Towards a Semantic Layer for Italian Emergency Plans

Massimo Cossentino[1], Salvatore Lopes[1], Luca Sabatucci[1] and Mario Tripiciano[1]

[1]CNR (Italian National Research Council), ICAR, Palermo, Via Ugo La Malfa, 153

Abstract

Emergency plans require a complex collaboration among multiple departments and roles. They are generally long textual documents containing practical instructions for hazard responses in natural language. This work focuses on converting informal documents to a more rigorous structured-text representation by taking advantage of well-known techniques from the literature. However, this task is costly, it requires technical skills and sound domain knowledge, and it is entirely subjective. To this aim, we propose a semantic layer that supports the formalization of an emergency plan by identifying essential elements of the input document and highlighting inconsistencies, redundancies, and ambiguities.

Keywords

Emergency Plans, Semantics, Text to Formal Conversion,

1. Introduction

The Italian landscape of emergency plans definition is essentially based on a set of laws issued by the Italian Government that create some milestones for managing emergencies. Firstly, they instituted the Civil Protection agency in 1982. Consequently, they defined the command and control chain, identified responsibilities, and set guidelines for the definition of emergency plans to be written and maintained updated.

Emperor Octavian Augustus, in the first century before Christ, said that "the value of planning diminishes with the complexity of the state of affairs". In this sentence, he caught the essence of modern planning strategies that relies on *simplicity* and *flexibility*. This approach inspired the purposefully so-called "Augustus Method" [1], introduced in 1997. It addresses a flexible planning approach and defines a simplified way to identify, activate, and coordinate the emergency response assets. The key idea is to overcome the classical approach based on the bureaucratic census of equipment used in civil protection interventions with a new focus on assets availability.

We are considering these laws in the context of N.E.T.TUN.IT[1], a research project for devel-

WOA 2021: Workshop "From Objects to Agents", September 1–3, 2021, Bologna, Italy
massimo.cossentino@icar.cnr.it (M. Cossentino); salvatore.lopes@icar.cnr.it (S. Lopes); luca.sabatucci@icar.cnr.it (L. Sabatucci); mario.tripiciano@icar.cnr.it (M. Tripiciano)
http://www.pa.icar.cnr.it/cossentino/ (M. Cossentino); http://www.pa.icar.cnr.it/sabatucci/index.html (L. Sabatucci)
0000-0003-1258-9767 (M. Cossentino); 0000-0003-1488-9755 (S. Lopes); 0000-0003-2852-9355 (L. Sabatucci); 0000-0002-2285-4862 (M. Tripiciano)
© 2021 Copyright for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).
CEUR Workshop Proceedings (CEUR-WS.org)

[1]Net de l'Environnement Transfrontalier TUNisie-ITalie (N.E.T.TUN.IT), Cross-border Cooperation Programme of the EU Community, Italy-Tunisia 2014-2020

CEUR-WS.org/Vol-2963/paper9.pdf

oping a fully operational platform for cross-border data collaboration to cope with shared risks and disasters due to emergency scenarios. In the project, Italian and Tunisian partners simulate the response to an imaginary accident involving atmospheric and marine pollution, nearby population health risks, also considering meteorological issues involved in the scenario.

One of the project's objectives is to support the modelling, verification and run-time adaptation of emergency procedures. The first challenge is that emergency response plans are expressed via informal natural language documents. Converting them into detailed emergency process models is a challenging task, requiring technical skills and deep domain knowledge. Gathering a good understanding of an emergency plan is a costly activity performed through several iterations. Despite all the effort one can make, the same document may rise different interpretations and different conceptual models. For these reasons, we introduce a semantic layer for emergency plans that can facilitate giving a more strict structure to the text-to-formal process.

In this paper, we propose a semantic layer that helps formalise emergency plans with a specific focus on the Italian landscape. Such semantics would help understand the input text, but it would also enable highlighting inconsistencies, redundancies, and ambiguities. In future, we hope to integrate the semantic layer into software platforms for the automatic execution of certain parts of the emergency plan. Anyway, this is the first step for enabling run-time adaptation of the procedures according to contextual events.

The rest of the document is structured as follows: Section 2 introduces the Italian landscape in the definition of emergency plans and it proposes some modelling techniques for providing a more rigorous view of the informal plans. Section 3 provides an overview of the long term agenda on which the current work relies. Section 4 is the core of the paper, presenting the semantics using keywords and templates. Finally, some conclusion is draft in Section 5.

2. State of the Art

Emergency plans use complex protocols, involve collaboration and interaction of multiple departments and roles, containing practical instructions of hazard emergency responses in natural language. This section firstly illustrates the Italian landscape on emergency management, and then it discusses the state of art in modelling them.

2.1. The Italian Landscape

In this section, we will depict the Italian landscape of emergency plan definition. That is based on the so-called "Augustus Method" [1], produced by the Italian Civil Protection Agency and issued by the Ministry of Interior of Italy in 1997.

The Augustus Method sees the territory as a body with organs, called Support Functions, with specific managers that will be made responsible for maintaining alive the plan with drills and updates. In normal conditions, the organs operate according to their duty to maintain the efficiency of the body. When a disease (the emergency) hits the body, all the functions cooperate to heal that.

The Augustus Method defines nine Support Functions for each municipality and five more at the regional level. They include technical advice and planning, health-social assistance and veterinary services, mass media and information, voluntary organizations, transportation, circulation and traffic, and several other functions.

The Method also clarifies the roles of the different operation centres, from town-level to nation-level granularity. The participation of Support Function managers in these centres ensures the availability of the required assets when needed and their collaboration in facing the emergency.

According to the Augustus Method, the plan is structured in three fundamental parts: *(i)* General part, *(ii)* Outlines of Planning, *(iii)* Model of intervention.

Regarding the General part, it should report all information relating to the knowledge of the territory, the existing monitoring networks, the risks in the area and the related scenarios. The second part (Outlines of the planning) defines the objectives to achieve when an emergency arises. Finally, the Model of intervention assigns responsibilities at the various levels of command and control to manage civil protection emergencies. The constant exchange of information is carried out in the central and peripheral system of the civil protection agencies; resources are listed in the plan and their (continuously updated) capability, location and status of maintenance.

In 2005 a new directive from the President of the Ministry Council refined the structure of the plan. The previous organization deeply inspires the new version, and it includes the following sections: General Part, Incident Scenarios, Organization Model for Intervention, Information to Population, and Cartography.

In this paper we will study 4 plans [2],[3],[4], [5] that have been selected because they represent different examples in terms of scope, size and responsible institution (that authored the plan). They are all reasonably recent (mostly updated in the last five years), and some of them passed through several releases (the most recent is, of course, considered for this study).

We are interested in the active part of the emergency plan, and therefore, we mainly considered the Organization Model for Intervention chapter.

Interestingly, the studied plans show two different outlines for this section: some adopt a 'phase-based' structure, while others a 'role-based' one. The first category (for instance [2]) includes plans for each phase and the role of each stakeholder in that (a chronological description of the tasks and functions by all the stakeholders involved in that phase).

Plans of the second category (for instance [4]) initially describe the different phases (pre-alert, alert, emergency, ...) and which events trigger them. A description of roles and what they should do (one unique list for each position discussing their tasks in all phases) follows. Notably, the second type of structure is preferred in longer documents, likely because it localizes the information regarding each stakeholder, thus facilitating the access to information in an urgency.

This distinction is relevant to this paper because we found that the two structures generate different kinds of ambiguity. Plans in the first category sometimes are vague about who should do a specific task (a consequence of the attempt to avoid repetitions in the text), while plans in the second category eliminate this risk but are less clear in reporting the relationship between each phase and the tasks to be performed within that.

2.2. Modeling Emergency Plans

Emergency plans are usually provided as textual descriptions in natural languages throughout the world. Inevitably, they include ambiguities and imprecise descriptions related to natural languages. There is a broad research [6, 7, 8, 9] pushing the adoption of (semi)formal representation. The objective is to enable rigorous analysis and validation of process models. Often, a graphical representation provides intuitive means for increasing the understanding of such plans. Notably, the approach we are proposing is intended to represent documents (emergency plans) that are written before the emergency and therefore can be processed offline. Other approaches in the field of emergency management deal with emergency operations enactment the related run-time knowledge [10].

The literature broadly promotes supplementing natural language with standard notations and languages for business processes, such as the Business Process Modeling Notation (BPMN). However, designing high-quality emergency response process models is a great challenge that needs domain knowledge and process modelling techniques. A recent study, mainly focusing on Chinese emergency plans, proposes automatic extraction of business process models from textual descriptions [8]. Another representative example comes from the Norvegian emergency management processes detailed in [9]. The authors claim that authorities and rescuers better understand plans expressed in visual and textual form, and therefore, they can be more proficient in facing unanticipated events. This study also focuses on highlighting roles in the organisations and how they have to interact. The same research recognises some problems using the BPMN standard: some difficulty to model task duration and in reusing a process diagram from one environment to another.

Another study identifies other limitations in the adoption of BPMN for modeling emergency plans [6]. Despite all the advantages, the authors recognise that standard BPMN elements are not comprehensible enough to consider some special requirements of disaster recovery management. For example, the importance of location-related information or multiple resources.

They propose to extend BPMN with some disaster recovery management requirements. In particular, they emphasise the role of resources: the distinction between human and non-human resources, inter-dependencies between resources, various resources properties.

Another branch of research proposes to replace (sometimes to complement) BPMN diagrams with other non-imperative modeling notations. In particular, the Case Management Model and Notation (CMMN) [11] seems a promising candidate.

As stated in the OMG standard[2], CMMN provides a graphical notation used to capture working methods based on the management of complex cases. CMMN is helpful for those cases that require several activities whose order of execution is unpredictable a priori in response to evolving situations.

Using an event-centred approach and the concept of a case file, CMMN expands the boundaries of what BPMN can model, including less structured work efforts and those driven by knowledge workers. Using a combination of BPMN and CMMN allows for covering a much broader spectrum of work methods.

While traditional business processes can be described by a priori defined sequences of activities using the BPMN notation, the CMMN notation offers more natural support for dynamic workflows. In [12], authors stress the fact that an emergency response is a knowledge-intensive process. To model and automate such process is a challenging task. Authors use CMMN to build a template model for a generic emergency response process.

[2]https://www.omg.org/cmmn/

The OMG also defined a third language, the Decision Model and Notation (DMN), a standard notation for describing and modelling repeatable decisions within organisations. The modelling language triad, BPMN, CMMN and DMN, is defined to cover different areas of process management due to their different focuses. Indeed, in [13], authors investigate how to use a combination of these three modelling languages precisely in the context of crisis management.

3. Motivation: From Free Text Plans to Adaptive WF-based Plans

This section will overview our long-term purpose of introducing adaptive workflows in the execution of an emergency plan.

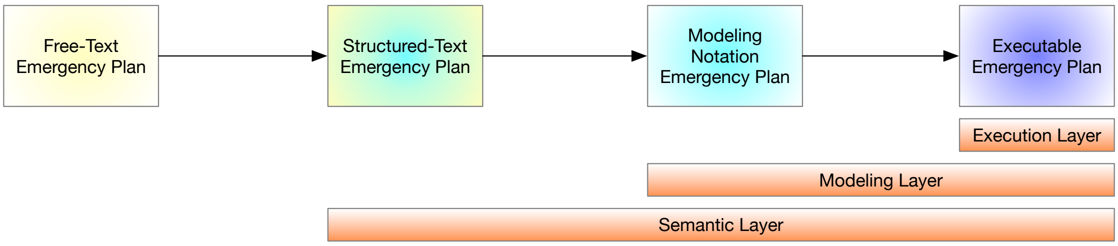

Figure 1: The proposed process for transitioning from free-text emergency plans to executable plans.

As already described, an emergency plan is usually provided in free text form according to a generic format as prescribed by specific laws.

We aim to introduce the support of adaptive workflows in the data exchanges required to face emergencies involving both sides of the Sicilian Channel in N.E.T.TUN.IT project. We see that activity as a part of more extensive scope research to introduce adaptation into the execution of the overall emergency plan.

We conceived a process based on the three steps (see also Fig. 1) as described below.

From Free-Text Plan to Structured-Text Plan: this is the step described in this paper. It includes two sub-steps: *(i)* the construction of a set of keywords used to *(ii)* fragment the free-text plan in a list of notable items for its representation in a specifically conceived modeling notation (see below). The main contribution of this paper is the semantic layer for processing the free-text plan and producing a structured-text version (see Section 4). This layer includes a list of keywords we propose to use to represent a structured-text version of the informal plan. The idea is that these keywords will be specifically supported by the proposed modeling notation and will receive a specific implementation in the execution layer.

Representing the Structured-Text Plan with a Modeling Notation: we are devising a specific modeling notation to represent an emergency plan. An essential requirement for this notation is that it will easily support adopting an adaptive middleware for the execution and coordination of the plan's activities. The definition of this notation is still a work-in-progress activity, but we have identified the main contributions it will receive from a few well-known standards. The BPMN notation is a part of that but not so central as it could be expected. The

Augustus directive prescribes that a plan provides general indications for the management of the emergency, whereas details are to be defined at emergency time. For this reason, we are considering to adopt the Case Management Modeling Notation (CMMN) that allows to represent scenario-based situations, and the Decision Modeling Notation (DMN) that allows to formalise critical aspects of decisions to be taken during the development of an accident, also including decision criteria (like data values reported by personnel on scene) and the reference documents to be consulted. Finally, some parts of the free-text plans naturally convey the opportunity to introduce a model of the goals related to the responsibilities of involved stakeholders (like the authorities and the support functions described in a plan).

Adaptive Execution and Management of Emergency Plan: this part of the process presents some interesting challenges: first of all, an essential issue of emergency management is in the central role of the persons in charge at the different levels of the command chain. They have to maintain complete control of the running activities, and they need updated information, like the availability of resources, for proper accident response.

Unexpected events may spoil the validity of any detailed a-priori planning: the actual plan has to emerge from the consideration of the specific accident, environmental conditions (for instance roads practicability, weather, and so on), assets (fuel, food, transportation, and so on), operational capability (for instance their numerical consistency together with their intervention time and need for logistic support). These considerations raise interesting issues from the scientific point of view, since they prescribe the availability of an accident management system that includes relevant features of adaptive workflows where human resources play a key role not only as activity performers (human-intensive system) but also in the decision making role. Stakeholders involved in playing the decision role need to be made well-aware of the situation. Therefore they need specific support to access just-in-time precise and updated knowledge. Decision support systems may help in the decision phase, also referring to archive data and simulated scenarios. The system also needs a spatial-referred representation of the environment and involved assets. Finally, communication capability is a key element. The support for emergency communications is already existing, and great care is devoted to the adoption of standardized content protocols for messages, as the Common Alerting Protocol (CAP) [14] that is an XML-based data format for exchanging public warnings and emergencies. Although that is of relevant value, more is still to be done on the telecommunication infrastructure resilience and the automatic support for alternative delivery channels.

4. The Proposed Semantic Layer for Emergency Plans

This section describes our work on the semantic layer that we use to process the free-text plan and produce the structured-text plan manually. This layer blends lexical semantics (i.e. investigates word meaning) and conceptual semantics (explaining properties of argument structure). In other words, we propose a set of keywords to be either extracted from the input text or derived from the context. A keyword is an (Italian or English) word that has a specific meaning for modelling purposes. Each keyword has a precise definition, and it is related to a set of properties.

It is now necessary to clarify some rules we adopted in defining the keywords:

- Keywords must belong to the general structure of the emergency response plan: this means that domain actions related to the management of a specific accident (even if common to other cases) are not part of the semantics. The reason for this choice is to limit the number of keywords and to remain general by leaving apart domain-dependent items that change with the kind of emergency or that may depend on the adoption of new strategies and new technologies.

- When possible, keywords (or their synonymous) should appear in the free-text version of the plan. Our idea is to respect the problem knowledge and comprehension that the writer of the plan has. Some keywords expressing decisions and sometimes goals are not explicitly named in the plan's text, but the document's structure helps deduce them.

Each keyword is therefore described by a *label* (the keyword itself), a *list of synonymous* (addressing the same meaning in the plan and sometimes used to avoid repetitions), the *addressed meaning* (a clarification of the meaning to improve the comprehension of the way the keyword is to be intended, also with the use of examples), a *sentence template* (used to exemplify the common use of the keyword), and a *table of properties* (like the actor responsible for performing an action or the target of a message).

We provide the table of properties with a twofold objective: (i) it helps to clarify the syntactic role of words in the free-text version of the plan; (ii) it helps in disambiguating situations in which the same word fits different keywords (with slightly different meanings).

For instance, a Message Event is always produced by a source and consumed by a target. This essential feature is rendered by the 'from' and 'to' properties.

Because of their object-oriented nature, in this work, tables of properties may be related one to another by inheritance relationships. The motivation is basically for clarity and saving space: notably, as we will report later on, some properties are common to many keywords. Some elements are mandatory in a table of properties for assigning a meaning to the corresponding keyword, whereas others are optional. Graphically, we used an asterisk for intending required elements.

The designer will parse the free-text plan to identify the keywords (or their synonyms). For each identified keyword, she will fill the corresponding table of properties. When the table of properties is complete, then the designer may instantiate the sentence template. This is a syntactic structure aiding to recognise words with given meaning in sentences. In other words, it represents a shortcut for the keyword in the specific context to be used for modelling purposes. For instance, it can represent the name of a BPMN task.

The rest of this section discusses keywords and some of their most relevant properties deduced from the free-text plan.

As already discussed, the proposed semantics will represent the emergency plan except the domain-specific actions used to solve the accident.

We group the resulting keywords into five categories: actors, events, actions, decisions and responsibilities (goals). We detail these categories in the following subsections.

Although these categories emerge from the list of empirically discovered keywords found by processing the plans, we should also consider that they relate somehow to the parallel definition of a modelling notation we are performing at the same time.

While actors and actions have evident relevance in a plan, events have a motivation. They trigger changes in the different phases of the plan (for instance, from pre-alert to alert) or trigger responses to the accident's evolution reported by observations or incoming news. Responsibilities represent why a specific actor is involved in the emergency management plan, what she should care and pursue, what she could be considered accountable for according to the law. We devote specific attention to the decision category for the impact decisions have on the execution of the overall plan; more on that in subsect. 4.4 .

4.1. Actors

A fundamental aspect of the innovation proposed by the Augustus method consists in clearly assigning responsibilities. For this reason, it becomes very relevant to create a list of actors involved in the execution of the plan. The list includes names, acronyms and the definition of the actor.

In the numerous plans we studied, we found many actors, often referred to with acronyms. We noted that the ambiguity allowed by the Italian language sometimes creates indecision about the actor responsible for performing a specific action. This indecision mainly happens in plans where the description is ordered using time or event-related criteria. Plans, where activities are clustered according to actors, do not present this ambiguity, of course. The list of actors is long and includes authorities (Mayor, Prefect, ...), personnel with specific skills (engineers), and groups (committees, operation/command centres, associations of volunteers, ...). We will not entirely report them for the sake of conciseness and because the complete list would add nothing significant to the proposed argumentation.

We differentiate between individual actors and collective actors. With the term individual actor, we will address the common-sense meaning of a participant in an action or process. Collective actors represent a more refined concept where according to [15] collective actors perform a coordinated and collaborative decision-making process where one individual speaks for the group. Collective actors share the same interests, integration mechanisms, an internal and external representation of the collective actor and an innovation capacity.

Examples of individual actors include some of the already cited authorities: Mayor, Prefect, chairs and participants of committees (that are collective actors), for instance, the Responsible of the Town Operating Centre or the Civil Protection Officer on duty.

Examples of collective actors include the operation room of the Metropolitan Police, the Rescue Coordination Center, the Regional Agency for Environment Protection, the Integrated Regional Operation Room, and so on.

4.2. Events

Emergencies exist because events arise in the environment; this is a simple fact that justifies the importance of events in the field.

Emergencies exist because events arise in the environment; this is a simple fact that justifies the importance of events in the field.

From our analysis, we recognised two types of relevant events for the structured representation of the plan: Data Events and Messages.

Data incoming represents the arrival of some data from monitoring activities or the acquisition of information from any possible source. The Message event represents the arrival of a message related to the emergency, for instance, a phone call from the responsible manager of a plant affected by a significant fire blast. Messages belong to two subcategories: Informal and Formal. Informal messages refer to phone calls, media diffusion of news, and so on. The essential feature of an informal message is that it does not have any kind of template specified in the emergency plan. Formal messages are delivered using traceable communication means (emails, other types of computer-based messages, telegrams,…). An essential feature of formal messages is the adherence to a format specified in the plan. Frequently formal messages are encoded using some emergency communication protocol, like the Common Alert Protocol (CAP) [14].

It is notable to consider that incoming/outgoing data are different from messages since with the data event, we represent the availability of the information, for instance, the read from a sensor or the output of a simulation. Of course, data events reach some actors using a message whose arrival/departure are other events occurring at successive times.

In the structured-text plan, we represent events extracted from the free-text plan by using the sentence templates proposed in the following sections, together with the list of their properties. Notably, all events share one specific property, the timestamp, since the concept of the event has a well-defined location position in time.

4.2.1. Data Event

As regards the *Data Event*, the template is:

```
Data Event [source/target] [thresholds] [values]
```

The 'source/target' represents the originator of the data (for input data) or the recipient (for output data), for instance, a sensor or a computer application. 'Thresholds' specifies the thresholds that are to be monitored, for instance, the level of a river that should not reach one meter. The reading of such level measure is the data event that has some significance for accident management; 'values' represent the information enclosed in the event; it may include the unit of measure or other significant information.

The presence of the 'threshold' property may seem odd in this event type since it is necessary to perform some action to compare the actual reading of a sensor with the threshold value. Although formally speaking, this is true, in the plan, we often found that data readings become significant only when they reach or overcome some specific value (for instance, a pollutant concentration in the atmosphere). All data readings that do not reach the threshold are not significant, and thus they do not generate a 'Data' event (if a threshold is specified).

4.2.2. Message Event

The *Message Event* is detailed by using the following template:

```
[Formal/Informal] Message [subject]
```

’Formal/Informal’ reports the adoption, for the message, of a well-defined syntactic structure, often included in in the free-text plan, the ’subject’ field contains a short description of the message content, ’properties’ include a list of slots as discussed in the table below:

‘Message’ properties	
From *	Sender actor
To *	Recipient actor or actors’ list
Priority	Priority of the message
Content*	The information content of the message
Communication channel	The channel used to dispatch the message
Template	Reference to the message template from the plan
Exception	Description of how to deal with unsuccessful delivery of the message

Significantly, in some plans, we found the explicit indication of how to deal with the impossibility to reach the destination person (for instance, by contacting a specified alternate contact person). For this reason, we introduced the Exception slot in the properties list.

4.3. Actions

Actions are the essential brick of an emergency plan. Actions can be atomic or composed; initially, we will refer to an abstract concept of ’action’ that will found a realisation in a set of concrete keywords of the semantic layer: orders, activates, arranges, gathers data, informs, plus generic domain-specific acts.

All the keyword’s tables of properties inherit the properties of a mother class *Action Properties.* This factored all the common properties the other templates inherit and specialize, and allows not to repeat them in every table:

‘Action’ properties	
owner (actor)*	is responsible for the action and operates for its enactment
on-behalf-of (actor)	*delegates the action*
assistant (actors)	*supports the owner’s duty in the enactment*
precondition	*execution context*
temporal constraints	*start, duration, period, and due time*
resources	*(min/max) assigned resources*
quality requirements	*minimal expected quality of service*
ack to	*when present, a notification is required when completed*

In the following, we will avoid repeating the fields common to all templates. We will mention only cases in which there is a clear difference of meaning.

The first keyword we specialise from *Action* is suitable for situations in which an authority sets an order via either a formal or informal message. This action is typically described by a template sentence like:

`[authority] Orders [personnel] to [do something/address an outcome]`

When the act is formal, the order is issued by some decree, ordinance,. . . , sometimes the order does not concern a specific person, but it is rather directed to all the citizens. An example occurs when the Civil Protection Office Head in a town (after having been delegated by the Mayor to do that) orders to close some roads to the Metropolitan Police Chief. The properties of the 'Orders' keyword are reported below:

Orders	
Matching with Italian words: ordina, dispone	
owner (actor)*	issues the order
on-behalf-of (actor)	*delegates the order*
target (actor)*	receives (executes) the order
object*	the action/goal to be undertaken
formal deed	*legal/official document issuing the order*
comm channel	*how the order is communicated to the target actor*

Another keyword that we specialise from *Action* is *Activates*. It covers situations where a state transition is required. It is similar to the keyword 'orders' but describes an operation and could be the consequence of the order. The corresponding sentence is:

`[somebody] Activates [something]`

Differently from *Orders*, here the personnel is an actor responsible for enabling something (a sub-plan, an office, a function) to become working/operative.

Examples:

- the Civil Protection Office Head activates the weather monitoring team;
- the emergency manager activates the External Emergency Response Plan.

Activates	
Matching with Italian words: attiva, pone in essere	
owner (actor)*	is responsible for the transition
object/state*	the target to be activated

We also considered the *Arranges* keyword. It resembles the *Orders* and *Activates* ones but it implies some kind of preliminary coordination/organization/planning before the subject becomes active. This is a frequent occurrence in the plans we studied. The sentence template is the following:

`[someone] Arranges [a subject]`

The properties list is reported below:

Arranges	
Matching with Italian words: predispone, prepara	
owner (actor)*	is responsible of planning/organising/…
participant actors	*supports the target actor(s) in performing what planned/organised by the owner actor*
object*	the plan/organization to be enacted

Very central in dynamic contexts, such as those of emergency responses, the *Gathers Data* keyword refers to the act of acquiring data from direct observation, from monitoring sensors, from experts on the field, and, sometimes, from citizens. It is also used for checking the state of resources. The corresponding sentence template is:

```
[someone] Gathers Data about [a subject]
```

where the subject specifies the kind of data to be acquired/monitored.

Gathers Data	
Matching with Italian words: raccoglie informazioni, opera monitoraggio	
owner (actor)*	is responsible of collecting data
assistant actors	*aid in collecting data*
subject*	data, information or event to be acquired/monitored
data source	*the source of the data*
frequency	*specifies the frequency of data acquisition*

Examples:

- The Regional Civil Protection Agency gathers information about the accident.
- The head of the Resources Department gathers data about the status of resources and personnel.
- The head of the Civil Protection Agency identifies suitable places to shelter displaced persons.

The last example shows the use of a synonym ('identifies' in place of 'gathers data') in the proposed sentence. The use of synonymous is quite common, especially in the Italian language, and it will be discussed in Subsect. **??**.

This sentence is also an intriguing case of ambiguity. It could also be intended as a decision about what are the best places to shelter displaced persons. However, we deduced that the sentence refers to a 'gathers data' act by looking at the context.

Informs is the last non-domain-dependent keyword, derived from Action. It represents the act of sending formal/informal messages. It concerns situations in which:

```
[somebody] Informs [recipients] about [an object]
```

where the message may be a formal act, following a structured protocol, or an informal communication like a phone call. The action 'Informs' may be done once or repeated every time an event occurs (thus updating the information).

For example: the head of the Civil Protection office informs the commander of the Municipal Police about the emergency status.

Informs	
Matching with Italian words: informa, comunica, aggiorna, mantiene informato	
owner actor*	is responsible of outgoing messages
assistant actors	*aid in sending messages*
object*	sent data, information, or acknowledgement
recipient actors*	will receive the information
regularly	*when flagged, the activity is repeated every time there are updates*
formal deed	legal/official document issuing the order to inform
means	how the order to inform is notified to the owner actor that will execute it

As a prototype sentence for the final item of the semantic layer, we propose an abstract *Acts* keyword that is to be instantiated in the different domain-specific actions performed to face a disaster:

```
[somebody] [Acts] [on something]
```

The Acts keyword is the mother class of a range of domain-based actions that are not classifiable in the previous categories. One or more actors can operate it as the consequence of an order or a plan, an event may also trigger it. An action could not be allowed (for instance for security reasons) in some phases of the emergency.

Examples are: (i) on-site paramedics provide first treatment and help in evacuation of injured people, (ii) bulldozers remove debris from the road, (iii) the Metropolitan Police deploys road signs to prevent unauthorised access.

Acts	
Matches with Italian words: (related to the domain)	
owner (actor)*	is responsible of action execution
input	*expected input data necessary for action completion*
post-condition	*expected outcome of the action*

4.4. Decisions

Decisions are a type of action requiring information, quick access to knowledge (i.e. maps, technical schematics of plants) or expertise (i.e. support from technical staff). Decisions in the plans are often described in terms of the actor who has to take them and the possible alternatives (i.e. trigger alert or deactivate the pre-alert phase). Sometimes some supporting actors are also listed. Decisions are the part of the plan that we have often found lacking relevant details; for instance, criteria for deciding may remain blurred and rarely formalised.

Often, plans do not explicitly use the ’decides’ word; they instead address the concept of a decision to be taken by someone by describing the incoming events and expected decisions in terms of orders issued or actions undertaken. Sometimes, events may be related to the emergency development and decisions regarding the acts necessary to perform to face the new event.

In order to define a template for the decision act, we use the following sentence:

```
[somebody] Decides [something]
```

where ‘somebody’ is the main responsible for the decision, and can be supported by assistants.

The placeholder ‘something’ concerns the outcome of the decision process. Typically taking decisions requires specific background knowledge and contextual data. Moreover, norms, criteria, and best practices that are prescribed to respect during the emergency development.

This keyword may not be found in the emergency plan; the interpretation of a portion of text rather generates an instance of the sentence template that we will introduce in the structured version of the plan to represent the act of deciding something as a consequence of some data/event

Decides	
Matching with Italian words: decide, stabilisce, assimila, delibera	
owner (actor)*	gets the responsibility for the decision
on-behalf-of (actor)	*has delegated the decision*
assistant actors	*aid in taking the decision*
temporal constraints	*start, duration or due time*
input	*expected input data/event, necessary for taking the decision*
knowledge	*required background information for taking the decision*
criteria	*formalized rules as a support for the decision*
output*	*the outcome of the decision*

4.5. Goals

As issued by Italian law, an emergency plan assigns specific responsibilities to the participant actors. For instance, according to the Augustus Method, each Support Function manager is in charge of a specific responsibility such as ensuring health-social assistance, managing mass media and information, organizing voluntary organizations, controlling circulation and traffic and so on. Responsibility is the commitment to address an objective under the criterion of personal responsibility that means the actor can be prosecuted if results are not expected.

We labelled this keyword as *Goal* because we intend to create a correspondence with strategic actor relationships that originates from social modeling [16] and Goal-Oriented requirements engineering [17] and to pave the way for multi-agent system automatic support. In this perspective, responsibilities (hereafter we refer to them as goals) lead to direct actions or delegations to other parties.A template sentence for the goal is:

```
[precondition], [someone] is responsible for [objective]
```

Properties of the goal keyword are reported below:

Goal	
owner (actor)*	is responsible of pursuing the goal
objective*	the objective that the owner actor will pursue
alternate owner (actor)	is responsible when the owner is not available or reachable
on-behalf-of	*the owner acts on behalf of this collective actor*
participant actors	*support the owner actor in performing her duty*
precondition	*preconditions to be verified for triggering goal pursuing*

Several parts of the emergency plan assign responsibilities to actors involved in emergency management. However, as well as happened for decisions, goals are often implicitly defined in the emergency plan. Indeed, the primary goals can be extracted by the Support Functions that are explicitly listed in the plan as the Augustus Method prescribes. Other goals require additional effort in the identification (task supported by using the property table). In the following, we will present some examples of goals extracted from the analysed plans:

- during the Alarm Phase, the Chief of the Provincial Fire Brigade is responsible for coordinating the technical and scientific staff;
- the Provincial Health Agency General Manager is responsible for activating the necessary organisation for the specific type of accident;
- the Chief of the City Brigade Fire is responsible for coordinating all operative structures forming the Rescue Coordination Centre.

4.6. Synonyms

To write the present work we have studied and analysed a number of Italian Emergency Plans [2],[3],[4], [5] to compare the different approaches, styles and terminologies.

Each author expresses the guidelines using her sensibility and linguistic knowledge; this often leads to using different words (synonyms) to address the same event or the same action. The use of synonyms may even occur in the same document where, for the sake of elegance and avoiding repetitions, the author uses synonyms to address the same concept.

To identify these linguistically different but semantically similar words, we have defined a correspondence table. A portion of this table is shown in Table 1. A synonymous table is significant because it limits the arbitrariness in interpreting the free-text plan and passing from it to the structured-text version of the same plan.

Table 1
Table of Synonyms

Term from the Emergency Plan (Italian)	Corresponding Term in English	Synonymous Keyword in our semantics	Example
Dispone	Arranges	Orders	The prefect arranges a continuous monitoring of air quality in relation to wind direction, intensity and height
Aggiorna	Updates	Gathers Data	The Manager shall update the Prefect and other interested parties by means of messages using the template specified in the attachments
Segue l'evoluzione	Monitors	Gathers Data	The Mayor monitors the development of the situation and informs the population that the state of emergency has been revoked.
Acquisisce	Acquires	Gathers Data	The operations room manager acquires all relevant updates on the status of technical and rescue operations.
...			
Istituisce	Sets up	Activates	The Technical Rescue Director sets up an Advanced Command Post using his own vehicle.
Pone in essere	Implements	Activates	The Manager implements the Internal Emergency Plan

5. Conclusions and Future Works

This paper focused on inconsistencies, redundancies, and ambiguities that hinder understanding and formalizing emergency plans. The need to convert informal documents to more rigorous conceptual models require a semantic layer for identifying essential elements of the input text and resolving linguistic issues that may be present. We extracted essential keywords through an empirical study of several Italian documents reporting different kinds of emergency plans. Our analysis allowed us to discover recurrent structures in these documents. Sometimes, these linguistic structures are evident, other times are hidden, and some interpretation of the text's meaning is needed. We support identifying them by using templates with required and optional properties to be filled in all the cases. We will use the proposed approach in the context of the N.E.T.TUN.IT research project. We plan to provide automatic support for the execution of emergency procedure plans, with the long-term objective of enabling the properties of robustness and adaptivity.

6. Acknowledgments

The research was conducted for the Net de l'Environnement Transfrontalier TUNisie-ITalie (N.E.T.TUN.IT) research project, founded by Cross-border Cooperation Programme of the EU Community, Italy-Tunisia 2014-2020.

References

[1] E. Galanti, Il metodo augustus, DPC Informa "Periodico informativo del Dipartimento della Protezione Civile" (1997).

[2] P. B. F. Mereu, A. Alferi, Piano di protezione civile per la salvaguardia della popolazione dal rischio idrogeologico derivante dalla ostruzione del canale sotterraneo papireto ed 2015-16, Technical Report, Comune di Palermo, 2015.

[3] Protezione Civile Provincia di Ravenna, Piano Provinciale di Emergenza Piano Provinciale di Emergenza Rischio Chimico-Industriale, Technical Report, Prefettura di Ravenna - Provincia di Ravenna, 2009.

[4] Prefettura di Siracusa, Pianificazione di emergenza esterna per gli stabilimenti a rischio di incidente rilevantea, Technical Report, Siracusa, 2019.

[5] Prefettura di Palermo, Piano Emergenza Esterna Esso Italiana S.r.l Deposito oli minerali Via Messina Marine 813 Palermo, Technical Report, Palermo, 2016.

[6] H. Betke, M. Seifert, Bpmn for disaster response processes, INFORMATIK 2017 (2017).

[7] N. T. T. Le, C. Hanachi, S. Stinckwich, T. V. Ho, Mapping bpmn processes to organization centered multi-agent systems to help assess crisis models, in: Computational Collective Intelligence, Springer, 2015, pp. 77–88.

[8] W. Guo, Q. Zeng, H. Duan, G. Yuan, W. Ni, C. Liu, Automatic extraction of emergency response process models from chinese plans, IEEE Access 6 (2018) 74104–74119.

[9] V. Nunavath, A. Prinz, Norwegian emergency management process by using business process modeling notation, in: Proceedings of the 8th IADIS International Conference on Information Systems 2015, 2015.

[10] P. Brunetti, A. Croatti, A. Ricci, M. Viroli, Smart augmented fields for emergency operations, in: Proc. of The 5th International Conference on Current and Future Trends of Information and Communication Technologies in Healthcare (ICTH 2015), 2015.

[11] M. A. Marin, Introduction to the case management model and notation (cmmn), arXiv preprint arXiv:1608.05011 (2016).

[12] A. Y. Shahrah, M. A. Al-Mashari, Modelling emergency response process using case management model and notation, IET Software 11 (2017) 301–308.

[13] M. P. R. Herrera, J. S. Díaz, Improving emergency response through business process, case management, and decision models., in: ISCRAM, 2019.

[14] OASIS Standard, Common Alerting Protocol Version 1.2, http://docs.oasis-open.org/emergency/cap/v1.2/CAP-v1.2-os.html, 2010. Accessed: 01 July 2010.

[15] A. Pichierri, Lo sviluppo locale in Europa. Stato dell'arte e prospettive, Rubbettino, 2005.

[16] S. Eric, P. Giorgini, N. Maiden, J. Mylopoulos, Social modeling for requirements engineering, MIT press, 2011.

[17] A. Van Lamsweerde, Goal-oriented requirements engineering: A guided tour, in: Proceedings fifth ieee international symposium on requirements engineering, IEEE, 2001, pp. 249–262.