;
- The interface should show which the most critical tactics are, so that the specialists can dedicate more attention to them. (Note: this feature was incorporated in the evaluated Web Tool version).

In a meeting with OGC-D, the specialist comments about the demo of an early Web Tool prototype were:

- There are two problematic ICS forms to produce, ICS 215 (Resources) and ICS-234 (Tactics Plan). The prototype Web Tool has a very desirable approach for ICS-234;
- It would be desirable if the Web Tool showed which the critical Tactics are. (Note: this was also requested by OGC-C above, so the evaluation Web Tool implemented a criticality status flag at Tactics).