Leveraging and Limiting *Practical Drift* in Emergency Response Planning

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Abstract

A knowledge gap exists between what emergency responders know from their direct experience and what emergency planners know from analysis and reflection. The theory of practical drift suggests that shared understanding between planners and responders may break down as local response practice adapts and evolves with respect to static planning knowledge. Here we discuss how practical drift impacts emergency preparedness and, using Schön's theory of reflective practice, describe how design of collaborative technology might help mitigate this knowledge disparity. We draw on two field studies, one national, and one at the local level, to illustrate dimensions of the problem space.

1. Introduction

Emergency planners and emergency first responders are responsible for two different but obviously related tasks. Planners collect information from a wide variety of sources including handbooks and manuals, simulations and exercises, meetings and other collaborative events, and through reflection on their own experience. The knowledge generated from planning tasks is meant to inform practice, to help guide and direct the activities of police, fire, medical, and other service members who respond to emergency events.

An especially important planning task is constructing mechanisms for coordinating multi-agency response, setting up lines of command, control, communication, and intelligence (C3I) to help ensure smooth integration of the disparate people and equipment that are activated in response to more significant crises [5, 7, 8]. Though much attention has been given to this problem of interagency coordination, less work has considered intra- and interagency knowledge sharing issues, especially between groups separated by organizational hierarchy and function.

The members of emergency response and other high reliability organizations (HROs) identify closely with their profession and especially those with whom they work directly. The process of enculturation into these professions is characterized by trust-building between close-knit groups of first responders, who value personal reliability in the field above conformance with more abstract organizational norms, such as policies and sanctioned procedures developed at the planning and command level [12]. Indeed, this level of bonding between those engaged in dangerous occupations seems indelible in the ethos of these organizations, especially in the aftermath of September 11th. As analysis of the response to that disaster showed [13], however, inadequate communication and the resulting lack of shared knowledge between planners and first responders can exacerbate the already extreme danger posed by such events.

This paper explores the knowledge gap between emergency preparedness planners and emergency fist responders. This gap is framed as an organic problem, necessarily arising from organizational structures that in other ways optimize emergency response operations. We apply the theory of *practical drift* [17] to describe the danger of allowing local practice to move away from the prescriptions arising from considered, reflective analysis and planning. We contrast this perspective against the acknowledged value of allowing emergency response personnel to improvise and adapt to situations they experience in action [1, 14, 19].

The paper presents results from two case studies that exemplify the problems of resolving practical drift with the reality of indigenous knowledge. We use Schön's theory of the reflective practitioner [16] to help develop ideas for the design of collaborative technology to address the identified knowledge gap and knowledge sharing issues. Finally, we lay out a set of principles for designers of technologies in the emergency response domain, and in other HRO domains where closer integration of planning and activity-based knowledge can make a real difference to group and organizational effectiveness.

2. Practical Drift

The theory of practical drift [17] emerged from the work of Scott Snook who analyzed the root causes of a friendly fire incident in which two U.S. Army Black Hawk helicopters were shot down by Air Force F-15s while on routine patrol over Iraq. The theory posits that though organizations develop plans and set procedures for dealing with crises and dangerous scenarios, these plans and procedures are subject to local modification as those charged with implementing them find ways to work around

plan aspects that impede fluid performance of work tasks. Drift occurs in the seams between the organizational, group, individual, and technical dimensions of a problem space, and especially between those charged with planning and policy making and those who implement these in practice. Issues arise when these local improvisations evolve steadily further from the rationale behind set plans and lose some of the benefits of reasoned reflection, such as safety. In addition, local practitioners experiencing practical drift lose the benefits of expert planning done by experienced, senior emergency response personnel.

Practical drift describes a decoupling of task design from local realization of activity. This drift is not only dangerous, as in the case of friendly fire incidents, but knowledge inefficient as in most cases the wisdom derived from senior analysis and reflection on lessons learned is diluted not only in adaptive, but in maladaptive ways. The most critical scenario is when different groups of local responders are asked to work with each other under the assumed umbrella of shared policies and procedures, for example, in response to the 9/11 attacks or, more recently, the large scale emergency response to a South Carolina train wreck and subsequent chlorine gas leak [6]. In these cases, practical drift becomes especially dangerous as groups are asked to shed their locally evolved practices and to re-engage with global plans and procedures, all in an environment of intense activity and stress [21]. Snook's analysis is a call for tighter coupling of planning, procedure design, and policy development with the realities of practice in environments that are often harsh and dangerous.

3. Evolution & Adaptation

Research in computer-supported work suggests that one of the unintended consequences of introducing collaborative technologies to support work is that these technologies necessarily constrain the form that work takes. Seminal in this research stream is Suchman's [19] work exploring the relation between explicit, structured knowledge, in the case of the knowledge needed to populate a help system for advanced copy machines, and the situated, tacit knowledge that seemed to be employed by users of these machines. Her key finding was that some sort of embodied tacit knowledge, rather than set-piece plans and strategies, was generated and/or put to use in the course of highly goal-directed, situated behaviors. Since then many have found similar results in their studies of the relation between localized practice and the from-the-top-down plans that putatively describe this work.

Button [1], for example, argues that information technologies to support distributed work over-constrain or over-determine the form that work can take and thus result in underutilization of these technologies, or utilization that deviates, sometimes wildly, from the intentions of the technology designers. This is the other side of practical drift; plans, procedures, and the technologies developed to reify them are often ill-suited to the tasks they are designed to support and the workarounds developed by local responders are often optimizations within the constraints these technologies impose.

Orr [14] describes how copy machine technicians develop a range of improvisational, collective techniques to carry out their work. The techniques are improvisational in that they represent workarounds with respect to often poorly documented procedures developed and published by the device manufacturer. They are collective in that they involve the sharing of stories among the members of a close, local community of practice, collocated technicians who swap tips, tricks, and parables informally between themselves. By ignoring the technical knowledge embedded in these local cultures of practice, or even worse, working to diminish them as functional entities, organizations fail to leverage an important source of expertise for planning knowledge-intensive tasks.

A common theme running through studies of local, situated activity and improvised work practices is that these improvisations have a beneficial effect on the ability of personnel to succeed, to be effective, and to be satisfied with their work situation. All of these positive attributes contribute in obvious ways to the overall effectiveness of the organization towards its goals, and at the same time make for a more progressive work environment. The goal of this paper is to point out benefits derived from consideration of the other side of this argument, that is, the benefits gained from development of and adherence to a shared set of operational principles as embodied in plans, policies, and in procedures.

4. Emergency Planning & Response

Emergency response planning is concerned with ensuring that a community has the necessary people, equipment, and procedures to respond effectively to emergencies and disasters of varying scale. Whether natural or man-made, emergencies are almost always sudden and unpredictable events. Emergencies are knowledge intensive, requiring expertise in a range of skills and sciences in order to formulate an effective response. The National Response Plan [20], for example, names 12 essential emergency functions including: transportation, communications, public works and engineering, firefighting, information and planning, mass care, resource support, health and medical services, search and rescue, hazardous materials, food, and energy. Each of these areas itself is informed by a range of sciences and specialist disciplines, and emergency planners must be familiar enough with each to understand the nature of the events they prepare for and the tools and techniques brought to bear to manage their consequences.

Emergency preparedness and readiness emerges from three primary activities: planning, training, and response

exercises [7]. The knowledge informing execution of these activities is sometimes derived from practice, but it is as often derived from best guesses of what might happen and what might constitute effective mitigation of the emergency event's effects. With respect to the relatively new but distinct terrorist threat, for example, we in the United States have little direct experience to draw on when planning effective mitigations and responses to these emergencies. One common attribute of emergencies is that they all present significant information and knowledge management challenges. In the case of a house fire, responders want to know where potential victims may be located, whether or not the house contains any special hazards, such as propane tanks, the materials techniques used in construction, weather, especially prevailing winds, and so on. As the scale of the emergency increases, information and knowledge management challenges increase exponentially. The creation of the Federal Emergency Management Agency (FEMA) in 1979 was a direct response to the acknowledged need for co-location and closer alignment of the knowledge possessed by those responsible for crisis preparedness [9].

Events such as the recent train wreck in Graniteville, S.C., in which extremely dangerous chlorine gas was spilled, generated an immense and complex emergency response. Over 98 emergency organizations were called out to this event creating significant challenges of response coordination [6]. Such events are opportunities not only to employ existing knowledge, but also to generate and capture new knowledge about what works best 'on the ground' during a crisis response. Some significant challenges, however, stand in the way of effectively capitalizing on these knowledge-generating opportunities.

Emergency response organizations are designed to scale in direct proportion to the threat of the emergency; first response is typically handled by the services of a town or city, but can escalate to the county, region, state, and federal levels. In urban areas first responders are almost exclusively professionals, employed full time to man a firehouse, patrol the streets in a squad car, or respond to medical emergencies. But in more rural areas scaling occurs with even relatively minor emergencies, such as when volunteer firefighters and emergency medical technicians are called upon in response. This scaling results in *mode escalation* and shifts in knowledge requirements as the familiar environment of a single fire truck and team gives way to negotiated teamwork with other trucks, departments, and agencies.

A key function of emergency response personnel is to bring coordinated expertise and knowledge to situations that threaten lives and property. It is argued that the most important role of emergency response organizations is to act as repositories for the accumulated knowledge needed to effectively respond to these threats [9]. Lindell and Perry [9] claim six key factors as the most important aspects of emergency response: time, anticipation, uncertainty, complexity, criticality, and assumptions. The effectiveness of an emergency response is highly time dependent. Saving lives and otherwise limiting the damaging effects of a fire, accident, or spill is largely a function of the time it takes to enact the response. Anticipation involves correctly inferring the most likely secondary dangers arising from the effects of the primary event, for example, anticipating a chlorine plume from a rail freight disaster.

5. Plan-Action Breakdown

In the sections following we present two case studies from emergency preparedness planning. The first is a study of anti-terrorism and force protection (ATFP) planning at U. S. Marine Corps installations. The second is of emergency response planning in the Centre Region of Pennsylvania. The first represents emergency planning on a national, highly distributed scale, while the second describes a local, semi-rural sceenario. Though the two have very different missions, priorities, and constraints, they also share some attributes related to how they collect, integrate, make sense of, and then disseminate the different kinds of knowledge important to their respective tasks. Each provides examples of practical drift between planners and actors in the field.

5.1 Anti-Terrorism/Force Protection

Since spring of 2002 we have been working with the U.S. Marine Corps on a methodology, decision model and cognitive support system to be used by installation commanders and their staffs when making resource allocation decisions for anti-terrorism/force protection mitigation projects. The model consists of three major components: facility prioritization, determination of mitigation project utility, and optimized resource allocation. These three, along with supporting services (e.g., security, management of standing data, etc.) have been implemented as a distributed, web-based cognitive support system.

The ATFP model and cognitive support system were evaluated using informal design reviews, focus group design reviews, and more formal, one-on-one guided walkthroughs. Design reviews were used early to clarify and refine understanding of the domain and to develop strategies for providing cognitive support. Once a working prototype of the system was complete, we conducted system usability studies with prospective users in the field.

One finding from our field study was the extent of heterogeneity in the target user population. Prospective users include active duty Marine officers and non-commissioned officers, Naval officers who provide civil engineering support to Marine Corps installations, and civilian employees of the Marine Corps, largely in the area of facilities planning. Another dimension along which prospective users differed was in their role as ATFP planners versus first responders. Almost immediately

apparent was the wide disparity between the focus of planning personnel, and the provost marshal's office (PMO) and crash-fire-rescue (CFR) personnel who work in the field to actively manage threats and respond to crises that occur at the installations. Accidents involving military aircraft (both fixed and rotary wing) are relatively common, given the training mission of most U.S.-based Marine Corps air stations, and the demands of providing close physical security at bases that have significant civilian traffic in and out each day put significant pressure on military police resources.

5.1.1 ATFP Planner Knowledge

Marine ATFP planners possess significant knowledge of the anti-terrorism issues facing a particular installation as well as the stance of the Marine Corps and Department of Defence towards how best to manage and mitigate perceived national threats. Installation anti-terrorism officers (ATOs) regularly meet – each installation has at least one ATO – to discuss doctrine and to obtain advice from government contractors and consultants who provide specialist knowledge from their ATFP planning experiences at other military and government facilities. Often though, they have less knowledge and experience with the specifics of what to do about issues they have identified as important or problematic. For solutions, planners typically rely on specialist facility, civil engineering, PMO, and CFR personnel, who possess the 'how-to' knowledge but are disconnected from the rationale driving initiation of a particular ATFP project.

"But when it comes to the actual physical construction stuff like that you know, then I defer to [facilities person] and his guys over here because they've been through the schools. And I mean I run the program as opposed to getting down into the construction side." (Anti-Terrorism Officer)

Especially important to planners is the ability to integrate knowledge from functional specialists into a justification for decision making. Adherence to plans provides a sort of audit trail for actions in the field back to the original justifications for those actions.

"It helps the CO when we do his risk assessment you know, we think this is what is out there facing you as a threat, these are where we think you're vulnerable, this is how we want to address the vulnerabilities. Part of it he makes a gut decision but also if you can give him hard number crunching you know, to support that decision, it ties right into the risk assessment process…" (Anti-Terrorism Officer)

Within the community of planners there are knowledge disjunctions between specialists from different planning areas. These differing skill and knowledge levels and the inevitable misinterpretations that occur between them may affect the coherence of a given plan and play a part in the ability of local operators to implement them.

"An ordinary community planner or an engineering technician will not know or will not really get into this, really not get involved. The budget, the budget officer to finance officer, the engineering director, would be getting involved in this. Also, the assistant to the engineering director would be involved with this cause he would involved him because he doesn't have that much to support him, so he would be involving this person. But an ordinary community planner will not be getting involved with this." (Facilities Planner)

A problematic dimension of ATFP planning in the military especially is the transience of those responsible for the planning task. Military officers typically rotate in and out of positions (billets) every three years. This means that the high-level, strategic knowledge they acquire over the course of a three-year tour as, for example, an ATO, is largely lost when they move on to their next billet.

"But I'll have been doing this for three years by the time I retire and I would say, Marine Corps-wide, that's the exception. Now if they're smart, you know, we recommend it to them, you know, you get my position probably civilianized so that you can get continuity. It takes time to learn all these things and build up those things." (Anti-Terrorism Officer)

Planners are particularly interested in the kinds of standards and best practices applied by other organizations for emergency response. In some cases this is simply because that is all the knowledge they have at their disposal to use as a guide for their planning activities. In others it is recognition of the value of emergent practices that have been identified, reified, and proven effective across multiple emergency response domains and scenarios.

"Yeah, I think there ought to be a standard you know, for consistency you know, so that the East Coast isn't going off on their merry way you know, and they come up with answers that would be you know, diametrically opposed to how we think of things out here on the West Coast." (Anti-Terrorism Officer)

The advantage of planning and the value embedded in the planning process is largely derived from the analytic and reflective nature of the planning task. Planners necessarily envision. Though are also guided by the kinds of scenarios they have experienced in the past. This kind of envisioning involves putting together thought experiments based on what they think might happen, what might constitute an effective response to such an event, and, importantly, why.

"…it can be there to explain you know, just what these various things are just so you know the benefits. You can make sure the people know what you're trying to accomplish with those things." (Anti-Terrorism Officer)

5.1.2 ATFP Responder Knowledge

Anti-terrorism planners make assessments of asset priority based on both pre-established and ad hoc criteria sets tuned to their particular geographical location and mission profile, as well as to the special priorities of the installation commander. Their assessments of the relative weights of these criteria, for example, the population density at different installation facilities at different times of the day, may not reflect the local knowledge of those personnel such as the PMO who patrol the entire installation night and day and are more intimately familiar with the ebbs and flows of enlisted and NCO personnel,

who make up the larger proportion of the base's population and who are arguably at greater risk.

In the quote below, for example, an officer from the provost marshal's office, the military police, discusses how a blast wall constructed in front of the base headquarters building came from someone of a higher echelon within the Marine Corps.

"Here on this base, somebody of my rank and experience wouldn't be the one to dictate that that needed to be done. I'm sure that blast wall either came from the CO of the Air Station or maybe even headquarters Marine Corps identified that as a need."(Provost Marshal's Office - Military Police)

Indigenous knowledge is crucial to effectively managing response to emergency events. One problem with information technologies is that in abstracting away 'unimportant' details of the entities they model, information important to responders but not, conceivably, to emergency planners, is lost in the design of data structures. One participant, for example, commented on how geographical information systems, while useful in may regards, often fail to represent information important to both planners and responders when making decisions.

"You can't for example, keep a vehicle away from a gas station. The whole intent is to get the vehicle right up next to the gas pump." (Facilities Planner)

Often plans are based on probabilistic thinking about what might happen and the effective response to the most likely sorts of events. Emergencies tend to each have their own unique character, however, and only when one occurs does the appropriate course of action become apparent. These planners therefore make decisions that they believe are correct in the local context, and which keep them out of trouble within their management hierarchy.

"But if I had to, I'd have to go to the General and say, General, I want to shut down that road because that's what DOD says to do. But I look at it and I say, do I really want to bother the General. Well, considering the way the buildings are constructed, probably not." (Anti-Terrorism Officer)

One barrier to effective communication and knowledge sharing between different levels and functions is the chain-of-command structures that exist not only in the military but also common in most emergency response organizations, both fire and police departments have sergeants, captains, and, of course, chiefs. While the chain of command is a time-test means for ensuring orderly functioning of large and complex organizations, they also serve to increase the communicative distance between those tasked with carrying out the basic work of the organization and those responsible for planning that work and how individuals and functional groups are integrated into an effective whole.

"No. I mean I could, I mean if I, any Marine, if they saw something that they felt needed to be corrected or need to be done, they could bring it up and go up the chain of command. But if I went to somebody and said, hey you know, I think we should put a blast wall in front of the fuel farm over there you know, I mean I don't know that anything would be done about it." (Provost Marshal's Office - Military Police)

5.1.3 ATFP Knowledge Sharing

Despite the apparent lack of knowledge flow between ATFP planners and responders, study participants often expressed a desire to change this situation, to improve knowledge sharing both between different specialties and between specialties at different installations. For example, we discovered that an effective means for translating different perspectives was through the use of detailed scenarios coupled with the planning models developed to address the problems they describe. We embedded a scenario editor in the anti-terrorism planning system and found in successive walkthroughs that both planners and responders wanted tighter and tighter integration of scenarios with model parameters and design rationale, the what and why respectively of the models created to address the specifics of the problem domain as captured and described in the scenarios.

The original intention behind including a scenario editor and browser was simply to capture some of the specific situations understood by both planners and responders as germane to the anti-terrorism planning and response tasks, but their functionality evolved into something more important. By moving between scenarios, which describe the concrete situations that many USMC planners and responders are familiar with, and the more abstract decision models and model parameters, we saw that users of the system were better able to understand how a particular planning model, and, importantly, the system's abstract representation of the model, was designed to function.

This movement between the abstract and the concrete, back and forth between scenarios and models, turned out to be a productive channel for information exchange between people in different roles and ranks within the Marine Corps organization. Co-reflecting on scenarios helped to evolve decision models while reflection on decision models helped to better understand the salient elements of the scenario from which it emerged. At the same time, reflecting on both and their representation within the ATFP system served as a mechanism for formative evaluation of what was essentially still a design project.

5.2 Centre Region Emergency Response

On a more local level, we have conducted a study of emergency management practices in Centre Region, Pennsylvania. Our approach was to establish a partnership with the local emergency management coordinator. Using ethnographic methods, we observed both public and private emergency preparedness meetings for the local area. Some of the meetings were led by the local coordinator and in others he acted as a participant, all of them provided an internal view of the local emergency activities.

Centre Region is located in rural, central Pennsylvania and includes six municipal townships. It is the home of

Penn State University with 40,000 students and about 10,000 faculty and staff employees. The rural location does not suffer many large-scale emergencies, but the high concentration of people necessitates emergency preparedness.

The local emergency management coordinator plays a unique role, as he is the emergency manager for both the University and the surrounding townships. This means that he is responsible for potential hazards both on and off campus and is in charge of developing and managing appropriate emergency plans. He also acts as a bridge between University and town emergency personnel and resources. For instance, he regularly meets with the local fire chiefs to discuss fire issues related to campus. For example, he was instrumental in having the regional townships' generator regularly maintained and stored with the University's generators.

5.2.1 Centre Region Planner Knowledge

The local emergency coordinator was previously a county emergency manager in Florida. For more than 10 years, he interacted with the University of Florida and dealt primarily with hurricane disasters. His approach to emergency planning involves a process of taking advantage of the existing policies and procedures in place. He terms his role as "connecting the dots", or bringing together these different, current emergency practices. To do this, the local emergency management coordinator respects local individuals' expertise and incorporates these people in the planning efforts. He does not claim to know how to fight a fire or deal with a hazardous material, leaving these skills to the first responders. Rather, he brings the fire chiefs, police chiefs, and the emergency medical services (EMS) coordinators together to share agency-specific information and coordinate actions.

Meetings with agency leaders are not always as successful as one might hope. Emergency planning groups often need to meet many times to agree upon a shared plan. Different agencies bring different issues and the group often needs significant time to debate issues and make decisions. For instance, the local emergency management coordinator researched and drafted an emergency plan for the University's football stadium. The plan was reviewed with each of the local fire chiefs individually and then presented at a fire chiefs association meeting. There were very few questions at the meetings because the football season was imminent, but the group requested an exercise be conducted after the upcoming season and prior to the next season. As the local emergency management coordinator prepares for this exercise, he realizes that the fire chiefs may in fact not know the details of the emergency plan. The group regularly reviews the plan and, more importantly, reassesses the decisions it encompasses and disseminates this information. The local emergency management coordinator's reasoned and systematic plan is not assumed to be accepted, let alone practiced, without this constant process of information sharing.

Another example of the emergency management coordinator's efforts relate to the local airport. The coordinator regularly attends the emergency planning meetings at the airport. The University Park Airport is small; it has one runway and no air traffic control tower. To be prepared for an emergency event at the airport, the airport director arranges planning meetings and invites leaders from local emergency response agencies, including the 911/Emergency Communications Center directors, fire chiefs, police chiefs, ambulance service directors, and the local FBI agent, as well as the expert, local emergency management coordinators. This group collaborates to write and revise the airport emergency plan.

During our study, we observed the monthly meetings at the airport. The announcements for the planning meetings occurred through email a couple days beforehand and the group convened in a conference room. There were no personal or handheld computers at the meetings, but some took notes with pen and paper. At these meetings, the group worked together to organize and conduct a "functional" exercise, which was also observed. A "functional" exercise is simulated exercise in which the first responders walk through their response to an event. They are situated in different physical locations and use landline telephones, portable radios, and cell phones to communicate as they would in an actual event response. At the airport, this exercise was used to evaluate and improve interagency communication among first responders. It also acted as a test of the existing emergency plan for the planning committee. It showed whether the first responders knew the plan they had written, whether the plan worked as desired, and how the plan might need to be changed.

5.2.2 Centre Region Responder Knowledge

Many of the first responders in Centre Region are volunteers. They belong to organizations, such as the all-volunteer fire department or the University EMS team. They wear emergency pagers and radios and give their time when the need arises. In talking with these first responders it became clear that they are not familiar with the local emergency management coordinator. This may be in part because the role is new, but also because they receive their assignments from an agency leader, such as a fire chief. If they happen to know the local emergency plans, it is because their agency leader has shared it with them.

The "functional" exercise at the airport demonstrated how first responders have different perceptions of emergency plans and how they improvise during an event. During this exercise there were breakdowns in communication among the first response agencies. This led to a review and subsequent revision of the plan. For example, in the beginning of the exercise the airport fire service anticipated receiving a radio communication

channel from the 911 Center. They planned to use this channel to communicate the initial scene report and inform arriving first responders of how to proceed.

"We were expecting to receive maybe a frequency, a ground frequency to go to, and we actually had to call back and ask." (Airport fireman)

Reviewing the plan, there is a statement that the airport should call 911, but there is no description about how the onsite fire service will establish communication with the incoming responders. This lack of details in the plan and the improvisation during the exercise led to agencies on different channels and a lack of communication.

In another example, a University policeman believed he had established a physical command post for the incident. During the simulated exercise, he announced his arrival at the airport over the radio and informed the emergency dispatcher of the location of the command post. There was a communication breakdown, however, in that he notified the University Police dispatch office and not the county-level 911 communications and dispatch center.

"That was one of the problems, when I first got here I set up command in the staging area, but the unfortunate part of using two dispatch centers for communication, because I don't use Centre County I use [the University]. " (University policeman)

The policeman followed his usual procedures, which were problematic for the multi-agency airport response. This resulted in other first responders not knowing if the command post was set up and, in turn, not knowing where to report. Consulting the plan again, it does not resolve the issue. There is no explanation of how the command post should be established in situations where both dispatch centers are involved.

5.2.3 Centre Region Knowledge Sharing

Centre Region has issues with knowledge sharing, as alluded to earlier. In the Pennsylvania, there are restrictions on making emergency plans publicly available because they are considered to pose a security risk. The state legislation takes the stance that if someone knows the planned response, he/she can undermine it. This causes problems with communicating emergency plans. Only a handful of formal documents are printed in hardcopy, bound, and distributed. These documents sit on bookshelves in the offices of privileged, key individuals. If we disregard the state's position, posting the plans online is also not a reasonable solution. The Internet may not be available in an emergency situation, such as power outage, which could make the most up-to-date plan inaccessible.

The problem of knowledge sharing is exacerbated by the nature of volunteer work. Organizational leaders periodically change and the turn over can be significant for volunteer groups This creates a problem, as each successive fire chief needs to be made aware of the emergency plans.

The airport "functional" exercise reveals how emergency planners in Centre Region are working with first responders to improve their documented plans. Through this exercise, the planning committee experienced firsthand how the local first responders communicate during an event. This revealed problems with both the current plan and the first responders' approaches, pointing to ways to develop a more effective plan. Additionally, the exercise gave the first responders an opportunity to comment and reflect on the airport plans. The open discussion at the end of the exercise allowed everyone who attended to offer criticisms and suggestions for improvement.

6. Discussion

One of the contributors to the problem of practical drift relates to the essential nature of plans themselves. Plans need to be flexible enough for effective local improvisation, especially when the improviser is trained and has the authority to make important local decisions, while still providing useful guidance to responders. The challenge is to find the 'sweet spot' between reasoned, reflective planning and the need for responders improvising at the scene of an emergency. In the ATFP case we found that sometimes plans are *designed* to be vague enough to allow for practical drift in the form of local adaptation.

In both of the cases discussed here we see examples of a planning organization clearly concerned with the state of emergency preparedness for their respective organizations, but also problems with whether and how the knowledge encapsulated in their analyses and plans is communicated to different emergency response echelons. Both point to the potential for practical drift to occur, though our evidence is so far largely inferential. Nonetheless, our reading of other, related domains and experiences with specific incidents in the cases reported point to the potential for practical drift to play a role in the effective transference of knowledge between different groups working in emergency response.

6.1 Co-Reflection

We see a useful perspective on the related issues of practical drift and indigenous knowledge in Schön's [16] theory of the reflective practitioner, in particular, in the idea of planner/responder co-reflection as a response to the knowledge sharing needs of these disparate groups. As a design response we suggest that collaborative technologies may play a key role in helping to realize this co-reflection. Especially important in the latter is the idea of integrating 'horizontal' technologies, the day-to-day information technologies supporting e-mail, document production, and operations databases, among others, with the more specialized 'vertical' applications that can help cross organizational and specialist boundaries between disparate groups.

Work practices that evolve away from considered plans and policies lose some of the valuable knowledge embedded in these plans while at the same time picking up new knowledge from the local particulars of the activities

the plans are designed to support. Between these two points exists a union of synthesized knowledge that in combination represents the most effective fusion of differing expertise.

Schön characterizes the professional practice of reflection-in-action as a dialectic between the problem's context, the problem-solver's prior experience, the materials of the immediate situation, and the results of informal, personal micro-experiments that lead to a solution. He argues that those who confront and work through difficult, ill-structured problems do so mindful of the broad and heterogeneous array of goals, values, concerns and interests that attend the work they do, but that they do not rigidly apply rules or policies to solve the problems they encounter. Instead they artfully negotiate solutions through a dialog, or conversation, with the materials in the problem space.

Schön uses cases drawn from architectural design, psychotherapy, engineering design, scientific research, town planning, and management to exemplify his theoretical positions. Preeminent among these is his description of reflection-in-action, the "embodied knowing" that is dependent on "tacit recognitions, judgments, and skill performances" [15] that largely resist attempts at formal explication. Central to the theory however is that professionals do sometimes stop and reflect more deeply on the features of the problems they address and the candidate solutions they produce. It is these episodes in which problems "talk back" to the professional that are most characteristic and important to the skill development and learning of the reflective practicioner.

Our concern in this paper is with the applicability of Schön's theory to the design and use of information technology to support emergency response planning. Of special interest are tools that may act to bridge the gap between planner and responder knowledge, thereby helping to diminish practical drift while at the same time exploiting indigenous knowledge and feeding it back into the planning cycle. In particular, we are interested in providing emergency response system users with the means to engage in the *"conversation with materials,"* in this case, emergency domain and mitigation resource knowledge, that Schön claims as characteristic of reflective practice.

Two phenomena are central to our ability to deal with these difficulties, *knowing-in-action* and *reflection-in-action*. According to Schön, an expert professional's normal operating mode is based on knowing-in-action where:

"Our knowing is ordinarily tacit, implicit in our patterns of action and in our feel for the stuff with which we are dealing. It seems right to say that our knowing is in our action." ([16] p. 49)

However, situations such as encountering a particularly difficult problem, or experiencing surprise at a particular outcome, result in a change of mode from knowing-in-action to *reflection-on-action*. In these situations, support for analysis becomes the dominant requirement:

"As he tries to make sense of it, he also reflects on the understandings which have been implicit in his action, understandings which he surfaces, criticizes, restructures, and embodies in further action." ([16] p. 50)

Co-reflection [22] refers to practices that transcend individual cognition to include two or more individuals working as a group, actively reflecting together towards establishment of meaning and consequent understanding of a problem or other situation. While Schön's reflective practitioner is typically viewed as an individual engaged in navigating a problem space, co-reflection extends his conception to account for the additional power gained from groups reflecting in and on action towards the goal of improving practice.

Emergency planners reflect *on* action while first responders reflect *in* action. Each group collects and produces knowledge needed by the other to be effective in their designated roles. Such knowledge transfer is however problematic and though there are opportunities to facilitate more effective sharing through the use of information technology, significant challenges exist.

6.2 Plan Rationale

Providing plan users with access to the rationale behind the plans they are asked to implement may be one of the keys to supporting active co-reflection. If local users understand the rationale behind the plans they are asked to implement, they are more likely, we surmise, to understand drift consequences when they decide to improvise locally. Effective improvisation, as in jazz and in fine art, requires mastery of the instrument or materials in use. Capturing and making available to responders the design rationale [10] underlying plans supports understanding one of the key materials attending emergency response. Promoting the use of plan rationales to understand why plans exist and why they are applicable to a given scenario may provide an important tool for closer planner-responder empathy.

Fostering co-reflective practice between planners and responders requires addressing individual and group patterns of behavior that act as barriers for effective knowledge transfer between different organizational roles and units. These include especially the 'stovepiping' that inevitably occurs between groups with different short and long-term goals, and with different frames of reference that guide how they go about achieving these goals. This stovepiping is often perpetuated by information systems that implement organizational boundaries. Such systems, one anti-terrorism planner referred to them as just "Another widget that starts and stops," fail to provide the integration necessary to promote interaction and cooperation between planners and responders.

Providing real-time access to plan rationale may help to ameliorate and even leverage practical drift because these rationales act as information-rich *boundary objects* [18] for

learning, task performance, and results analysis. Implementation of plan rationales as boundary objects could take a range of different forms, from plans and their surrounding discussions posted in *wiki*-style, shared web repositories, to after-action reports produced by responders as a grounding resource for planners. A key facilitating attribute of information technologies is their ability to extend the reach of information resources, to make them more durable and portable between different groups, and to make them more malleable in the hands of each.

Facilitating co-reflection with collaborative technologies designed for communication and shared understanding between different groups may help to both leverage and limit the effects of practical drift. Recall that practical drift describes the steady evolution of the local practice away from set plans, policies, and procedures. Sometimes this drift arises from lack of awareness and transparency on the part of both planners and responders of the intentions and beliefs of the other group. Access to plan rationales may serve to expose the subtleties of an event scenario and its corresponding plan and allow both planners and responders to benefit from the reasoned reflection of others.

The cost and effort of undertaking large-scale emergency response exercises severely limit the important benefits that can be gained from planners and responders working together in the field to assess documented plans and procedures, and to reflect on their rationales. One technology solution that may hold promise in this area is the use of computerized simulations of emergency events scenarios, including simulating the activities of response organizations and the kinds of information flows necessary to ensure smooth group inter-operation [5]. Event scenario simulations augmented with rationale can be experienced as a shared point of co-reflection for planners and responders and may help to expose the specialist knowledge that each group otherwise would not have opportunities to share.

6.3 Reachback & Lessons Learned

Another opportunity for supporting responders in the field with information technology involves two fundamental capabilities: *reachback* functionality to help tap the full base of knowledge resources potentially useful in a crisis, and a *lessons learned* repository to support them bringing back from an incident details of how plans, policies, and procedures performed in action. Realization of either of these opportunities is hampered by the difficulties entailed in designing technologies with the affordances necessary to make them truly usable in field settings. Prototype and example working systems do exist however, such as personal digital assistants that can be loaded with planned evacuation routes, or the location of hazardous materials within a particular building [11].

Military and other government organizations increasingly acknowledge the need for collaborative repositories to act as knowledge stores of corporate memory. The Marine Corps Lessons Learned System (MCLLS), the Army Center for Lessons Learned, and CompanyCommand.com are all examples of knowledge management initiatives designed to capture and communicate knowledge and experiences from field operations between units with similar missions and between field units and command (i.e., planning) officers. These systems are explicitly designed to foster co-reflection on the efficacy of different tactics, techniques, and tools.

Another type of technology employed by military organizations are *reachback* tools that allow forces in the field to access the combined knowledge of the organizations they represent. Reachback systems are essentially mobile information portals that give time-pressed responders in the field the benefit of the analytic, reflective knowledge produced by different research, service, and support organizations within the military.

One final point relates to the importance of tools to enable activity awareness [2, 3] and its role in helping to achieve common ground [4] between planners and responders in the emergency management domain. Planners need awareness of what responders do, what works and what needs improvement based on their experiences in the field. Responders need awareness of how existing plans, policies, and procedures inform how they can implement effective response, and what can be done to improve the fidelity of plans for their own and other response units. As with the other potentially useful collaborative technologies discussed here, additional research and design studies are required to better understand the kinds of affordances most effective for these applications.

7. Conclusion

Emergency preparedness and response plans are important. They represent the accumulated wisdom of those charged with ensuring our safety, and are developed in consideration of the range of capabilities and constraints that affect both what is desirable and what is possible to do in response to a crisis. On the other hand, emergency responders possess local, indigenous knowledge about the tasks they perform, and of the rich contexts they experience in response to crises. Planners collect and analyze knowledge that is rarified and, with the benefit of time and hindsight, reflect on and plan courses of action for first responders. Though first responders have some contact with these plans — through their training, perhaps through meetings, and from field exercises — these are seemingly less important than the experiences they have shared with colleagues. Each group, planners and responders, requires access to the other's knowledge in order to most effectively manage emergencies.

In the background of the emergency planning task is the knowledge accumulated from planners' information gathering and analysis activities, and from their collective

but possibly outdated experience. Planners need responders' indigenous and up-to-date knowledge as the fuel for effective *and* reflective planning practice. First responders know-in-action and reflect-in-action, but at the same time it is critical that they also co-reflect *on-action*, in particular, on the plans, policies, and procedures that require feedback from practice to maintain their relevancy.

This paper explored the problems of bridging planner and responder knowledge requirements and use. We have proposed theoretical perspectives, including those of *practical drift* and the *reflective practitioner* as well as information technology design response to help limit this gap while at the same time leveraging the reasons why drift occurs between different groups. Information technology, may act to help integrate the different knowledge of emergency response planners and responders to the benefit of all who rely on the effectiveness of emergency preparedness planning.

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