Association for Information Systems
AIS Electronic Library (AISeL)

ICIS 2008 Proceedings

International Conference on Information Systems (ICIS)

2008

Transacting Expertise in Emergency Management and Response

Panos Constantinides
Lancaster University Management School, p.constantinides@lancaster.ac.uk

Angelina Kouroubali
FORTH-ICS, kouroub@ics.forth.gr

Michael Barrett
University of Cambridge, m.barrett@jbs.cam.ac.uk

Follow this and additional works at: http://aisel.aisnet.org/icis2008

TRANSACTING EXPERTISE IN EMERGENCY MANAGEMENT AND RESPONSE

Transaction d'expertise dans le management de cas d'urgence

Completed Research Paper

Panos Constantinides
Lancaster University Management School
Department of Organisation, Work &
Technology, Lancaster, LA1 4YX, UK
p.constantinides@lancaster.ac.uk

Angelina Kouroubali
FORTH-ICS,
N. Plastira 100, P.O. Box 1385,
Vassilika Vouton,
GR 700 13 Heraklion, Crete, GREECE
kouroub@ics.forth.gr

Michael Barrett
Judge Business School, University of Cambridge,
Trumpington Street, Cambridge, CB2 1AG, UK
m.barrett@jbs.cam.ac.uk

Abstract

In this paper we extend transactive memory systems (TMS) theory to develop an understanding of the distributed coordination of expertise in high-reliability organizations. We illustrate our conceptual developments in a study of emergency management and response in Greece. We focus on the interaction between operators/dispatchers, ambulance crew, and specialist doctors, including the information and communication technologies (ICT) they use to respond to emergency incidents. Our case contributes to an in-depth understanding of the ways in which high-reliability organizations can sustain a distributed coordination of expertise over the duration of emergency incidents. This is achieved through the cultivation of TMS during a socialization and training period, the dynamic development of trust in emergent actions, and a commitment to shared protocols, which allow for improvisation and bricolage during unexpected incidents. Our findings also explore the role of ICTs in inscribing TMS in computerized protocols, while mediating the development of trust across the team, as well as mediating the construction of running narratives, which enable leaders to coordinate expertise in unexpected incidents.

Keywords: Distributed coordination, expertise, emergency response, high-reliability organizations, transactive memory systems

Résumé

Dans ce document nous prolongeons la théorie TMS (transactive memory systems) pour développer une compréhension de la coordination distribuée d'experts (ex. médecins spécialisés) dans des organismes requérrant une haute fiabilité. Nous présentons nos développements conceptuels dans une étude de cas de gestion des urgences au Centre Nationale de Secours Urgents (Centre ambulancier « EKAB ») en Crète.

Σύνοψη (Greek)

Στο άρθρο αυτό επεκτείνουμε τη θεωρία TMS (transactive memory systems) για να κατανοήσουμε τον διανεμημένο συντονισμό διαφόρων ειδικών (π.χ. ειδικών ιατρών) σε οργανισμούς υψηλής-αξιοπιστίας. Παρουσιάζουμε τις εννοιολογικές μας επεκτάσεις, μελετώντας την διαχείριση επειγόντων περιστατικών στο Εθνικό Κέντρο Άμεσης Βοήθειας στην Κρήτη και αναλύουμε θεωρητικές και πρακτικές επιπτώσεις για περαιτέρω έρευνα.

Introduction

Organizations that manage to remain error-free for long periods of time despite the fact that they operate in hazardous, fast-paced, and highly complex social and technological systems, are thought to exhibit high reliability (Roberts 1990a, 1990b). High reliability organizations are characterized by their extreme variety of components and systems, their task interdependence, hierarchical differentiation of roles, the presence of many decision makers with frequent and immediate feedback between them, a high degree of accountability, compressed time factors, and synchronized outcomes (Bigley and Roberts 2001). Consequently, the capacity to continuously and effectively manage emerging, often hazardous and deadly, conditions is a vital quality or competency of high-reliability organizations (Weick 1987, 1993, 2001). To develop such a capacity, high reliability organizations must coordinate resources and expertise in time and in ways in which a problematic situation can best be dealt with and contained. However, coordination becomes very difficult in high reliability organizations due to their dependence on distributed, interdisciplinary teams of specialized individuals, and, thus, an emergent process of linked know-how and interrelated actions (cf. Argote 1999).

In this paper, we draw on recent extensions to transactive memory systems (TMS) theory (Majchrzak et al. 2007) to develop an understanding of the coordination of expertise in accident and emergency teams, a type of high-reliability organization. Transactive memory is the shared division of cognitive labor with respect to the encoding, storage, retrieval, and communication of information from different domains of expertise that often develops in close relationships (Brandon and Hollingshead 2004). What makes transactive memory systems transactive are the transactions (exchanges) among individuals and their organizing schemes that connect knowledge held by each individual to knowledge held by others in the system (Majchrzak et al. 2007). These transactions come in the form of socialization, i.e. the shared experiences and informal interactions with one another (Hollingshead 1998; Wegner et al. 1991), but also formal group training or specialization (Liang et al. 1995; Moreland and Myaskowsky 2000) and trust or credibility among team members in relation to one another's competence and reliability to carry out different tasks (Kanawattanachai and Yoo 2007; Lewis 2003). Because of the distribution of expertise in emergency teams – i.e. the embodied competencies (Blackler 1995) of a team are distributed based on specialization (e.g. paramedic, intensive care physician etc.) – we understand expertise to be transacted among team members through their codification of information and delegation of responsibility across designated 'experts' (Brandon and Hollingshead 2004; Majchrzak et al. 2007). In particular, we focus on the distributed coordination of expertise with an emphasis on the temporal and situated nature of emergency management and response (Faraj and Xiao 2006).

We contribute to TMS theory by exploring its application in high-reliability organizations, and by examining the role of ICT in the transaction of expertise. Our key research question asks, *how do high-reliability organizations sustain a distributed coordination of expertise over the duration of emergency incidents?*

We develop an answer to this question through a longitudinal study of emergency management and response across a geographical region of Greece. We pay particular attention to the interaction between operators/dispatchers, ambulance crew members, and specialist doctors, including the information and communication technologies (ICT) (e.g. Triage protocols, radio, GPS, and telemedicine) they use to interpret and respond to an emergency situation, as well as to project its outcome. Our findings contribute to the literature by providing an in-depth understanding of the ways in which high-reliability organizations are able to sustain a distributed coordination of expertise over the

duration of emergency incidents. Firstly, in agreement with past research on TMS, we find that the cultivation of a TMS in high-reliability organizations during a socialization and training period helps to map out which member is supposed to know what across the collective epistemic knowledge of the team. Secondly, unlike past research on TMS, we find that trust among members of a high-reliability organization does not solely depend on shared experiences around the competency and reliability of one another, but also on emergent actions as mediated by resource constraints and time pressures. Thirdly, in agreement with past research on TMS, we find that the development of task representations of who should do what and when in high reliability organizations is based on shared protocols. However, unlike past research on TMS, we also find that members of high-reliability organizations improvize these shared protocols in practice as they engage in practices of bricolage to manage unexpected and uncertain incidents. Our findings also examine the ways by which these coordination efforts become mediated by various ICTs, something which has not been explored in the TMS literature to date. Firstly, we find that the emergency team's TMS becomes inscribed in computerized protocols, thus, reinforcing the collective epistemic knowledge of the team. Secondly, we find that ICTs track and transmit information about the status of emergency incidents and the actions taken by involved team members contributing to the dynamic construction of trust across team members. Thirdly, we find that ICTs mediate the construction of mental images or running narratives around emergent incidents, which enable leading individuals to geographically locate each team member (via GPS and radio), and coordinate expertise (via telemedicine and radio) towards the effective management of emergencies.

In the next section we describe our analytical directions in more detail. We then describe our methodological choices and provide some background information to the case study. This is followed by our analysis of the findings. We conclude with a discussion of some implications for theory and further research.

High Reliability Organizations and Expertise Coordination

High reliability can be understood as the capacity to continuously and effectively manage emerging, often hazardous and deadly, conditions (Bigley and Roberts 2001). Achieving high reliability is dependent on the context - the organizational culture – in which work occurs (Barling, Loughlin, and Kelloway 2002; Hofmann and Stetzer 1996; Weick 2001). However, organizational culture is not something that is created and controlled by senior people at the top of an organization (Weick 2001). Organizational culture is embodied in the vocabulary of the organization such as procedural and substantive routines, preferred communication channels, meeting agendas, and socialization practices. In other words, organizational culture is distributed in the frames of reference of organizational members and enacted in practice through various organizational activities (Shristava and Mitroff, 1988). Organizational culture, thus, emerges from the "tight coupling between action and cognition that is created by the necessity to explain behavioral commitments to oneself and to important peers" (Weick 2001:80). Achieving high reliability by drawing on cultural premises and assumptions, therefore, involves improvization and bricolage, both of which are in sharp contrast to relying solely on rules, regulations and standards of practice, all of which require high surveillance and control (Weick 2001). Bricolage means to use available resources, including tools and skills, to perform whatever tasks one faces. Invariably available resources will not always be best suited to dealing with a problematic situation, but they are all there is for a bricoleur to do so (Thayer 1988; Weick 1993). In the context of leadership, Thayer (1988:239) explains the role of the bricoleur to be about "fixing things on the spot through creative vision of what is available and what might be done with it".

Improvization and bricolage become very important when coordinating resources and expertise in emergency situations (e.g. industrial accidents, medical emergencies), since these are, by definition, emergent and, thus, to some extent deviating from any planned interventions. Certainly, members of high reliability organizations dealing with such emergencies are subjected to an intense period of training where a set of core practices and values are socialized into them, before they are turned loose to enact those practices and values in their own improvized ways; it is only through this prior period of intense training and socialization that decentralized, improvized action is possible (Weick 2001). In order to understand this transformation from a formal, structured approach to dealing with emergencies to the more improvised, decentralized actions of the people immersed in emergency situations we need to focus on the temporal and situated nature of emergency management and response (Faraj and Xiao 2006).

One approach to understanding the way groups deal with problematic situations is through transactive memory systems (TMS) theory, which understands expertise to be distributed in the organizing schemes of organizational members and enacted in practice through various organizational activities (Hollingshead 1998; Liang et al 1995; Moreland and Myaskowsky 2000; Wegner et al. 1991). The difference between TMS theory and other approaches is that, the distribution of labour and expertise is clearly defined: each individual in the team specializes in areas on the

basis of their relative expertise, skills or experiences, formal assignments or negotiated agreements. As a result, individuals tend to focus on learning information in their own areas of relative expertise, and they expect others in their team to do the same (Hollingshead 1998; Wegner et al.1991). This division of labor and expertise reduces the amount of information for which each person is responsible, yet provides each person access to a larger pool of information across domains. In consequence, the extent to which people in relationships share expectations about who has (or is expected to have) various information can affect coordination, communication, and task performance (Hollingshead 1998; Wegner et al. 1991).

Past research drawing on TMS theory has been primarily experimental in nature, testing group processes and performance in laboratory settings (Hollingshead 1998; Liang et al 1995; Moreland and Myaskowsky 2000; Wegner et al. 1991). More recently, there have been some field studies providing some early evidence on the value of TMS theory in organizational settings (e.g. Austin 2003; Lewis 2003). However, even these studies draw entirely on survey samples from such organizations as an apparel and sporting goods company (Austin 2003), university student groups, MBA consulting teams, and technology companies (Lewis 2003). So far, there have not been any empirical studies exploring the relevance of TMS theory in high-reliability organizations. In addition, emphasis has not been placed on the role of ICTs in transacting expertise. To this end, we build and extend on TMS theory to contribute to the literature on high-reliability organizations.

Developing Transactive Memory Systems in High Reliability Organizations

In our application of TMS theory to the study of high-reliability organizations we draw links between the two literatures while also exploring the role of ICT. Firstly, we develop an understanding of the preconditions in the development of TMS in high-reliability organizations as implicated in a period of socialization and training (Hollingshead 1998; Levine and Moreland 1991; Moreland and Myaskowsky 2000; Wegner et al. 1991). This period of socialization and training is well researched in studies of high-reliability organizations, whereby knowledge of roles, task routines, and processes become established across organizational members (Bigley and Roberts 2001; Weick 2001). The difference is that, in high-reliability organizations, socialization and training are constantly informed by lessons learned from team outcomes on expertise coordination (Roberts 1990a, 1990b; Weick 1987). Secondly, we drew on Majchrzak et al's (2007) extension to TMS theory from an understanding of trust as implicated in shared experiences (see Brandon and Hollingshead 2004; Moreland and Myaskowsky 2000) to the development of trust in emergent actions. Issues of trust are once again well researched in the literature on high-reliability organizations (see Cox et al 2006) with considerable emphasis being put on swift trust, a type of task-based or role-based trust that emerges in practice (Meyerson et al 1996; Weick 1993, 2001). Thirdly, we drew on Majchrzak et al's (2007) extension to TMS theory from an understanding of expertise coordination in stable conditions as enacted through shared group models (Brandon and Hollingshead 2004; Liang et al 1995; Moreland and Myaskowsky 2000), to the coordination of expertise in emergent situations through dialogic on-the-spot coordination practices. The relationship between shared group models – what Weick (1987, 2001) describes as culture – and emergent actions in the coordination of expertise is well explored in the literature on high-reliability organizations through the concepts of improvisation and bricolage, as discussed earlier (Bigley and Roberts 2001; Weick 1993, 2001; Weick et al 1999). Finally, we add an ICT dimension to these processes of TMS development to explore the role of different technologies in the socialization and training of different individuals into emergency teams, the dynamic construction of trust across team members, as well as their transactions during the coordination of expertise. These conceptual developments are summarized in Table 1, and discussed in more detail below.

Table 1. Developing TMS in High-Reliability Organizations (HRO)		
Traditional TMS processes	**Additions to TMS processes from research on HRO**	**Additions to TMS processes in relation to the role of ICT**
Cultivation of TMS through a period of socialization and training	*Socialization and training constantly informed through lessons learned from team outcomes on expertise coordination*	*Inscription of TMS in computer-based information systems*

Development of trust through shared experiences	*Development of trust through emergent actions (swift trust)*	*Mediating trust development by managing risk through ICT use in recording and monitoring team tasks and outcomes*
Expertise coordination through shared protocols	*Expertise coordination through improvisation and bricolage*	*Mediating expertise coordination by aiding the construction of running narratives and mental images around emergent situations*

In traditional TMS studies, TMS are thought to be cultivated through socializations among team members (Hollingshead 1998; Levine and Moreland 1991; Wegner et al. 1991), but also through formal group training (Liang et al. 1995; Moreland and Myaskowsky 2000). Through such training and socialization the expertise of each team member is collectively decided. Expertise is hereby defined as the know-what, know-how, and know-why of a knowledge domain (Majchrzak et al. 2007), what has been previously referred to as embodied competencies (Blackler 1995). In the context of high-reliability organizations, training is constant and based on complex technologies (e.g. simulation technologies in aviation, computer-aided dispatch systems in medical emergencies), which inscribe the collective epistemic knowledge of the team according to various tasks that need to be completed for an emergency to be successfully managed and contained (Roberts 1990a, 1990b). For example, different scenarios of medical emergencies (e.g. heart attack, broken leg, etc.) and associated required responses are inscribed in computer-aided dispatch systems, which help dispatchers interpret different emergency calls and make decisions for action according to the level of priority (i.e., whether they are life-threatening or not) and the epistemic knowledge of the team (i.e. whether to dispatch a more specialized unit or not). A heart attack in a busy shopping mall may require a first response by a motorbike unit, followed by an ambulance for patient transport (Blandford and Wong 2004). Thus, ICTs hold representations of different scenarios and the ways in which a team might respond to those. Through these representations, ICTs classify relevant epistemic knowledge while emphasizing the existence of epistemic boundaries between different domains of expertise (cf. Faraj and Xiao 2006).

During the period of training, each team member is allocated to particular tasks. In practice, the allocation of individual members to particular tasks translates to their willingness to take on the responsibility of those tasks and become accountable for them to the rest of the team (Brandon and Hollingshead 2004; Majchrzak et al. 2007). Trust in each member's assigned tasks and actions is, thus, implicated in the shared experiences of the team in knowing who is supposed to do what (Hollingshead 1998; Liang et al. 1995). In high reliability organizations, the development of trust among team members is more dynamic and emergent, because the team is distributed geographically and temporally, and incidents are unexpected and uncertain. In such contexts, there is an implicit threat of common fate that forces team members to trust one another and take immediate action, or face more harm both as a team and as individuals (Majchrzak et al. 2007; Meyerson et al. 1996). "The threat encourages risk taking, while the generation of action increases the willingness to trust others' knowledge without social proof" (Majchrzak et al. 2007:154). The role of ICTs is key in this process in that, by recording and monitoring information about the outcomes of each individual task, as well as the overall team performance, they make individual actions more visible and raise issues of responsibility and accountability across the team.

Finally, different domains of expertise come to be coordinated through the shared cognitive models cultivated during the period of socialization and training, but also through various dialogic on-the-spot coordination practices (Faraj and Xiao 2006), as implicated in emergent trust relations (Majchrzak et al. 2007). Traditionally, TMS theory has conceptualized expertise coordination as dependent on shared cognitive models, a directory of who has which embodied competencies, as well as a set of cues for encoding and retrieving information from each team member (Hollingshead 1998; Liang et al 1995; Moreland and Myaskowsky 2000; Wegner et al. 1991). More recent extensions to the theory have added the importance of dialogic coordination practices by recognizing that action, communication, and cognition are essentially relational, highly situated, and possibly contested (Majchrzak et al. 2007). These dialogic coordination practices are key in high-reliability organizations, as team members are often required to cross epistemic boundaries and break their shared cognitive models or protocols to deal with unanticipated or unplanned consequences (Faraj and Xiao 2006). In this context, by keeping track of distributed information on team tasks, ICTs mediate the construction of a running, collective narrative of the decisions and actions taken and not taken (Boland and Tenkasi 1995) that helps the team move beyond the shared cognitive models to deal with rising contingencies in a more improvised way (Majchrzak et al. 2007). The various transactions

recorded during the coordination of expertise in different emergency situations will then feed back into the further cultivation of TMS across the team by refining training processes and the very models of expertise coordination (cf. Roberts 1990a, 1990b). These analytical directions influenced the selection of empirical research methods, which are discussed next in detail.

Methodology

This paper examines the emergency practices of the regional pre-hospital emergency care centre in Crete, Greece over the period 2003-2006. Given our analytical focus on the distributed aspect of the coordination of resources and expertise, the primary methodological direction was to study the training of, and interaction between, different specialized personnel during emergency management and response in the region, in an effort to understand the processes of coordination over the duration of emergency incidents.

The data collection progressed through six fieldwork phases (January 2003, July 2003, June-July 2004, November-December 2004, September 2005, July 2006). During these fieldtrips we conducted a total of 49 interviews and approximately 60 hours of observations with (a) operators/dispatchers, (b) ambulance crew members, and (c) specialized doctors (including the director of the emergency care centre). Interview questions directed to operators/dispatchers revolved around the ways of interpreting and classifying emergency calls according to Triage protocols (discussed in the next section), in addition to dispatching ambulance units to emergency sites according to resource availability, expertise, and severity of incident. Interview questions directed to ambulance crews revolved around the communication between the instructions received from the operators/dispatchers and the physical 'image' of the emergency site faced by the crews. Finally, the questions directed to specialized doctors (e.g. anaesthesiologists, intensive care specialists) focused on their senior role in the hierarchy of emergency teams, with an emphasis on their interventions in containing emergency situations from spiraling out of control. These interviews were supplemented by real-time observation of the practices of operators/dispatchers at the emergency care centre with audio access by radio communications to ambulance crews, as well as teleconsultation practices of specialized doctors also at the emergency care centre to ambulance crews either through radio or through telemedicine. Extensive, detailed notes were taken during all interviews and observations that were then transcribed as soon as feasible to preserve our exact experiences as freshly as possible. Each succeeding phase used the analysis of previous transcripts to formulate interview schedules and content. Thus, interviews became more structured and commonalities among particular themes emerged in time (Langley, 1999). These emergent themes were then integrated into subsequent interviews. As some of these themes gave rise to more fruitful data we began to delve into them further while centering our thinking around them as analytical concepts. These systematic efforts of data collection and analysis were employed in an attempt to maximize the reliability and validity of our findings (Golden-Biddle & Locke, 1993).

Data analysis was conducted in a four-step process. First, we separated the data into three main groups: statements or actions of operators/dispatchers; ambulance crew members; and specialized doctors. This was followed by intra-group analysis of similarities and/or differences in answers to particular issues. For example, all interviewees were asked to describe whether they found different technologies (e.g. GPS technologies for locating ambulance units, telemedicine applications for teleconsultation between ambulance crews and doctors at the emergency care centre) provided adequate support for their work practices. Inter-group analysis followed, where we compared the categories generated by each group's data to determine whether they reflected common themes. Finally, all field data were re-examined to determine whether the proposed set of categories covered as much data as possible. Conceptual analysis proceeded along our TMS framework.

The next section will provide a brief description of the case study. This will be followed by analysis and discussion using our analytical directions as developed in the previous section.

Background to the Case

The regional emergency care centre in Crete is part of the National Centre for Emergency Care (NCEC), the only public health organization in Greece offering pre-hospital care for chronic and emergency cases. In addition to its ambulance care function, NCEC provides educational services to the medical community through the Pre-hospital Emergency Medicine Program, and to the general public through training on basic cardio-pulmonary resuscitation (CPR) and basic life support.

NCEC is divided into a central unit located in Athens and regional units located throughout Greece. The NCEC unit of Crete (NCEC Crete), Greece's largest island, consists of a central unit located in Heraklion, and three peripheral units in the remaining three districts of Crete: Rethymnon, Chania and Lassithi, providing accident and emergency services for Crete's four districts. NCEC Crete covers a geographical area of over 8,336 square kilometers and services a resident population of more than 500,000. NCEC Crete consists of the dispatch centre and the ambulance fleet. The central dispatch centre located at Heraklion (the capital) coordinates and manages the ambulance service in each of the four districts of the island, Chania, Rethymnon, Heraklion and Lassithi. NCEC Crete staff includes, doctors trained in pre-hospital emergency care, paramedics, operators/dispatchers, technicians, and administrative personnel. Daily and for 24 hours, there are 5 fully equipped ambulances with a doctor (mobile units) and 13 Basic and Advanced Life Support (BLS, ALS) ambulances operating throughout Crete. Ambulances also operate in primary care clinics located in rural areas throughout Crete. All ambulances are coordinated by the central dispatch centre. In Crete, consistent use of triage protocols through an integrated information system and regular continuing education have greatly contributed to effectively coordinating resources and expertise while minimizing inappropriate management of incoming calls (Kouroubali et al, 2005). These innovative practices are discussed next in more detail.

Protocols for Emergency Triage

Incoming calls are triaged at the coordination centre. Until recently, triage at NCEC Crete was based on the experience of operators and the doctor who was on call. To assist operators/dispatchers in prioritizing calls and providing important information to the public, special protocols have been developed for several emergency situations. They were designed to be simple and easy to use and were developed in collaboration with experienced dispatchers and emergency care doctors. Throughout development, all changes and additions to the protocols were based on clinical tests.

The process starts with the dispatcher asking key triage questions after establishing the exact location of the incident and the phone number of the caller: (1) 'tell me what the problem is (tell me exactly what happened)'; (2) 'is s/he conscious'; (3) 'is s/he breathing'. These questions are then followed by more specific questions according to the answers received, through which the dispatcher attributes a severity score to the call and categorizes it into the following color categories: red - immediate response with a mobile unit with a doctor; orange - immediate response with an ALS ambulance (defibrillator); yellow - immediate response with a BLS ambulance; green - delayed response. A negative answer to 'is s/he breathing?' or an indication that the patient is suffering agonizing breathing along with a negative answer to 'is s/he conscious?' indicates a severity score of red or orange requiring the immediate response of a mobile unit. Triage protocols contain specific instructions to assist in the exact evaluation of each incident and a special section with the title 'remember' that includes specialized instructions to the dispatchers for each category of emergency call. In each case, specific instructions are also given to the caller and to the crew of the ambulance for the initial handling of the episode.

Pre-Hospital Emergency Management System (PHEMS)

In 1997, the manual protocols used at NCEC Crete were incorporated into a computerized pre-hospital emergency management system (PHEMS). PHEMS provides solutions for geographical tracking of ambulances and mobile units, optimal use of available resources, acquisition, transmission, analysis and storage of vital signs for patient telemonitoring, and an electronic emergency incident archiving, currently containing more than 50,000 records, and medical triage protocols for prioritization of emergency calls. More specifically, the system consists of the following applications: an operator/dispatcher application; a doctor application including a telematics subsystem; an administrative application; and a satellite geographical information system (GIS).

Figure 1. The Pre-Hospital Emergency Management System
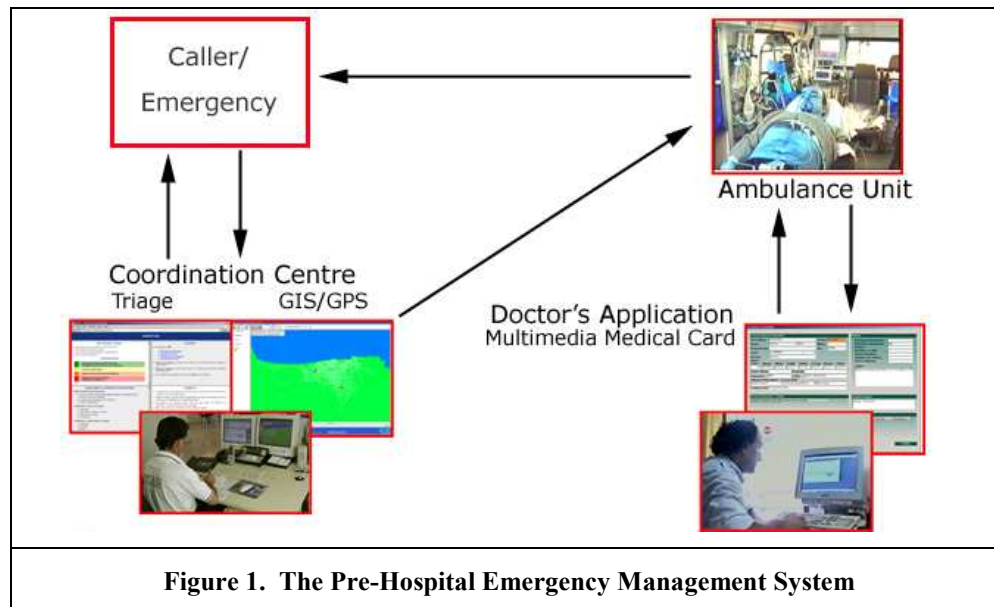
The operator/dispatcher application allows creating, completing and printing the electronic 'Incident Card'. Based on specific algorithms (online triage protocol), it offers help with regard to incident severity estimation and the selection of the most appropriate resources (e.g. ambulance car or mobile unit). The application keeps track of all incidents being dispatched or waiting to be dispatched displaying them in a list.

Mobile units are equipped with appropriate technology to obtain and transmit vital signs and electrocardiographs (ECGs) directly to the doctor's application at the dispatching centre allowing for remote monitoring and management of the patient within the ambulance. Using the 'Multimedia Medical Card', the doctor may record all relevant details for patient's condition and therapeutic actions throughout the incident. The application within the mobile unit almost automatically acquires and transmits vital signs and ECG requiring minimum crew involvement to allow the crew to concentrate fully on the patient. The telematics subsystem stores all vital signs and the ECG of an emergency patient handled by the Mobile Unit.

Finally, the dispatching centre operates a GPS satellite GIS system that depicts the exact position of the ambulance and allows the dispatchers better coordination of resources. All ambulances are equipped with this system.

The TMS of the team was, thus, inscribed in the PHEMS. Firstly, the system made available electronic versions of the triage protocols to the operators/dispatchers, thus, speeding up their decision-making by refreshing the screen with relevant instructions on what to do in different scenarios. Secondly, it helped to keep track of who was doing what at the accident site through a telematics subsystem. Thirdly, it provided the geographical position of each ambulance unit helping operators/dispatchers calculate the time it would take to respond to an emergency call.

Emergency Education and Training

Another innovative practice established at NCEC Crete primarily through the efforts of its Director was mandatory continuous education for doctors, crew and dispatchers, including training on triage protocols, disaster recovery, and a basic life support course for the public.

At NCEC Crete, education and training was not differentiated between dispatchers and crew members. All staff went through the same training and were ready to occupy either position. In practice, there was a rotation system where staff circulated from being an operator/dispatcher at the coordination centre, to a crew member in the ambulances. Rotations have been particularly effective in establishing good communication between operators/dispatchers and crew members, as each team member knew how it felt to be on either side of handling an emergency episode. Table 2 lists the key roles and responsibilities of each team member, including their required qualifications and training.

Table 2. Characteristics of the Team at NCEC Crete		
Team Member	**Role & Responsibilities**	**Required Qualifications & Training**
Operator/ Dispatcher	*Role:* Receive emergency and non-emergency calls and direct them to a source of assistance. Triage calls and dispatch appropriate ambulance units. *Responsibilities:* - maintain constant status information on all running episodes; - operate computers, telephones, radios, and other technical equipment; - work according to 24-hour scheduling with work hours subject to change according to demand (including weekends, holidays, and overtime as necessary) - restricted ability to leave workstation	*Required Qualification:* - successfully complete the program of the Institute of Professional Education of the National Emergency Care Centre. *Training:* - management of multiple simultaneous tasks that must be performed on demand in high liability and high stress situations; - use of the computerized system of NCEC Crete including electronic protocols and the geographical information system.
Ambulance Crew	*Role:* In collaboration with the Operations Centre provide immediate care to the critically ill and injured, and transport the patient to a medical facility. *Responsibilities:* - evaluate the scene to determine safety, mechanisms of injury or nature of illness, total number of patients and request additional help if necessary; - triage the injured in accordance with standard emergency procedures; - provide simple and/or advanced rescue services (opening and maintaining an airway, cardiopulmonary resuscitation, care of simple and multiple system trauma) based on the incident and the directions of the Operations Centre and/or ambulance doctor.	*Required Qualifications:* - successfully complete the program of the Institute of Professional Education of the National Emergency Care Centre; - driver's license for category C vehicles. *Training:* - management of multiple simultaneous tasks that must be performed on demand in high liability and high stress situations; - interpersonal skills for collaboration in mass accidents with other organizations, fire brigade, police and others.
Doctor	*Role:* Lead and coordinate disaster planning, training, and management in the prehospital areas aiming for the timely transfer of critically ill or injured patient to a tertiary hospital. *Responsibilities:* - examine, diagnose, and treat initial and acute phase of illnesses and injuries; - provide training and supervision of non-physician health care personnel in aspects of prehospital care; - provide training to the public for basic life support; - ensure that the emergency care system provides quality care and meets the needs of the patient population it serves.	*Required Qualifications:* - degree of doctor of medicine (including specialization) from an approved school of medicine *Training:* - additional knowledge in aspects of emergency care. - participation in the postdoctoral program in prehospital emergency medical education.

In addition, weekly presentations of interesting emergency cases have been established among doctors and crew with the Director acting as facilitator in the discussions. Most importantly, the discussions were very informal in nature with everyone – irrespective of specialization – being given an equal chance to express their opinion and inform future emergency practices. This was the Director's approach to treat everyone as an equal colleague, in the process flattening the organizational hierarchy and encouraging participation in continuous education and training. In fact, this type of socialization – of bringing the team together – encouraged reviews of practice towards a refinement of the existing triage protocols.

These unique characteristics of the education and training of the team at NCEC Crete, as well as the role that PHEMS played in helping them to respond to emergency incidents, are discussed next in more detail.

Findings

The findings are presented in accordance to the TMS framework developed earlier and summarized in Table 1, in relation to the cultivation of TMS across the team, the development of trust, and the coordination of expertise.

Cultivation of TMS

Socialization and Training in a Culture of "Philotimo"

A key finding from our study was the presence of a culture of "philotimo". The concept of philotimo kept popping up in the interviews without any prompt from the researchers, something which in the end forced us to ask interviewees to define it. One ambulance crew member captured the meaning of philotimo as a will to contribute, as well as to improve, the practices of the collective; "that, even if you are not obliged to do something, you do it because you know it will help; you may save a life." Other interviewees confirmed this view while adding that philotimo is a disposition to help oneself and others and "one either has it or not," as another crew member told us. However, they also agreed that philotimo can be cultivated in interaction with others. In fact, the cultivation of philotimo across the team was put down to the efforts of the Director of NCEC Crete to encourage collegiality among all NCEC Crete's personnel, while also subjecting them to continuous training towards improving the expertise of the team, as well as securing the team's safety – a critical issue in high reliability organizations (see Cox et al 2006; Edmondson 1999; Pidgeon 1991).

From a TMS perspective, philotimo can be interpreted as an effort to cultivate TMS among the team, both through socialization and training. First, in terms of socialization, by employing a bottom-up approach to leadership, the director of NCEC Crete managed to cultivate a sense of collective interdependency towards one another. One operator told us:

> *"From the very beginning, our director had approached us as his friends as his colleagues. He told us, 'I see you as friends as colleagues; I don't see you as office workers'. And that's how it should be. When you catch a Greek person by his philotimo, then he works better."* (operator)

This view was echoed across both operators and crew members, but also doctors, with all of them recognizing the importance of this culture of philotimo. More importantly, this culture of philotimo was seen to transcend social interaction and to influence the training and development of expertise across the team. One anaesthesiologist told us:

> *"Our work has a limit. Many things here have gone beyond this limit just because of philotimo… The seminars I was telling you before are usually in the morning. Not everyone is on duty that morning. Some of them will come to the seminar, which will last for 1 or 2 hours and then come back in the afternoon to work. They come because they want to become better at their job"* (anaesthesiologist)

In particular, even though training programs were never made obligatory they were offered on a continuous basis, which encouraged members of the team to eventually commit to them. Further, operators/dispatchers and crew members were obliged to rotate between both posts in order to gain experiences both from the field and at the coordination centre which, once again, meant that they had to go through the training in order to do so, as one operator explained:

> *"[training] helped everyone to go through all posts. This turnover helped everyone see all phases of our job."* (operator)

We are not suggesting that the culture of philotimo was simply created and subsequently controlled by the director of NCEC Crete, since this culture emerged from the collective social interactions of the team (cf. Weick 2001). However, there is strong evidence to suggest that the director cultivated the susceptibility of the team towards philotimo to establish some cognitive interdependencies among them.

Inscribing TMS in Computerized Protocols

The cultivation of TMS across the team came both through specific means of socialization and training, but was also positively mediated by the integration of ICTs into the emergency practices of the team. In particular, the computerization of triage protocols greatly contributed to mapping out the epistemic knowledge of the team in relation to how to classify emergency incidents, as well as when and with what means to respond to them. One intensive care physician told us:

> *"The system we use – which according to some leading symptoms the caller gives us – allows us to plan how, with which sort of response, how fast and with what means we are going to respond"* (intensive care physician).

The director of NCEC Crete added:

> *"Ever since the initial installation of the system in 1998, which was followed by further 3 improvement stages, we have had over 70% success in identifying incidents that needed immediate attention and differentiating them from non-emergencies."* (Director)

Computerized protocols helped to improve the success rate of the operators' identification of emergencies from non-emergencies, but also helped to define the epistemic boundaries of each 'expert', by pointing to who was supposed to do what and how each task contributed to the practices of the whole team. One crew member explained:

> *"When the operator can make an evaluation and inform us beforehand of what is going on then we can prepare until we reach the incident. In such cases, the relation between the crew and the operator is very important… this is cooperation between professionalism and philotimo."* (crew member)

This view confirmed the presence of a shared TMS across the team, but it also raised issues of trust in relation to the ways in which different team members became accountable for their actions on particular tasks to the rest of the team.

Development of Trust

Trust as Implicated in Shared Experiences and Emergent Actions

As evident from the above, there is a strong relationship between the culture of philotimo and the professional or epistemic knowledge of each of the team members. This relationship is built on a type of trust that is based on the expectation that each team member can depend on each other to act in a way that reflects their expertise, as well as their colleagiality towards each other (Majchrzak et al. 2007).

> *"I have to respect and trust you so that I can help you in what you want"* (crew member)

This view was echoed across a number of interviews and pointed to an understanding of trust as implicated in the shared experiences of the team around individual and group values, embodied competencies, and the patterns of behaviours that determine the commitments of one to another (cf. Brandon and Hollingshead 2004). However, because of the emergent nature of their job, as well as the emergent structure of ambulance units depending on who was on shift when, trust was also dynamically constructed in emergent actions.

> *"We know who of our co-workers are more experienced and who we can depend on, can rely on; we know who are relatively new at the job and not so fit for the job."* (crew member)

> *"Some of our crew members are very very (sic) capable and you can rely on them that they are even able to intubate, to ventilate, to set an IV line and there are others that the only thing I would trust them with is to measure the blood pressure but nothing else."* (intensive care physician)

Evidently, despite the fact that all team members received the same training, some were found to be less able to remain calm and focused on their tasks in more difficult incidents. So, depending on who was on duty when and how severe an incident was, trust on one another's expertise varied (cf. Meyerson et al 1996).

> *"...deep inside, you wish, when such situations come up that you have to cooperate with a certain group of people."* (intensive care physician)

Despite references to such variations in trust across the team, however, we did not find any evidence of incidents whereby a team member was penalized or his/her reputation sanctioned because of poor trust in his/her expertise. In fact, we found evidence of mechanisms intentionally implemented in various subsystems within the PHEMS to protect the team from such sanctions.

Mediating Trust Development by Managing Risk through ICT Use:

The PHEMS was found to record and monitor individual tasks and team outcomes in an effort to enforce canonical practice as defined in the protocols. This helped to make actions visible across the team while distributing accountability to responsible owners of those actions.

> *"Since we are not doctors to make a diagnosis, we send the data to the doctor at the operations center using telematics to get instructions… [For example] in high blood pressure incidents, you will take the patient with a pressure of 200. You can't do anything unless the doctor tells you to give medicine. If he says that, it will be recorded on the radio and you can give it to the patient… This way the doctor [at the hospital] can't say that the patient was already dead when he came. You take the responsibility off you and you give it to the doctor"* (crew)

Thus, the system provided security to the 'limited' expertise of the ambulance crew by enabling them to shift responsibility of their actions to the more specialized doctors at the operations center. By recording the times of all actions and the vital signs of the patient, the system also protected the whole team, including the doctors and the operator at the operations centre, from possible legal disputes with collaborating hospitals.

In one example, during one of our observation sessions of the team at the operations centre, the operator had received a call about an old man who apparently had choked on a fruit nut. After triaging the call, the operator dispatched an ambulance, which arrived at the site eleven minutes later. A while later, we heard the ambulance driver's voice on the radio saying, "we've been waiting here for three minutes and nobody has shown up." Then, after an exchange between the driver and the operator, the latter told us, "they have lost the 'golden time'". The relatives of the old man eventually reached the ambulance, but it was too late by then. "We have performed all possible actions but we cannot get a pulse nor any breathing," the ambulance driver's voice on the radio echoed. The operator responded, "CPR, oxygen and straight to the hospital." On the operator's computer screen the incident details read (vital signs were not recorded because the patient was already dead):

> *Call: 15:42*
> *Arrival: 15:53*
> *Departure: 16:04*
> *Description: Choke*
> *Code: RED*
> *Comments: The patient was dead when the ambulance arrived – P1 [dead]*

This was a horrible outcome, but one that the team was not to be blamed with. However, we had been informed of other such incidents, which were seriously disputed as to the accountability for the death of the victim and which eventually ended up in court. In fact, the director of NCEC Crete told us that the PHEMS was implemented to account for such potential disputes by providing enough security to the team to do their job without getting into legal trouble. He believed that by enforcing the protocols through the system, the team would act as they were supposed to, while trusting one another to perform according to their training and expertise. This view was confirmed to some

extent in the majority of interviews. However, such reliance to shared cognitive models was questioned in the coordination of expertise in complex and difficult incidents.

Coordination of Expertise

Improvization and Bricolage Builds on Shared Models and Routines

Previous studies on high reliability organizations have pointed out the importance of shared cognitive models in the coordination of expertise (Bigley and Roberts 2001; Roberts 1990a; 1990b). However, they have also stressed that, improvisation and bricolage follows after intense periods of centralized efforts to routinize certain cognitive models on organizational members (Weick 2001). That is, improvization builds on routine (Berliner 1994) and the experiences of the team in dealing with various emergency incidents.

In the case, the NCEC Crete depended on their shared group models encoded in the computerized protocols to respond to emergency incidents. These protocols were developed out of the team's previous experience with similar incidents, which fed into the continuous training programs instigated by the director.

> *"The protocol opens, the questions appear, along with the information, the instructions… We developed the protocols and then we installed them in the system… They are made based on our own experience so that they will be practical for us."* (Director)

However, this is not to say that these protocols were always followed blindly. Rather, they provided the ground upon which new incidents could be interpreted, managed and contained. These protocols provided the ground for improvisation and on-the-spot coordination practices.

> *"There is no rule that tells you what to do in every incident. We can't work only by the book. Each incident is different… Yesterday a colleague had given an adrenaline shot to someone that was bitten by something. The young man died. He was 35 years old. He died. Nothing had bitten him of course. It just looked like an allergic shock. The autopsy showed that he had a problem with his heart, megalokardia, narrowing of the aorta. The adrenaline didn't hurt him but ok. The crew did something when they had to, to save him... [but] we are not allowed to give medicine."* (crew)

As it was later explained to us by this crew member, as well as the director in another interview, in such incidents, crew members are supposed to follow some general protocols. However, at the same time, when an emergency incident risks running out of control, they are encouraged to intervene, sometimes in ways that break the protocols (cf. Majchrzak et al. 2007; Meyerson et al. 1996). In some cases, the inevitable (i.e. death) cannot be controlled, but the improvizations of emergency crews are important because they may give a dying patient a second chance.

Mediating Expertise Coordination through ICT:
Aiding the Construction of Running Narratives and Mental Images around Emergent Incidents

The role of ICTs is key in acts of improvisation. For example, by constantly combining distributed data about an emergency incident, ICT's enable the construction of mental images or running narratives, which allow the team to improvise decisions collectively (cf. Blandford and Wong 2004). These running narratives represent the new collective cognitive model of the team and are constructed in situ. In one incident, the Director of NCEC Crete highlighted the way in which ICT's were used to coordinate expertise in a mass accident:

> *"Last week we had a massive accident on the highway between Heraklion and Rethymno involving a passenger bus and a lorry carrying gasoline… When you have a massive accident you are weighing the odds along two scales: on the one hand you have needs, which in this case we couldn't really know in advance but we did know they were many, and on the other hand you have available resources. This scale was constantly changing based on information we were receiving from ambulances that had already arrived at the accident scene as well as our own experience with similar accidents… the GIS helped us coordinate activities by enabling us to identify where exactly each of the ambulances was located... The second thing was that the (telephone-based) system here in the coordination centre helped us to locate hospital intensive care units across the region with available patient beds to which to transfer the patients… Overall we dispatched 6 ambulances with 12 rescue crew members and 6 doctors on the accident site… even though our staff are very*

well trained in moments like those emotions get in the way which may inhibit a clear thinking; many of them were ready to jump into the fire… The role of the coordination centre is this, our cold-bloodedness; that we are outside of the fire; that we have clear thinking of our protocols. When you are on site your blood starts to boil… After having received the first information from the site we painted an image that allowed us to coordinate activity. With that image in mind we kept giving instructions to the rescue staff; we didn't leave them to drift away. (director)

Because of the unexpected and deadly conditions faced by the crew and doctors in responding to the mass accident, emotions such as panic or complete disrespect for danger led to a projected deviation from the protocols. In response to this came the "cold-bloodedness" of the coordination centre and their ability to stay focused and interpret the information sent by the crew on site to help construct a mental image of 'what if' scenarios and relevant actions. However, this leadership from a distance was again negotiated in situ as this physician notes:

"In such cases, when you have to deal with somebody who is almost in a state of panic, the best thing you can do is to give them three, four most, short, very accurate directives... Like, 'check the airway', 'keep the airway open', 'look for a pulse', 'try to insert an IV line'… Usually they can't comprehend and they can't apply more than that… Even the best protocols won't be of any help if you don't understand how and when to put them into use…" (intensive care physician)

In other words, even though the distance of the coordination centre from the accident site helped ensure the effective, cold-blooded, interpretation of incoming, distributed data, the sustained coordination of resources and expertise came about through a combination of protocol-following and the collectively negotiated actions of the team, as those were mediated by various ICTs. These negotiated actions were very much implicated on the cultural and professional dynamics of the team, as those emerged in practice. These dynamics changed as the team structure changed, depending on who was on shift when, the level of experience and expertise they exhibited, but also whether they could rely on one another. There was, thus, an issue of trust in the expertise of one another, as well as in the social interactions among the team. In consequence, these dynamics necessitated improvisation and bricolage in the coordination of the team. In particular, even though improvised acts were performed by all members of the team, it was the director of NCEC Crete and the specialized doctors that acted as bricoleurs, effectively creating order out of whatever resources and expertise were at hand. It was their leadership skills of remaining creative under pressure, as well as being able to provide guidance and to combine resources and expertise into constructive mental images or running narratives that helped to pull order out of nearly chaotic conditions (cf. Weick 1993).

Discussion & Implications

Returning to our research question, our case highlights the way in which sustaining a distributed coordination of expertise over the duration of emergency incidents depends on a tight coupling between shared cognitive models (e.g. triage protocols) and the negotiated actions of the team. These negotiated actions emerge in situ through the cultural and professional dynamics of the team, requiring improvisation and bricolage. Even though these cultural and professional dynamics emerge in situ, the improvisations that the bricoleurs enact to organize emerging contingencies very much depend on an earlier period whereby cognitive interdependencies are cultivated. These cognitive interdependencies help to develop a mutual constitution of models of interpretation and action that allow the bricoleurs to negotiate even unknown and unanticipated situations and to guide the team towards the re-enactment of order (Weick 2001). In these negotiations, ICTs mediate both the construction of meaning as well as the delegation of action in the form of leadership from a distance. Our case shows how various ICTs, from computerized triage protocols, to GIS and radio telecommunications, and telemedicine, inscribed and enforced shared cognitive models in the form of computerized triage protocols. These ICTs were also found to mediate the decisions made by the ream at various points in time (from the operators dispatching ambulance units to the diagnoses made by the doctors) by helping the team to construct running narratives with which to deal with the novelties of emergent incidents.

These findings support recent research in high-reliability organizations by extending our understanding of expertise coordination beyond the traditional focus on shared models and structures towards a recognition of the situated and emergent nature of coordination (Faraj and Xiao 2006; Majchrzak et al. 2007). As our case illustrates, even though some cognitive interdependencies are cultivated during a period of socialization and training, during emergency incidents, emergency management and response is very much an improvised practice with the effective bricolage of key individuals leading the team and coordinating available resources. The very nature of emergency incidents

demands that emergency management and response is situated, emergent and contextualized, as the example of the megalokardia incident and the massive accident illustrate. Certainly, there is a tight coupling between shared cognitive models (e.g. triage protocols) and the negotiated actions of the team in that, improvisation and bricolage build on routine (Berliner 1994; Weick 2001). The coordination of expertise, thus, follows a recognizable logic and is only partially improvised (Faraj and Xiao 2006). However, even these partial improvisations challenge existing epistemic boundaries, i.e. the expertise of a team member, and require effective leadership (bricolage) towards trustful action and the safety of the team (cf. Edmondson 1999). That is, actions are emergent and implicated in swift trust among team members (Majchrzak et al. 2007; Meyerson et al. 1996). In the case, the director acting as a bricoleur, was able to coordinate the improvisations of his 'expert' teammates from a distance while securing the trust and safety of the team by guiding the collective response of the team to the needs of the massive accident and by not letting them endanger their own lives while doing so. There is, thus, a need for on the spot coordination that transcends both cultural and professional dynamics. Such on the spot coordination carries risks for the practices of the team, as well as the wellbeing of patients or victims in emergency incidents. However, with the help of shared cognitive models cultivated in an earlier period of socialization and training (e.g. the culture of philotimo in the case, as well as the triage protocols developed for and by the team), these risks are less difficult to manage and contain. Effectively, the distributed coordination of expertise very much depends on a combination of shared models and on the spot coordination practices. In addition, socialization as expressed through the culture of philotimo contributes to high reliability management by enculturing a collective understanding of expertise (Blackler 1995).

Extending more recent research on TMS theory (Brandon and Hollingshead 2004; Majchrzak et al. 2007), the findings from our case, also explore the role of different technologies in both the socialization and training of different individuals into emergency teams, but more importantly, their transactions during the coordination of expertise. In particular, unlike previous TMS research, our case supports the need for extending TMS theory beyond an understanding of stable group processes towards an understanding of the emergent coordination of expertise (Majchrzak et al. 2007). We also argue that TMS should be extended by focusing on the mediating role of ICT in the cultivation of TMS, the development of trust, and the coordination of expertise. As our case illustrates, ICTs help in the process of exchange, evaluation, and integration of knowledge across a high-reliability organization – what has been previously referred to as perspective taking and perspective making (Boland and Tenkasi 1995). In this process, members of high-reliability organizations are not only helped to develop and strengthen their own knowledge domain and practices (by inscribing TMS in computerized protocols), but also to respond to shifts and fluctuations in their domain by keeping track of who is doing what and when (by recording and monitoring tasks and outcomes through ICT), a necessary component for coordinated action. More importantly, in this process of process of exchange, evaluation, and integration of knowledge, ICTs help members of high-reliability organizations to create a running narrative of the emergent situation including the needs of the situation, available resources and actions performed. "Narratives do not represent a single shared understanding of a domain; rather they represent the multiplicity of events and actions a community is taking, as members are taking them" (Majchrzak et al. 2007:156). These narratives evolve and are mediated through ICTs, helping a high-reliability organization to respond to emergent and novel situations, by restoring the team's sense of canonical practice, the protocols (cf. Boland and Tenkasi 1995). For example, the operators/dispatchers in the case interpreted and confirmed the activities of the ambulance crews and the changing condition of patients from the moment they were picked up to the moment they were delivered to a hospital. The specialized doctors also had to intervene in the activities of the crews giving them guidance but also protecting them from dangers not accounted for on site due to the "blinding emotional state" the crews often find themselves in when dealing with emergencies, as one crew told us. In other words, individual improvisations were bricolaged by leading individuals back to canonical practice, the protocols, in an effort to contain emergent (often deadly) risks. In these situated, emergent and contextualized activities and interventions, ICTs record the collectively produced running narratives and feed them back into the TMS of the team. These feedback loops complete the cycle by becoming part of the new training and socialization practices of the team. To repeat an earlier quote by the director of NCEC Crete, "*We developed the protocols and then we installed them in the system… They are made based on our own experience so that they will be practical for us.*"

In conclusion, this paper provides a conceptual and empirical understanding of the distributed coordination of expertise over the duration of emergency incidents and makes two key contributions. First, it supports more recent research in high-reliability organizations by providing empirical evidence of the situated and emergent nature of coordination, thus, extending our understanding of expertise coordination beyond shared models and structures. Second, it extends TMS theory beyond an understanding of stable group processes and towards an understanding of the emergent coordination of expertise with a particular emphasis on the role of ICT. Our contributions are based on insights gained from a single site and, thus, may be limited. Our primary goal was to understand how pre-hospital

emergency services in a region in Greece coordinated expertise over the duration of emergency incident. Future research is, thus, needed to substantiate the extent to which our extensions to TMS theory are generalizable to other high-reliability organizations.

References

Argote, L. *Organizational Learning: Creating, Retaining and Transferring Knowledge*. Kluwer Academic Publishers, Boston, MA, 1999.

Austin, J. R. "Transactive Memory in Organizational Groups: The Effects of Content, Consensus, Specialization and Accuracy on Group Performance," *Journal of Applied Psychology* (88), 2003, pp. 866–878.

Barling, J., C. Loughlin, and E. Kelloway. "Development and Test of a Model Liking Transformational Leadership and Occupational Safety," *Journal of Applied Psychology* (87), 2002, pp. 488–96.

Berliner, P.F. *Thinking in Jazz: The Infinite Art of Improvization*. University of Chicago: Chicago, 1994.

Bigley, G. A., and Roberts, K. "The Incident Command System: High Reliability Organizing for Complex and Volatile Task Environments," *Academy of Management Journal* (44), 2001, pp. 1281–1300..

Blackler, F. "Knowledge, Knowledge Work and Organizations: An overview and Interpretation," *Organization. Studies,* (16), 1995, pp. 1021–1046.

Blandford, A., and Wong, W. "Situation Awareness in Emergency Medical Dispatch," *International Journal of Human-Computer Studies* (61), 2004, pp. 421-452.

Brandon, D. P., and Hollingshead, A. "Transactive Memory Systems in Organizations: Matching Tasks, Expertise, and People" *Organization Science* (15:6), 2004, pp. 633–644.

Cox, S., Jones, B., and Collinson, D. "Trust in High-Reliability Organizations," *Risk Analysis* (26:5), 2006, pp. 1123-1138.

Edmondson, A. C. "Psychological Safety and Learning Behavior in Work Teams," *Administrative Science Quarterly* (44:4), 1999, pp. 350-383.

Faraj, S., and Xiao, Y. "Coordination in Fast-Response Organizations," *Management Science*, (52:8), 2006, pp. 1155-1169

Golden-Biddle, K., and Locke, K. "Appealing Work: an Investigation of How Ethnographic Texts Convince," *Organization Science* (4:4), 1993, pp. 595-616.

Hofmann, D., and A. Stetzer. "A Cross-Level Investigation of Factors Influencing Unsafe Behaviors and Accidents," *Personnel Psychology* (49), 1996, pp. 307–39.

Hollingshead, A. B. "Communication, Learning, and Retrieval in Transactive Memory Systems," *Journal of Experimental Social Psychology* (34), 1998, pp. 423–442.

Kanawattanachai, P., and Yoo, Y. "The Impact of Knowledge Coordination on Virtual Team Performance Over Time," *MIS Quarterly*, (31:4), 2007, pp.783-808.

Kouroubali, A., Vourvahakis, D., Tsiknakis, M. "Innovation Practices in Emergency Medical Services in Crete", Bamidis, P.D., Bath, P., Egalestone, B., and Sotiriadou, A., (eds), *Proceedings of the Tenth International Symposium on Health Information Management Research*, Thessaloniki 22-24 September, 2005, SEERC, Greece.

Langley, A. "Strategies for Theorising from Process Data," *Academy of Management Review* (24:4), 1999, pp. 691-710.

Levine, J. M., and Moreland, R. L. "Culture and Socialization in Work Groups," In L. B. Resnick, J. M. Levine, & S. D. Teasley (Eds.), *Perspectives on socially shared cognition*, Washington, DC: APA Press, 1991, pp. 257–279

Lewis, K. "Measuring Transactive Memory Systems in the Field: Scale Development and Validation," *Journal of Applied Psychology* (88:4), 2003, pp. 587–604.

Liang, D., Moreland, R., and Argote, L. "Group versus Individual Training and Group Performance: The Mediating Role of Transactive Memory," *Personality and Social Psychology Bullettin* (21), 1995, pp. 384–393.

Majchrzak, A., Jarvenpaa, S.L., and Hollingshead, A.B. "Coordinating Expertise among Emergent Groups Responding to Disasters," *Organization Science*, (18:1), 2007, pp. 147 – 161

Meyerson, D., Weick, K. E., & Kramer, R, 1996. "Swift Trust in Temporary Groups," In R. M. Kramer & T. R, Tyler (Eds,), *Trust in organizations: Frontiers of theory and research*, Thousand Oaks, GA: Sage, 1996, pp. 166-195

Moreland, R. L., and Myaskowsky, L. "Exploring the Performance Benefits of Group Training: Transactive Memory or Improved Communication?" *Organizational Behavior and Human Decision Processes* (82), 2000, pp. 117–133.

Pidgeon, N. "Safety Culture and Risk Management in Organisations," *Journal of Cross-Cultural Psychology*, *22*, 1991, pp. 129–140.

Roberts, K. H. "Managing High Reliability Organizations," *California Management Review,* 1990a, pp. 101–13.

Roberts, K. H. "Some Characteristics of High Reliability Organizations," *Organization Science* (1), 1990b, pp. 160–77.

Selznick, P. *Leadership in Administration*. Harper & Row: New York, 1957.

Shrivastava, P., and Mitroff, I. "Enhancing Organizational Research Utilization: the Role of Decision Makers' Assumptions," *Academy of Management Review* (9), 1984, pp. 18-26.

Thayer, L. "Leadership/communication: a critical review and modest proposal," In Goldhaber, G.M., and Barnett, G.A., (eds.), *Handbook of Organizational Communication*, 1988, Norwood, NJ:Ablex, pp. 231-264.

Wegner, D. M., Erber, R., and Raymond, P. "Transactive Memory in Close Relationships," *Journal of Personality and Social Psychology* (61:6), 1991, pp. 923–929.

Weick, K.E. "Organizational Culture as a Source of High Reliability," *California Management Review, (29: 2*), 1987, pp. 112-127.

Weick, K.E. "The Collapse of sensemaking in Organisations: The Mann Gulch Disaster," *Administrative Science Quarterly* (38:4), 1993, pp. 628-652

Weick, K.E. *Making Sense of the Organization*. Blackwell Publishing, 2001.