Development of a performance management system for wildfire operations management using SSM

Emmanuel Adamides (adamides@upatras.gr)
Section of Management & Organization Studies, MEAD, University of Patras, Rion 26500, Greece

Anastasios Kanavos
Section of Management & Organization Studies, MEAD, University of Patras, Rion 26500, Greece

Vasiliki Rigatou
Section of Management & Organization Studies, MEAD, University of Patras, Rion 26500, Greece

Abstract

This paper describes the participative development process, and the outcome structure, of a performance management system for the operations processes involved in the confrontation of wildfires. To accommodate diverse stakeholder perspectives related to both prevention and confrontation, Soft System Methodology was used. The performance management system was developed in the framework of an EU funded project for benchmarking regional operations, and includes measures and improvement processes for needs assessment, knowledge and skills management, technology management and public awareness development.

Keywords: performance management, emergency operations, action research

Introduction

In general, there is a documented lack of research activity, as well as practice, towards the development and implementation of performance measurement and management systems for disaster management (Lettieri et al., 2009). A typical case of this lack of activity is the prevention and confrontation of forest fires, which constitute a major environmental and economic disaster, in addition to costing human lives. This is partly because wildfire prevention and confrontation is rarely considered as an *operation* that necessitates the employment of the methods and tools of operations management. In fact, wildfire (forest fire) fighting extends to both operations management and project management. Prevention involves the management of routine operations (repeated activities) involving a predetermined set of resources, whereas the actual fighting of specific incidents is a case-specific project for which resources should be gathered and needs to be accomplished in the most effective way in terms of casualties, time and cost.

Both activities involve a number of stakeholders with different backgrounds, operations logics and interests (government organizations, civil protection organizations, citizens, business, etc.), which need to have, for different reasons, measures of *readiness* and *effectiveness* of the management system. This can be accomplished by developing in a participative manner a performance management system that indicates the state of these two objectives, as well as prompting for improvement activities (Pidd, 2012). The purpose of this paper is to describe the development of such a system using Soft Systems Methodology. The objective, and the difference from existing ones, was to see wildfire management in a holistic view as an operations system, concentrating on the determinants of performance (execution of operations' activities), not only on performance indicators. The overall wildfire operations management process includes activities for both fire prevention and fighting, and the related performance management system needs to assess the degree of efficiency, efficacy and effectiveness of these activities. The paper concentrates on the development of a model performance management system to assist authorities in different European Union countries to benchmark their operations and performance management against it and accomplish the necessary interventions. Hence, the general research question addressed in the paper may be stated as: how to design a complex performance management system for organizations with different interests operating under diverse conditions.

The paper is structured as follows: The next section described the context in which the specific performance management system was developed. Then, Soft Systems Methodology is introduced, before demonstrating its application to the specific issue. The basic structure of the system developed is then depicted, before presenting the conclusions of the research.

The context

Regarding wildfire management, European countries have quite dissimilar organizational structures and procedures. While they share interests for fire prevention and fighting, they are faced with different environmental and social conditions, while their organizational structures and cultures vary. The PRoMPt (*Proactive Human Response to Wildfires Outbreak: Measure and Prepare for it*) project was defined by the European Community as a means to harmonize practices and promote cooperation between its member states' authorities. The aim of the PRoMPt, was to improve effectiveness of regional policies, action plans, operational procedures and equipment for coping with forest fires, especially in very sensitive areas, through identifying the best solutions to prevent the outbreak of wildfires or to mitigate their consequences. The intention was to move further from simply addressing forest fires dangers and crisis management after the outbreak of a fire, and deal with exchange of experiences and best practices in a context of *holistic* viewpoint of the readiness, thus, to act promptly and efficiently in order to avoid as much as possible human, animal and agricultural losses, as well as forest disasters. The development of the performance management system was part of this project and the whole process adhered to its philosophy.

Many different kinds of experts were involved in the project; from agencies with mission in making planning and conducting operational activities in firefighting, to organizations that contribute to supporting activities, such as informational services or technology consulting. The main participants of the project were the Region of Western Greece, the Research Academic Computer Technology Institute, the Municipality of Diacopto and the Industrial systems Institute from Greece, the Province of Macerata and the Mountain Union of Laga from Italy, the Bielsko Biala District from Poland, the

Camara Municipal de Baião from Portugal, the Regional Forestry Diretorate of Kardzhali from Bulgaria, and the Forest Sciences Technology Center of Catalonia from Spain. Nevertheless, additional organizations, relevant to forest fire confrontation, also participated in the different activities of the project in order to enhance its effectiveness.

Through the creation of working groups (task forces), exchange of expert personnel, and analysis of situations in different countries, took place in order to identify and validate the operational plans and procedures that specifically address issues, such as the suitable information to citizens about the risks and how to behave, the awareness and the capability enhancement of competent authorities, and the improvement contingency planning, to keep safe human life and the environment.

In total, seven workshops were held in different places, for better absorption of the local knowledge. During all these meetings, several of the partners' relevant experiences were individually presented and discussed. Cross-thematic meetings were also organized, between partners and other local authorities, concerning the correct and on-time information and preparation to confront the outbreak of a fire. Besides, there were visits to places that large forest fires took place, as well as to headquarters of Regional Fire Services and were presented special "fire cases" and local "emergency plans" that were established in order to decrease the risk of forest fires. The development of a performance management system was the objective of a specific task force in the framework of this project, and it was thought as central element in devising a mechanism to benchmark different national forest fire management systems.

To develop a common ground for systematic performance management, first, it was necessary to develop a model of (an ideal) forest fire protection and fighting operations system as a set of systems and processes, which could be understood and be acceptable by all interested parties. Associated with this, would be a performance management system built around its activities for assessing "how well" they are executed, what is their contribution to the readiness and effectiveness of the overall system, and how it can be improved. For wider acceptability, the construction of the model ought to involve as many as possible partners that have different perspectives and different views regarding what is a wildfire operations system and how its performance ought be assessed and managed.

Following an action research perspective and in order to include many different perspectives and reach an accommodated view, *Soft System Methodology* (SSM) (Checkland and Scholes, 1999) was used. SSM is a participative systems methodology that facilitates the development of human-activities constituting systems. It has been already used for the development of performance management systems in diverse domains (e.g. Jacobs, 2004; Piedade Fransisco and Azevedo, 2009; Lin, et al., 2012), when the objective has been to measure the performance of the determinants of the observed performance, not only observed behaviors.

Soft Systems Methodology in performance management

Soft System Methodology (SSM) (Checkland, 1981; Checkland and Scholes, 1999) is a participative methodology (framework of employing methods) oriented to learning. It assumes that the world is problematical but can be explored using systems models of concepts of purposeful activity to define "actions to improve". Models in SSM are intellectual devices to help debate (epistemologies), they are not used for predictive or prescriptive manner. SSM adheres to an interpretivistic philosophical base along its systemic inquiry process. It talks the language of "issues" and "accommodation" of views/perspective, and this is the reason that is employed in situations where there are

many different views and perspectives, different knowledge sources and different power statuses.

SSM is based on the idea that the social world is indeed characterized by systemic properties (emergence and interrelatedness), but we cannot assume that it comprises real social systems. After all, as Churchman has indicated, systems are not real entities existing "out there" waiting to be identified. Rather, systems are whole system judgments, that is, judgments made in the knowledge of the totality of relevant conditions. SSM employs systems concepts such as emergence and interrelatedness to interpret social phenomena through a collective cognitive process, rather than trying to identify and represent systems as if they existed in the real world.

SSM is a participatory, continuous-learning process of action research that can address the three fundamental and interrelated problems of performance system development, namely system boundary definition, system structure definition and definition of level of analysis through the accommodation of the stakeholders' world views. Responding to the critique that SSM has little to say about knowledge-power distribution and the way that it distorts the outcome of the debate of views (Flood and Jackson, 1991), Checkland includes a "political systems' analysis in the 'cultural stream of analysis'. Knowledge-power, as well as power distribution in general, is a critical issue in the development of performance management systems as there are stakeholders with different interests (they have interest in measuring and managing different issues). Hence, in addition to the subjective knowledge sources a stream of objective knowledge supply should be included in the system development process. This knowledge supply should be available through empirical research and should be controlled by the interpretive process of SSM.

Soft Systems Methodology consists of different stages that are accomplished in a participatory manner. In the initial stage the area of concern is considered problematic (e.g. we do not have a performance management system and need one) and is reached for any information concerning this problem. Information and tacit knowledge from different sources in various forms (interviews, documents, film, etc) is gathered, and then, in a subsequent stage, it is displayed (expressed) in a comprehensive manner for all participants. Usually this takes the form of a "rich picture" drawn by hand. According to Checkland (1981), a rich picture should make clear the purpose and the roles of those involved, the social context in which the effort to develop or to change something (e.g. a Performance Management System) takes place, as well as the political context (i.e. who holds the power, over which issues, etc.)

Following, a set of relevant systems is derived on the basis of different worldviews and defined using a structured framework called Root Definition. The Root Definition of these human-activity systems includes the Customer(s) of the system (who will benefit from the system?), the *Actor(s)* of the system (who will perform the activities involved in the transformation process?), the *Transformation* (which process will transform the input into output?), the *Worldview* (*Weltanschhaung*) (that makes this transformation important), the *Owner* of the system (who has the power to put the system in place and to operate it), and *Environment* (what are the contextual elements the determine the operation of the system). This framework is known as CATWOE.

After the relevant systems are defined using the CATWOE framework, conceptual models are derived. Deriving a conceptual model is a method of analyzing the activities which need to take place in order to clearly define what the actors need to do in order to achieve the transformation (what the actors will do in the context of particular (sub)systems processes. Conceptual models are defined in a graphical form and consist of interconnected human activities (alternatively dynamic simulation models may be

used for their definition and for checking their systemic coherence) (Adamides et al. 2009). An important component of these models/systems is the "monitoring and control" component, which includes the mechanisms that guarantee successful performance through measuring and monitoring efficacy, efficiency and effectiveness.

At the next stage (Stage 5) conceptual models are compared with the real world (real situation). The comparison and any improvements, corrections, etc takes place by showing the models to the diverse stakeholders and asking them to commend. The last stage before taking action (implementation) involves the analysis of changes in terms of feasibility, desirability, priorities and the risks involved.

In general, in the development of Performance Measurement Systems for complex systems, SSM is used to address issues such as:

- Which are the boundaries of the system *whose performance is measured*, i.e. what is in and what is out relative to problem discourse?
- Which is the structure of the system, i.e. the interrelationships among the constituent elements of the *universal* system *to be measured and managed*?
- What is the appropriate level of analysis*/detail required in performance indicators.*

These were the issues addressed by the use of SSM in the development of a performance measurement system for wildfire operations management.

Soft Systems Methodology in the development of a Performance Measurement System for wildfire confrontation

In the framework of the work of a specific task force in the aforementioned project, to develop a performance management system for wildfire confrontation operations management, the above process of SSM was carried out. The objective was to define relevant systems and to develop sets of performance measures for their efficacy, efficiency and effectiveness.

Four SSM sessions took place over a period of a year involving a diverse set of experts from each county, using and debating data that were collected from different sources by a variety of methods (stored data, interviews, best practice/case development, etc). In pilot use, the model performance management system was used to benchmark available wildfire prevention and confrontation systems in the regions of the participants of the project.

Initially, the basic requirements for effective wildfire prevention and confrontation on which performance measurement would be based were discussed and agreed. They can be summarized along three axes:

- Aware public for prevention, monitoring and fighting according to the needs of the region.
- Well-maintained, modern technology for prevention monitoring and fighting according to the needs of the region.
- Well-trained, skillful personnel for prevention, monitoring and fighting according to the needs of the region.

The discussion and debate about these objectives and the issues/problems that they raise took place through the process of the development of a rich picture. Then relevant systems were identified and defined in the CATOWE form. The four systems were:

1. A system for assessing the specific needs of the region and for developing requirements.
2. A system for acquiring and maintaining knowledge and skills for organizing and operating the monitoring, prevention and fire-fighting activities.

3. A system for acquiring and maintaining monitoring, prevention and fire fighting technology.
4. A system for improving local public awareness with respect to the monitoring, prevention and fighting of forest fires.

An example of a CATOWE definition for the last system is shown in Figure 1.

A professionally-manned system which, with the help of the participation of the area's citizens, plans and implements actions towards increasing the awareness of the public with respect to the activities required for preventing the outbreak of forest fires and the activities required for preventing or restricting losses when forest fires occur.	
C:	The public, policy makers, specialists for the prevention and fighting of fires
A:	Professional teams, trained citizens
T:	Unaware public becomes aware of issues related to fire prevention and fighting
W:	Supply of knowledge and information to the public makes it effective in the prevention and fighting of fires and reduces the magnitude of human and non-human losses
O:	Local Authority (depends)
E:	General policy-making system, fire prevention and fighting policy systems, fire prevention and fighting planning systems

Figure 1. Example of Root Definition for a Public Awareness system in CATOWE form

For each system, a conceptual model was constructed (which included the activities that should be accomplished) and defined the conditions for efficiency, efficacy and effectiveness (i.e. how activities will be executed efficiently and effectively). Figures 2, 3, 4 and 5 show these systems' models in *human activities* form.

Based on these conditions individual metrics for each system were defined. For the specific (idiosyncratic) needs assessment system, measures for appreciating climate conditions, economic activity, geo-physical/topographic conditions, human activity conditions, and risks and challenges were defined. For the acquisition and maintenance of technology system, measures for the processes of technology scanning, selection operations and maintenance of technology were defined. Similarly, for the knowledge and skills system, measures for assessing requirements, and acquiring and maintaining wildfire operations management knowledge and skills by the various parties involved were defined. Finally, for the operation of the public awareness system, measures to assess the operations for the design and implementation of promotional plan activities were defined.

The outcomes of the action research were evaluated by participants and were formulated into a structured document, which allows interested parts to select the measures that are most appropriate according to the human activities in the models for their specific conditions (an example is shown in the Appendix).

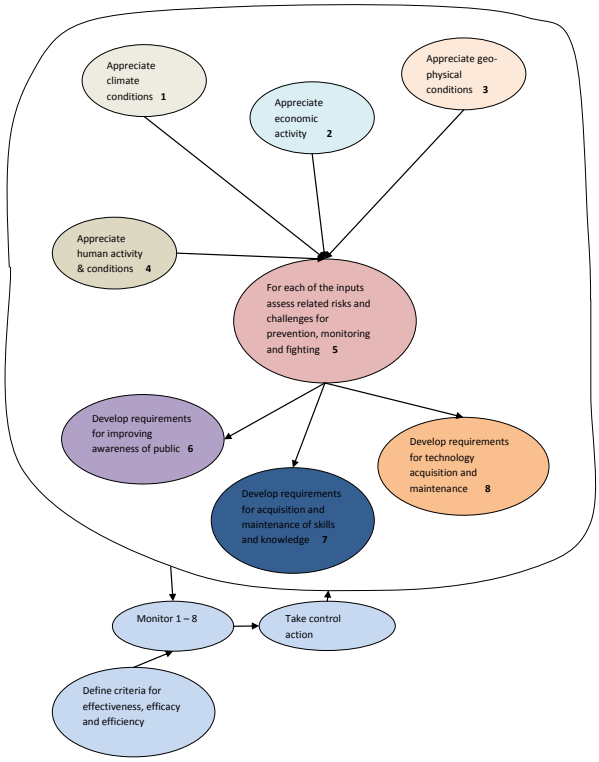

Figure 2. Conceptual model of a system for assessing the specific needs of the region and for developing requirements.

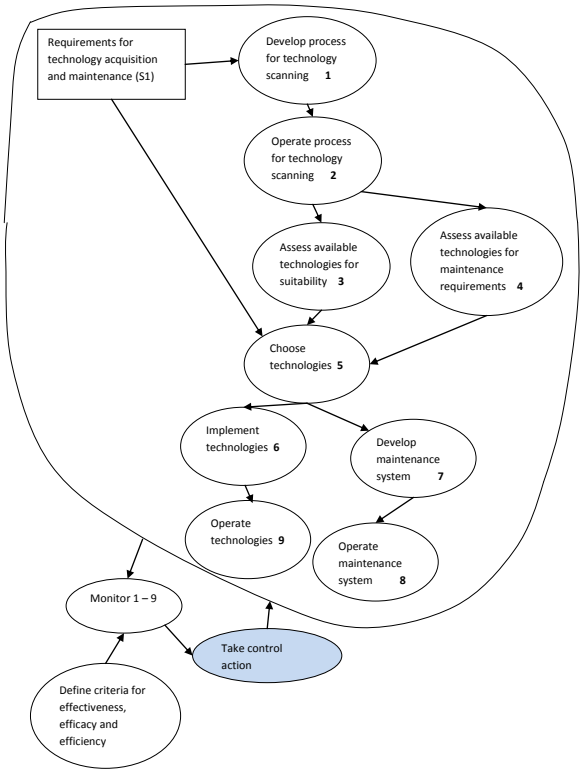

Figure 3. Conceptual model of a system for acquiring and maintaining monitoring, prevention and fire fighting technology.

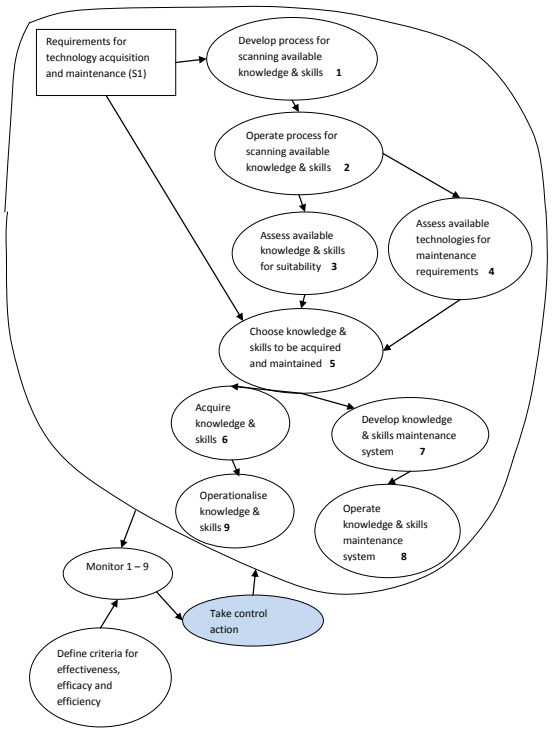

Figure 4. Conceptual model of a system for acquiring and maintaining knowledge and skills for organizing and operating the monitoring, prevention and fire-fighting activities.

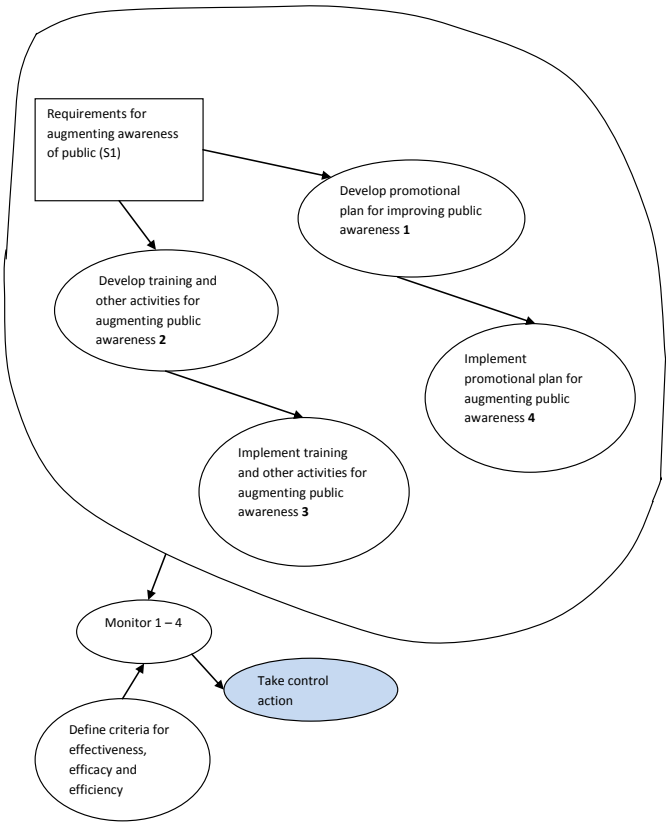

Figure 5. Conceptual model of a system for improving local public awareness with respect to the monitoring, prevention and fighting of forest fires.

Conclusions

Obviously, wildfire prevention and fighting are important societal activities that are related not only to economic and environmental losses, but also, more importantly, to human lives. In this paper, we have shown how an operations management (process) perspective and a systemic methodology can facilitate the development of a performance management system that assesses the readiness and effectiveness of all the parties involved in the protection from, and the fighting, of wildfires. In addition to crisis management, the methodology described in the paper provides lessons for the development of complex but flexible performance management systems in other large-scale distributed settings (e.g. multi-national conglomerates), where diverse parties are involved.

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Appendix

Example of measures for related to the system for assessing needs and developing requirements (System S1)

Appreciate climate conditions

EFNCY → availability of correct historical information for weather conditions
EFNCY → availability of short-term and medium-term weather forecasts
EFNCY → availability of current weather conditions (on-line)
EFCCY → availability of appropriate human resources to carry out activity
EFNES → production of reports and other artifacts that contain all information in a format to be used by fire prevention and fighting specialists

Appreciate economic activity

EFNCY → availability of information (maps, lists, etc) with main sites of economic activity (e.g. processing units, shops, agricultural activities, etc)
EFNCY → availability of prioritized lists with economic data of existing economic activities within region

EFNCY → availability of information about economic activities that require special attention and treatment (e.g. fuel storage)
EFCCY → availability of appropriate human resources to carry out activity
EFNES → production of reports and other artifacts that contain all information in a format to be used by fire prevention and fighting specialists

Appreciate geo-physical/topographic conditions
EFNCY → availability of detailed geo-physical maps of the region
EFNCY → availability of GIS
EFNCY → availability of detailed information for vehicle mobility (width of roads, condition of roads, etc)
EFNCY → availability of detailed information about the natural environment (vegetation) of the region
EFCCY → availability of appropriate human resources to carry out activity
EFNES → production of reports and other artifacts that contain all information in a format to be used by fire prevention and fighting specialists

Appreciate human activity conditions
EFNCY → availability of detailed information about residencies and their distribution in the region
EFNCY → availability of detailed information about special facilities/buildings/activities (schools, hospitals, public buildings, etc)
EFNCY → availability of detailed information about military facilities in the region
EFNCY → availability of information about people-gathering events in the region (regular and not)
EFCCY → availability of appropriate human resources to carry out activity
EFNES → production of reports and other artefacts that contain all information in a format to be used by fire prevention and fighting specialists

Assess related risks and challenges
EFNCY → availability of the output of human activity systems “Appreciate climate conditions”, “Appreciate economic activity”, “Appreciate geo-physical/topographic conditions”, “Appreciate human activity conditions”
EFCCY → availability of appropriate human resources to carry out activity
EFCCY→ availability of appropriate methods and tools
EFNES → production of reports and other artifacts that contain all information on risks and challenges for fire prevention and fighting for the specific region in a format to be used by fire prevention and fighting specialists