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Always Articulating: Theorizing on Mobile and Wireless Technologies

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Through this article we theorize on the nature and effects of articulation work relative to the take-up and use of information and communications technologies (ICT). Articulation work is "work that enables other work": that which links people, processes, and technologies within organizations. Articulation work in organizations is both common and too often invisible from a managerial or budgetary perspective. Drawing on data from a study of the introduction and implementation of mobile computing technologies into criminal justice organizations, we highlight two findings: (1) There exist ongoing but unmet articulation needs present in any organization or work system. (2) Articulation is cumulative. We find, that as work becomes more complex (such as adding new work tasks and using new technologies), there is more articulation needed. These findings raise issues with assessing the costs of articulation on individuals, and making arrangements to accommodate explicit and implicit articulation in organizational work, particularly around the take-up and ongoing use of ICT-based systems.

Keywords articulation, criminal justice, field study, information and communication technologies, mobility, organizations

Here we build on the work of scholars in sociology, social informatics, computer-supported cooperative work, and communications who note that the processes of identifying articulation needs and meeting those needs is one key to organizational longevity and success (Strauss, 1985, 1970, 1993; Star, 1991, 1995; Suchman, 1996; Eschenfelder, 2003; Pollock, 2005). Our premise is that the take-up and uses of new information communication technology (ICT) increase articulation needs for organizations and accordingly we pursue the following question: *How can the ICT-enabled articulation needs of organizations (met and unmet) be detected, explained, and made visible?*

A simple definition of articulation is "work that enables other work." For example, the work done to purchase and configure a laptop, install the correct software, prepare access via controls and passwords, and make it ready for network connectivity is all articulation work to allow workers to access e-mail while away from the main office. Articulation work is a commonly experienced event, as anyone who has ever changed the toner of a printer or copier can relate.

Too often, articulation work is invisible from a managerial or budgetary perspective. Having paid for the laptop and access, it is easy to overlook the time and effort workers invest to make sure they bring the proper cords to power the laptop, keep up with troubleshooting when connections falter or fail, find places to connect, and reorganize life and home time to get to their e-mail. In laying out this simple example, we further note that articulation is neither bad nor good work. Doing articulation work is often worth the time, as it allows one to be more productive. Articulation work can also be needlessly interrupting, as anyone who has had to take care of the paper jam in the copier that someone left without fixing can detail.

We use a study of the take-up and use of mobile computing devices and wireless access by criminal justice personnel[1] to examine articulation. The unexpected and often unmet articulation needs that arise from this take-up and use were unanticipated on the part of the device vendors, service providers, application developers, public safety and local government administrators, and finally by the officers themselves. This serial (and perhaps additive) blindness was at least a contributing factor to the mixed outcomes of the field trial of mobile access to criminal justice computing assets.

Studying the take-up and use of mobile computing in criminal justice work is appropriate for at least four reasons. First, the work of criminal justice officers is (and has been) highly mobile, knowledge intensive, and pervasive

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(Pattavina, 2005). Simply, their work has always been mobile. And, until recently, limitations of most available ICT made it difficult to adequately support these worker's information needs. For example, Manning (1996) has reported on the importance of this work and the large disparity between police officers' information needs and the capabilities of ICT enabled systems to provide them that information.[2] In addition, policing has always been atypically adept at contingency planning, emergency handling, and articulation management. Many of the day-to-day activities of the average police office are articulation management. Third, criminal justice organizations traditionally place an atypically strong emphasis on training and support. For example, officers are regularly scheduled to spend several hours each month for training related to weapons, skills, and procedures. A fourth reason is tied to the technological infrastructure relative to organizational boundaries (Pattavina, 2005). With the increased bandwidth available over third-generation (3G) wireless networks, it becomes possible to deliver data to the criminal justice personnel wherever they are. This change with respect to data access by users has potentially profound implications for organizational strategies in the criminal justice arena.

In sum, criminal justice is mobile work that relies heavily on information systems. The work is done by officers who are used to managing articulation. And with access to higher bandwidth computing infrastructure there exists the potential to make criminal justice work, which has always involved cross-organizational coordination, more seamless.

CONCEPTUALIZING ARTICULATION

Studies on work using an articulation approach explore the unplanned or nonrational aspects of work left out of rational work models. They point to the invisible yet important nature of this unplanned work for the achievement of an end goal. Articulation studies view organizations as fields of social and political struggle and in which actors may often work to achieve multiple, and sometimes conflicting, goals.

The concept of articulation in the workplace we use here draws on the work of Strauss (1985, 1988, 1993), Star (1991, 1995) Suchman (1991), and Eschenfelder (2003). Articulation is "the coordination of lines of work" (Strauss, 1988, p. 87). Articulation work is "a kind of supra-type of work in any division of labor, done by the various actors" (p. 87). Articulation work includes: (1) the merging of numerous tasks; (2) the clustering of tasks and segments of the total project, and the merging of efforts of various individuals, departments, etc.; (3) and the merging of actors with their various types of work and implicated tasks (Strauss, 1985, p. 8). Strauss sees work as a coordinated collective act involving multiple actors. Getting work done requires the interplay of actions between these actors, who may be more or less inclined to cooperate.

> "Articulation work" refers to the specific details of putting together tasks, task sequences, task clusters, and even the work done in aligning larger units such as subprojects, in order to accomplish the work. By contrast, "articulation process" refers to the overall organizational activities that brings together as many as possible of the interlocking and sequential elements of the total work, at every level of organization—and keeps the flow of work going. (Strauss, 1985, p. 175)

Strauss describes this interplay of actions in terms of four concepts: articulation work, arrangements, working things out, and stance.

Articulation work. The concept of "articulation work" originated with Strauss and has been employed by scholars focused on the design, take-up, and uses of computing (e.g., Gasser, 1986; Thoresen, 1997; Star, 1991, Suchman, 1996; Eschenfelder 2003). For example, Eschenfelder (2003) defines articulation work as having three characteristics; (1) invisible within rational models of work or work planning; (2) involved with the coordination of tasks, beliefs, goals, or standards of different actors involved with the work; (3) undertaken in support of a high level end goal (p. 3; see also Schmidt, & Bannon, 1992). General categories of articulation work include fitting, augmenting, working around, and boundary setting (Gasser, 1986; Thoresen, 1997). "Fitting" is adjusting regular work patterns to accommodate contingencies. "Augmenting" is taking on additional work in order to facilitate the arrangement. "Working around" is using alternative, or nonapproved, methods to keep work on track (e.g., Pollock, 2005).

Arrangements.

> Arrangements are tacit or explicit agreements between actors related to the actions necessary for carrying out the work. Arrangements are a temporary shared understanding of how things should occur, and may be continually reworked by actors via the working things out process. Powerful actors may dominate the working things out process and dictate the nature of arrangements. (Eschenfelder, 2003, p. 3; see also Strauss, 1985; Schmidt et al., 1992)

Working things out.

> This term refers to the upper level articulation processes through which arrangements are established, revised or kept going. Articulation processes include negotiating, making compromises, educating, lobbying, coercing etc. (Eschenfelder, 2003, p. 3; see also Strauss, 1985; Schmidt Bannon & Bannon, 1992; Pollock, 2005).

Stance.

> Stance denotes the position taken by actors toward the working-out process and the work itself. Stance is expressed through interactional strategies used in the working out process. (Eschenfelder, 2003, p. 3; see also Strauss,

1985; Schmidt & Bannon 1992; Fjuk & Dirckinck-Holmfeld, 1997)

Invisible Work and Articulation

Enmeshed with the concept of articulation is the concept of invisible work. Invisible work is that work done in invisible places, behind-the-scenes work, work defined as routine or manual that actually requires considerable problem solving and knowledge, and informal work processes that are not part of anybody's job description but that are crucial for the collective functioning of the workplace. In contrast, much work is visible. It yields to being mapped, flowcharted, quantified, and measured. When planning for work restructuring or taking up new technologies, visible work is the focus. It is the work that is seen, so efforts to restructure center on how visible work can be manipulated, redrawn, reorganized, automated, or supported with new technologies.

Understanding the nature and structure of invisible work is crucial to designing and managing organizations. As Pollock (2005) notes, when organizations are restructured do to new ICT and work is reorganized, invisible but often valuable work is neglected. No one recognizes that it is being done, or that it is of value, so the time and personnel that invisible work requires are not allotted in new plans. Articulation work is that which gets things back "on track" in the face of the unexpected. Strauss (1985, p. 275) notes that the important thing about articulation work is that it is invisible to rationalized models of work. "Articulation work" is another fundamental form of invisible work—"work that gets things back 'on track' in the face of the unexpected, and modifies action to accommodate unanticipated contingencies. . . . Articulation work . . . is invisible to rationalized models of work" (Star & Strauss, 1999, p. 10). They also stress that articulation work is not only invisible, but ubiquitous and permanent.

Scholars of computer-supported collaborative work have been the most active in pursuing articulation work. Primarily they see articulation as "overhead" that arises from coordinating work and engaging work artifacts (Raposo et al., 2004). The approach to reducing articulation work is to build systems and frameworks that, through their use, take away or automate some articulation activities among participants (e.g., Simone et al., 1999).[3] In contrast, here we look to extend our understanding and to theorize on the nature and role of articulation in work involving computer usage (e.g., Eschenfelder, 2003).

RESEARCH SETTING: MOBILE ACCESS TO PENNSYLVANIA'S JUSTICE NETWORK

For the purposes of the trial on which we report, the publicly accessible commercial telecommunications network provides enough bandwidth to receive desktop-like data transmission speeds to a mobile device such as a laptop or personal digital assistant (PDA). This increased bandwidth makes it possible to transmit photos and other large files securely to mobile and remote users. This is based on three elements of a technological infrastructure: mobile data network access, the use of Pennsylvania's Justice Network (JNET),[4] and mobile devices that the criminal justice officers (the users in this study) bring with them.

Mobile data networks (known as 3G for the third-generation technologies on which they rely) in the United States are private, and various service providers compete directly in each market. Wireless coverage is extensive, though no one carrier provides complete coverage of the entire expanse of the United States and there may be gaps in service even within covered areas. In other words, often there are service gaps where one provider's coverage is not alleviated by the coverage of a second. Moreover, the major carriers in the United States have deployed their 3G networks in different ways and at different rates.[5] Generally, though, they have focused on deploying in areas that are most populated (cities and suburbs) and most traveled (along major highways). Costs, reliability, and coverage vary greatly in all other areas. All these factors have implications for the trial because coverage in Pennsylvania is uneven and incomplete.

The JNET is a secure web-based portal connecting authorized users to a set of 23 federated databases via a query-based interface. The JNET architecture is characterized by four elements. First, JNET acts as a portal to the criminal-justice-related databases that the Commonwealth of Pennsylvania (and the U.S. federal government) maintains for criminal justice officers. Data are owned by the relevant state or federal agency (for example, Pennsylvania's Department of Transportation, or PennDOT, maintains driver's license records and the related picture database); JNET provides a query-based access to driver's license photos.

Second, and by law, JNET must be a secure system. Users are carefully vetted before they get access, their use is tied to specific roles, and these roles grant them varying levels of access to the range of data available. Further, use is tied to secure connectivity (enabled through encryption and virtual private networks), and this requires several forms (they have multiple layers of authentication required) to be used. Users must also reauthenticate periodically during their sessions in order to assure security during use. Until the trial we report on here, there was no mobile access: JNET security was tied to fixed lines and desktop computers.

Third, beyond data access, JNET provides messaging, e-mail, and reporting functions to users. In effect, it serves as a common message board for all criminal justice personnel in Pennsylvania. The e-mail alerts also provide

a means for officers to more easily keep track of investigative activity. For example, the system makes it possible for a parole officers to set up a query on a particular name, Social Security number, or case number(s). If that name or number comes across the message board, the officer will be alerted and can more easily follow up on the parolee.

Fourth, JNET has been operational since 2000 and supports thousands of queries each month (and use continues to grow by nearly 10% per month since inception) (Pennsylvania JNET, 2003). Simply, JNET is one of the most integrated policing information systems in the United States.[6]

The third element supporting mobile access to JNET is the devices being used to access its functionality while away from the fixed line access provided at police stations. To connect to the 3G wireless network, each mobile device had to have a special 3G-ready modem card. Most police cruisers have in them an integrated laptop computer, making this seemingly a trivial effort (put in the wireless modem card, load on the security software, and use a browser). However, there were a number of operational and legal issues that made this a nontrivial effort. For example, many of the in-cruiser laptops were not equipped with space to load the modem card. Second, the battery draw on police cruisers is substantial and this limits laptop use (and the 3G modem cards draw substantial power to run the antenna and maintain connectivity, as we discuss in more detail later). Moreover, some police cruisers' laptops have other software whose security and operational/licensing requirements precluded additional applications from being loaded.

For officers not in a police cruiser, the mobile device had to be carried on their person. Again, this is not a trivial effort, considering the fact that almost every square inch of the average police person's body is covered by some piece of gear. Moreover, the combination of current equipment (including communications, weapons, body armor, etc.) exceeds 25 pounds. This means that the mobile device must often displace something the officer already carries.

To work through these device issues, the field trial was done in two phases. In the first phase we provided officers in cruisers with a laptop (if they had one in their car, then meant the car then had two laptops). In the second phase we provided officers with PDAs. These PDAs had modem cards in an attached sleeve. Using a PDA reduced the officer's need to use the car-based laptop, allowing them to be independent of the cruiser. Because this was a trial, the laptops and PDAs were standard, off-the-shelf models.[7]

RESEARCH APPROACH

Heeding Orlikowski and Iacono's (2001) call to better theorize the information technology (IT) artifact, we conceptualized mobile access to JNET as a sociotechnical ensemble. Framing this analysis as a sociotechnical ensemble highlights the interdependencies of people (workers and managers) who use the (information and communication) technologies, the organizational rules and roles that guide both people's actions and the technologies' uses, and the situated nature of the relationships (that occur at specific times and places).

The field trial's design explicitly incorporated an emergent perspective on the roles of the mobile technologies and the multilevel nature of its likely effects on work and its governance (see also Markus & Robey, 1988). The field trial's design was focused on collecting data at and across three levels of analysis. At the *technical* level, we focused on the 3G network's coverage, access and connectivity/security, uses of applications (particularly JNET), and device operations. At the *individual* level, we focused on the take up and uses of the devices and JNET relative to officers' work processes and relevant tasks changed. At the *organizational* level, we focused on structural and governance changes relative to the tasks and business processes such as the role of dispatch, operational control, and interorganizational interactions.

By focusing on the criminal justice sector we partially control for industrial (extraorganizational) aspects. That is, by studying organizations in the same sector, we can focus on aspects such as the differences among organizations in criminal justice. Further, we can leverage the extensive literature on policing (for more on this, see Manning, 2003). The existing literature on police work provides detailed insights on the social norms, informal and formal organizational governance mechanisms, role of information, and an understanding of the ways in which police engage informational and communications-supporting technologies (see Manning, 1977, 2003; Klockars & Mastrofski, 1991).[8]

The field trial was designed as an intervention: Mobile workers were provided with either a laptop or a personal digital assistant (PDA) and secure access to the public 3G network. This was done in two phases for pragmatic reasons. The first phase lasted 3 months, included five participants, and focused on laptop usage. The small number allowed us to refine data collection protocols and ensured that we could meet the technological demands of supporting the access, security, and application use demands of a demanding operational environment. The second phase began directly after the first phase's completion, involved 13 participants, lasted 3 months, and focused on PDA usage. The five participants in the first trial were part of the second trial. This provided us with a subset of users who were engaged in mobile access to JNET for 6 months. The two-phase trial's 6-month duration was guided by practical constraints of users' ability to participate while doing their normal policing and official duties. The number

included in the trial was constrained by the costs of providing devices, connectivity, and field support.

Participants in both trials were police and other criminal justice officers from three organizations (one county-level and two local-level) located in one Pennsylvania county. Two incentives were used to draw participants. First, we promised that all participants could keep the mobile device(s) they were given to use (late-model laptops and high-end PDAs, both equipped with 3G modem cards, and, in the case of the PDA, an external sleeve and battery pack to support the modem card). Second, we made it clear that the participants' input would be used to drive the design of JNET for criminal justice uses, particularly for mobile access. Participants mentioned that both were important to their deciding to engage. In addition, we worked with the department heads and unit police chiefs to ensure that officers were given official recognition for engaging in the field trial. Participating department heads and unit police chiefs were both enthusiastic and supportive.

We used seven forms of data collection. First, we did pre- and postinterviews (at the beginning and end of each trial period) of all users. In the field study's first phase these were face-to-face, open-ended, and semistructured interviews that lasted from 60 to 90 minutes. In phase two we used a more structured, self-administered survey in place of some of the open-ended user interviews and followed up with a phone-call discussion. Second, we led focus groups of users following the trials. These were voluntary, and only two participants did not participate (for schedule reasons). Third, all users completed a 1-week time diary of work behavior during the field trial. Fourth, members of the research team did ride-alongs with users. We chose to ridealong with both police and court officers, and with both supervisors and patrolmen. Fifth, we gathered documents during all interviews, observations, and visits (and did extensive web and library research to support the field work). Sixth, we engaged in informal weekly interactions (via phone, e-mail, and in person) with users. Finally, we gathered data about laptop uses, wireless data transmission, and JNET usage via unobtrusive means (such browser logs, server logs, and telecom activity logs). Data from the first six sources were either transcribed into digital format or collected at source in digital format. Usage log data came in digital format.

This combination of data allows us to answer questions about where, when, and why 3G mobile access to JNET was used and why not. These data also allow us to answer questions about criminal justice personnel and their organization's uses of mobile access. Analysis focused on identifying evidence that provides insight at and across the three levels of analysis that structured the field trial: (1) technical, (2) individual/work, and (3) organizational/coordination of work.

At the technical level the analysis focused on identifying issues with the 3G network connectivity, speed and access, uses of JNET (and other sources/applications), and the roles of the mobile device. This was done through both a trouble-ticketing log, analysis of time use (drawn from the logs) regarding connection via 3G networks, volume of data transfer and time/usage of JNET, and through a series of topical analyses of the texts created from the six forms of intensive data collection.

Analysis of data relative to the individual and organizational levels of analysis, and for cross-level analysis, followed traditional qualitative data analysis approaches (see Miles & Huberman, 1994). In particular, we used three techniques: interim analysis of the data to guide future data collection and its interpretation, explanatory event matrices, and content analysis of the transcripts, logs, and field notes.

FINDINGS

We highlight two findings regarding articulation: (1) There are ongoing but unmet articulation needs present in any organization or work system. This is not unexpected, but it underscores that (2) articulation is cumulative. That is, as work becomes more complex (such as adding new work tasks and using new technologies), there is more articulation effort. To illustrate these findings, we begin this section by highlighting the common conceptualization of articulation as a transitory episodic (or event-driven) effort. We contrast this event-based view with evidence of unmet and cumulative articulation.

Common, Event-Based Articulation

Identified in the literature related to implementation of ICT in organizations are two common forms of articulation—the naive form and the event-based form. The naive form states that when new ICT is introduced into an organizational setting there will be increased articulation needs. These articulation needs will be resolved through additional organizational effort. This response will, in turn, lead to a reduced level of articulation over time and the organization will return to normal.

The second commonly discussed form of articulation is persistent or event-based articulation. In this case, as new ICT, are introduced into the organizational setting, articulation needs rise, and are met perfectly by organizational efforts. In this model it is recognized that as each new ICT is introduced, articulation needs increase. This further allows for ICT implementation that leads to unplanned for, secondary articulation needs. Although this model adds to the complexity of the situation, at all times the organization is depicted as meeting its own articulation

TABLE 1
Pretrial articulation issues

Category	Pretrial articulation issues
Service (access)	Dispatchers were unreliable (as they were turning over so often), the current and well-known CDPD telecommunications network was being terminated by the vendor, police cars had two radio systems: one for local operations, one to speak with state troopers. Existing access via landline systems was slow, costly, cumbersome, and not integrated.
Device	Two car based laptops (built-in and trial). Officers had personal cell phones, the two in-car radios, and multiple levels of authentication.
Applications (systems)	Separate systems for federal, state, county, local, and agency-centric uses. These include JNET, mobile report writing software, and another dozen nonintegrated applications.
Work (process/task)	Standard operations are busy and police must understand a complex set of legal, operational laws and codes. Police are conditioned to deal with articulation issues. Police are trained to handle contingency planning/responsiveness–emergency by following standardized procedures.
Governance	Decision rights and reporting follow a hierarchical, paramilitary, and centralized structure.
Security	Great attention to people and their personal goods, including information security of late.

needs perfectly and returning to a state of organizational normalcy in between implementations.

Unmet Articulation

The unmet articulation needs, those that existed prior to the trial and surfaced as the trial unfolded, stemmed from several elements of the officer's work. We identified, and list in Table 1, six forms of unmet articulation needs: service, device, applications, work, governance, and security. In terms of service, the officers had become accustomed to several problematic service, or access, issues. In the officers' car they were using CDPD[9] -supported mobile systems that were in the process of being phased out. The officers were unsure of what CDPD would be replaced with. They used two radio systems, one to contact the local dispatch and other local officers, and a second to contact state police and personal cell phones. In terms of pretrial device articulation issues, each officer had two laptops already installed in his or her vehicle. Their landlines at the home office or police station were slow, cumbersome, costly, unsupported, and unintegrated. The state system, federal system, and local systems did not communicate and in some cases were completely separate machines. The applications stored and used by these systems also provided for increased and unmet articulation issues in that they were also nonintegrated, required distinct logons and authentication paths, and required differing levels of technical knowledge for each.

Other pretrial issues that came into play in terms of unmet articulation issues were issues of the nature of policing itself. Policing organizations typically are tall hierarchies based on centralized decision making, standard operating procedures, strong chains of command, and a paramilitary structure. These led to increased articulation issues for the officers if there was no support from the central hierarchy where they would normally look for direction. The new devices we provided were intended to make the officers more autonomous in their information seeking and usage behavior. However, this was not possible without additional IT support, which was not available through traditional policing channels.

These pretrial issues came up again and again after we began our trial. The officers expressed interest in trying to solve some of the pretrial articulation issues, such as the service and application issues, through the potential of the new devices. For example, they exchanged information outside of their departments, that is, courts, lawyers, the state, county, etc., who have a range of systems, technologies, and requirements that are proprietary and noncompatible with the department's systems and technologies. This lack of interoperability is systemic and pervasive. Said officer number 5:

> If there was any way that we could put on our state software for what we do specifically to the realm of child support. . . If that had any way to be utilized through that laptop, that in addition to the warrant database and the JNET would have made a total package for us. I mean that's something that we could—we could have used wirelessly just regularly. When we arrest somebody and we need to know balances, I can't get that unless I call back to the office or I gather that information before I go there. I can't get, you know, payment histories on people, whereas if that were somehow usable in the laptop on a wireless phase, we would have access to it right there on the spot.

Officer number 7 observed:

> [We wish we could have] added the jail, our County prison program to it [laptop]. Now in order to access that, you had to separately plug that into a land line. . . At the same time, if it was wireless, that might help you, if someone reports that, hey, you got picked up last night and you go to the house, knock on the door to serve a warrant and they tell you that he got picked up and put in jail the night before, it would be nice to be able to check that out real quickly that way.

Officer number 6 noted:

> If our warrants were loaded onto this system and we had access to the warrants that are available or outstanding within the county which there are numerous, there's upwards of a hundred thousand warrants I think out, so you have that capability now that, if I've got Joe Public in custody, by going onto my laptop in my vehicle, I can see if anybody else wants him, and I can notify them just as quick, if I had the capability with the laptop to notify another jurisdiction, say, hey, I've got this guy in custody, I'm now transporting him to the Centre County prison, you might want to have somebody there meeting me with your warrant, you know. So faster, faster communications, more reliable communications, and we all get to see what's out there that we don't have now.

Officer number 12 explained:

> Sometimes I'll run into scenarios that I would have needed to gateway access to be able—and I can't go into their terminal because my profile's not built in, my certificate doesn't reside on there, and I then have to kind of abort the situation if we run into technical difficulties or things are not answerable at the off-site location, that I could pull that up on a PDA right then and there, go into the gateway, take care of my register information, confirm some things, and then get back onto the hard-wired end user that we're trying to troubleshoot their problem. . . currently, if we get there and there's technical difficulties and I can't determine some things onsite there, have to kind of just put everything to the side, say I'll have to come back over to my machine, logging in to get into the gateway in my office here and then determine some things and go back to the end users later on. So usually can save a good hour's worth of time by having it right then and there.

Cumulative Articulation

We propose that there exists a third form of organizational response to ICT implementation: *cumulative articulation*. Implementing new ICT increases the articulation needs of the organization. However, we claim that many of these needs go unrecognized and unmet by the organization. A gap forms between the unmet articulation needs and the organizational efforts aimed at fulfilling those perceived needs. The organization does not return to its "normal" state in which all needs are met. A "new normal" is formed in which articulation issues either become invisible or are handled in some disruptive or destructive fashion. When the next new ICT is implemented, the organization does not start from zero level relative to articulation needs. This next round starts with existing, and unmet, needs. The next new ICT adds additional articulation work and this widens the gap, increasing the resource costs of the implementation, likely increasing frustration on the part of the employees and misunderstanding on the part of the administration and ICT implementers. We find that the gap continues to widen between unmet needs and organizational efforts until a crisis point is reached in which the employees no longer will access or use the ICT required of them.

We found that upon entering the mobile JNET stage the policing organizations that participated in this case study had unmet and somewhat unrecognized articulation needs. We began our trial by offering devices and training to the officers only to find out later that the level of support they would need to use the devices was astronomical, that this support would not be offer by any of the industry or governmental partners, and that the policing organizations involved had no IT staff or IT support of their own. These organizations had substantial unmet IT articulation needs before the trial. Introduction of new technologies made this gap widen even more.

We found, as have others, that public safety organizations have limited IT support and diverse IT infrastructures (e.g., Northrop et al., 1995; Nunn & Quinet, 2002). The officers in our trial relied chiefly on themselves and on each other to learn to use and troubleshoot the devices. This seems to be the way they have learned and supported all their IT. Each of the three units who participated in the trial had different IT infrastructures and these were supported through a variety contracts to different third-party vendors. Officer 1 noted:

> One of the other problems. . . we don't have a computer person full time that can deal with our problems. We have a guy that, I don't know, he might be retired from IBM or something, and he lives out XXXX/YYYY area so it's like you got to call him up, either try to deal with things over the phone or he shows up once, he's like a consultant, I guess. I mean, he has other places, so that—that has been a problem for the township. We don't have a computer personnel on scene at the township all the time so if something happens, it might be a week, two weeks, or even a month before this guy can get in to look at our problems.

Officers also had an organizational history of their IT needs not being filled and articulation needs not being met. Officer number 1 went on to say:

> Well, we've had a lot of problems with our report writing system on our laptops in the car, XXXX I think is who we have and their technology has posed a lot of problems for us. . . I—what they said they could do, they're finding out they can't. . . It's software that was supposed to be created to make our jobs easier but I think what it's doing is it's making—giving certain people more work. Our secretaries have just been pulling their hair out because the reports aren't merging, they're not—different aspects of the software just isn't working the way it was supposed to.

Officer number three notes,

> My complaint with the report writing, not beating a dead horse but that was one place where technology was not a step forward, it was about three steps back because it was not easy, it was not painless, it was not simple, and it certainly wasn't anything that was designed with a realistic outlook on the real world.

To help resolve some of these unmet articulation needs we hired an undergraduate student intern to act as an IT support person to the officers concerning mobile JNET (see Figure 1). The trial IT support person was overwhelmed. This is due in great part to a backlog of unfulfilled IT needs, which any field IT person will have to deal with. Second, the battery problems and operating system (OS) changes to the PDAs also led to situations where reinstallations wiped clean important info (making officers reluctant to do this). Third, the JNET access was difficult to maintain. The officers are highly conscious of information security. They valued the steps taken by JNET to keep information secure even though it has added several steps to the logon process. Still, getting all the certificates and access elements to work takes time and limits use. During the trial we dedicated 20 hours per week of technical support for the participants and this was not enough to support 13 officers.

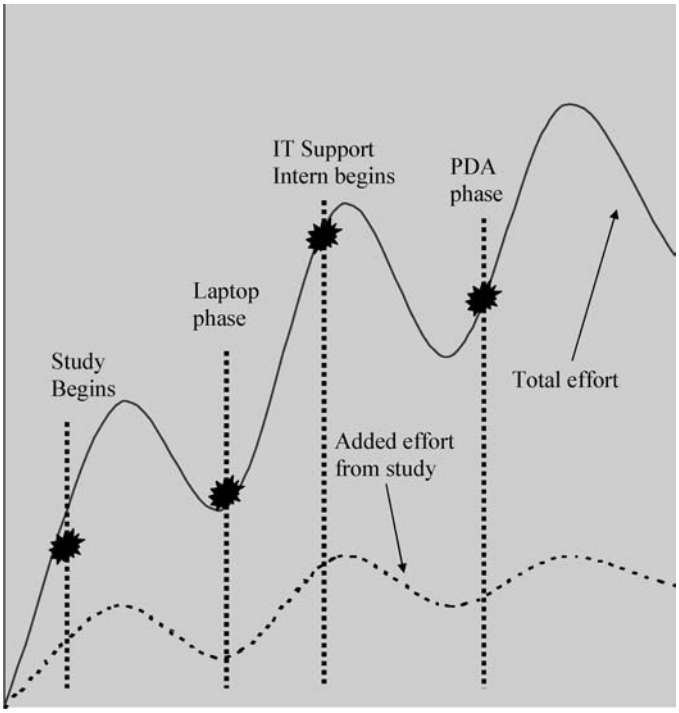

FIG. 1. Cumulative articulation.

ASSESSING THE COSTS OF ARTICULATION ON INDIVIDUALS

Using the cumulative model, articulation needs increase the costs to the organization (see Figure 1). Additional resources are required to address these needs. In the case of the policing organizations, since they bore no IT support costs, the increasing burden of the articulation gap is borne by the individual user. With no service, device, application, and general IT support, the officers were expected to manage the rising articulation costs on their own. We found that these articulation costs exceeded the benefits of technology use for the individual and became unreasonable.

Before our introduction of mobile JNET into the lives of these officers, the path for gaining necessary information while mobile was to place a radio call to the 911-dispatch center (see Table 2). Dispatch, or the 911 communication center, was central and will continue to be central to the officers. It was their touch stone in a time of information seeking as well in a time of crisis.

Officers made clear how reliant they were on dispatch. For example, our empirical work and the extant knowledge on policing make clear that information seeking is a critical, though time-bound, part of the officer's work. There is a great deal of coordination and communication work done via the radio and dispatch. The amount of information seeking is driven by incidents and events. During these time-constrained efforts, officers are unlikely to have the chance to search and type on screens. Thus, they also use dispatch to assist their search. When they need identity or criminal justice data, officers radio the police dispatcher. The dispatcher's proxy query takes place in parallel with the officer's incident management at the scene. Thus, there is no time penalty. And the officer at the scene cannot afford to take his or her eyes off or divert attention to deal with a query/response. Officers depend on the dispatcher to return a focused and limited response.

After our introduction of mobile JNET into the lives of these officers, the process became far more complex and unsupported. An officer needed to have or understand the following in order to gain access and use JNET:

- Knowledge of network: access, coverage, environment.
- Device knowledge: battery, interface, behaviors.
- Applications (local and remote): OS, CLEAN, JNET, local.
- Security: two factors, procedures.

The officer participants in this trial had to grapple with the constraints of secure access, limited coverage, and unstable access to the 3G wireless network. For example, the "always on" possibility that 3G networks provide (due to their use of packet-based, Internet protocol, spread-spectrum transmission, it is possible to maintain constant

TABLE 2
Individual articulation costs of mobile JNET

Pretrial remote information access	Mobile JNET
Radio call dispatch	Access JNET from a mobile device using a 3G network.
1. Place radio call. 2. Explain. 3. Wait. 4. Receive information. 5. Act.	1. Possess device, user name, password, and USB. 2. Drive to access point. 3. Log on to device. Log on to 3G service. Log on to JNET. 4. Form JNET query. 5. Wait. 6. Receive information. 7. Act.
Skills: Radio. Form verbal query. Ask verbal questions. Manage verbal answers. Remember answers.	Skills: Laptop/PDA navigation. Geographic access data. Query formation. JNET knowledge

connectivity to the network) was never realized because of the mandated constraints of JNET application security. The secure, two-factor, wireless login was both difficult to follow and time-consuming to initiate. And the VPN would shut down if the bandwidth fell below a certain point (and this meant users had to reauthenticate). Moreover, JNET operating procedures requires that users must periodically revalidate their identity and, if not, will shut down the session. Said officer 7:

> I have found that once a disconnection happens and I receive the message "There is no answer" then I continually get that same message each time I try to reconnect. Eventually I will get a message stating "The modem or connection device can not be detected. Check connections and try again." At this point I have found if I completely shut down or reboot, then the computer apparently senses all the equipment again. I have immediately reconnected every time after rebooting. This has happened regularly and shutting down or rebooting is lengthy but necessary. Not sure if we have a hardware or software problem or not. Again, this is only after loosing connection and retrying several times that it becomes necessary to reboot or shut down. Signal strength is usually still very strong when this connection problem happens.

The most common problem with this trial was the lack of 3G coverage within the rural trial area. Coverage maps provided by the vendor indicated more than 70% of the area was covered. In practice coverage was far less than expected.[10] Officer 1 noted, "[The wireless provider] to me represents the businessman or the business-oriented communications for people who are working in the cities and who are traveling the interstates. Because that's—it just looks like orders and there's no like mass coverage area and once you get off the interstate or you get out of the city, I think your service is diminished greatly." Officer 14 stated, "I have used my laptop to access the Internet and JNET but have been having problems getting anything on JNET other than photos. I think it has to do with a poor signal." Said officer 11:

> The biggest problem was connection. In [location] the [wireless provider] is pretty much useless with very little coverage and many dead spots. Many times I would need to use JNET but could not get coverage. Additionally sometimes when I could get onto [the wireless provider] I could not get into JNET. I really could not tell you why I got on sometimes and not others because there really seems to be no logical explanation behind it.

Officer 12 stated:

> My coverage in my office is nonexistent. . . I took it to my home hoping it would be better, and I'm sitting there looking at—now I can't qualify what's hanging on each of those towers but I can sit and look from my home at three towers above XXXX, and I'm looking at them and I walked the whole perimeter of my property with the PDA hoping it would work and I didn't even get the strength enough to even connect.

Officer five stated,

> I didn't have service, so be honest with you, when I was on call, the first week I took it home, when I realized it didn't work for me, I never even took it home again when I was on call, when I would have used it for that information.

Furthermore, the PDA battery's life was not sufficient to maintain connection to the 3G network over long periods

and this led trial participants to stop using their PDAs for mobile access. Officer one stated, "Short battery life, lack of reception area. Had to be in certain areas to get good reception, and if you weren't, then that drained your battery as well." Officer 3 stated, "The poor battery life was compounded by the fact that any PDA that lost its battery charge also lost all of its programming. Because of the complexity of the programs, restoring a PDA to a functioning unit required almost 2 hours."

We note that JNET applications that are very useful for deskbound workers are neither fast enough nor focused on the needs of mobile workers, making it difficult for them to use the applications by themselves in active incidents. Officer 11 stated:

> When I have gotten onto JNET it has been slow as molasses in getting returns. I truly believe this is because of [the wireless provider's] coverage in XXXX. I say this because I tried from home on day and JNET was working good and quick returns. Also the battery dies before I can get returns in most cases so I have to leave it plugged into the car. Overall the PDA has awesome potential but at this point has several bugs to be worked out.

The officers using mobile JNET developed some highly complex arrangements for much of the trial period in an effort to incorporate the devices into their work life. In Table 3 we note several examples of these articulation arrangements. Due to the fact that 3G service was scattered, slow, and unavailable in most locations the officers had to search for 3G hotspots, drive to those hotspots, and then make their connection to mobile JNET while parked. The problem with this model is that crimes did not happen where the hotspots were located. In the same way that a gun is important (even if 97% of all officers never fire their sidearm as part of their job), access to JNET is highly valued, and officers must be certain that it will work when they "draw it from their holster." The value is driven in great part by the reliability of their mobile connectivity. These officers' work worlds revolve around geographies of local communities, and they live balancing routine with emergency. In these moments of crisis the first responder cannot doubt that his or her weapon will function as expected. In that same moment, even if he or she has not used mobile technology for weeks, he or she must be certain that device will work on cue and as expected.

The devices themselves also presented many problems. For example, their poor battery life limited their use. So did the lack of a means to host the device in cars or on the officer. Thus, the PDAs in particular demanded more training and support than we could provide. The articulation arrangements made by these officers were to limit their use altogether or to supplement lack of on-the-job training with self-instruction and practice using the devices on their own time when no crises were anticipated. While on duty, the officers limited their use of the devices to down time and resorted to calling Dispatch via the radio when public safety was on the line.

In the last week of the field trial, no officers attempted to log on from a mobile device to the 3G network or to access JNET from a mobile device. The final arrangement that was necessary for the officers was to drop use of the devices altogether. The cost of the articulation became too high for the officers to bear alone.

IMPLICATIONS AND ISSUES

We note that the rising articulation needs of new ICT seem to be invisible to the organizational leadership and thus went unaddressed. These unaddressed articulation needs created a growing gap between met and unmet articulation needs and the articulation problems became cumulative. The administration of these policing organizations provided no IT support before or during the trial. The suppliers of the devices, service, and applications provided little

TABLE 3
Mobile JNET articulation arrangements

	Visible	Demands	Arrangement
Service (access)	Wireless 3G	Slow, unavailable in most locations	Drive to connection spots, avoid use
Device	New laptop/PDA	Steep learning curve, poor battery life, no room in car/person alone	Limit use, practice in off hours, read manual, self-instruct
Applications (systems)	Mobile JNET	Know JNET system well, know log-on system well	Limit use, never use in crunch time
Work (process/task)	Access to essential/timely information	Not timely; long log-on procedures	Drive to hot spot, plan to spend time
Governance	Individual self-governance	No IT or administrative support	Resorted to calling Dispatch in crunch time

or no support either. The problem of unmet ICT articulation needs seems to fall into the "someone else's problem" category when dealing with local policing organizations. Each entity thought that the other entities would be providing support, if support were even needed. When none offered support, it fell to the academic researchers to step in.

The administrators of these policing organizations saw value in participating in these trials and encouraged their officers to accept devices and take part. However, since they did not offer any organizationally sponsored support or training, there was a high reliance on the individual officers to climb the steep learning curves for the devices, service, and applications themselves. The officers were expected to use their own time to learn to use the mobile JNET system. And when the mobile JNET system did not work as expected, these officers, met with increasing articulation costs, were expected to individually create work-around arrangements to make the ICT implementation possible. We learned that as the articulation gap grows, the costs to the individual become unreasonable, and the costs exceed the value for individual. The response is that individuals reduce personal articulation burden by discontinuing their use.

It is possible that the uses of ICT may bring increased efficiencies or lead to more effective practices. However, this use also leads to increased articulation, additional work to make the ICT operate. We have noted the level of extra effort needed to make the devices and access work for the JNET trial. We also noted the pent-up and unmet demand for operational support of the existing computing platforms and applications. The implication here is that articulation is often conceived as a transient phenomenon—something tied to implementation or introduction. In this view articulation is a short-term training and learning cost.

Clearly implementation is a period of added articulation. However, our evidence is that any computer-based system adds work, and this added work may or may not diminish over time. That is, even if a computerization effort alters or removes some work, it adds other work. The added articulation work we observed included the effort needed to develop work-arounds when the device did not work, the increased work that JNET authentication and security demanded, the effort needed to find viable access points and clear connection to the 3G wireless network, the ongoing resolution of device/application conflicts, and the increased cognitive loads placed on workers. Relative to this last point, the increased cognitive load is often due to clumsy computerization (e.g., Patterson & Woods, 2001). That is, as work pressures increased (perhaps due to temporal pacing), computerized systems often demanded more attention from their users, or failed to work when needed. In this case, the computing designed to ease the cognitive work of users actually hinders their work.

The consequence of this increased cognitive load is that the introduction of computing cannot be seen as simply as a work-easing: It is work changing. Given the pervasiveness of direct effects beliefs, however, this is likely to lead to an oddly self-reinforcing system of adoption and use. That is, the ongoing belief that increased uses of ICT are beneficial leads to increased adoption. This adoption raises the level of articulation work. In doing this, the extra work decreases the value of the newly introduced ICT, and that leads to searching for another ICT. The accumulation of unanticipated, additional articulation work, it seems, overwhelmed the officers. They remained interested in the ICT, valued the experience, but could not sustain the personal level of commitment this organizational innovation demanded.

Theorizing Articulation

Our premise is that contemporary work is characterized by the centrality of ICT usage and dispersed, distributed, dynamic, and often formalized cooperative work arrangements that involve a large, varying, or indeterminate number of participants (see Schmidt & Bannon, 1992). In this working environment, articulation becomes increasingly complex and demanding. In these settings workers apply various mechanisms of interaction so as to reduce the complexity and cost of articulation work. We use as evidence a study of the take up and uses of mobile devices by police to show that articulation is ongoing, often unmet (and even invisible), and cumulative.

We further note that four mechanisms have been characterized as focal points for articulation intervention, with the premise that some combination of these reduces articulation costs:

1. "Organizational structures in the form of formal (explicit, statutory, legally enforceable) and less formal (implicit, traditional, customary) allocation of resources, rights, and responsibilities within the cooperating ensemble." (Schmidt & Bannon, 1992, p. 13; also see Strauss, 1985).
2. Plans and schedules (Schmidt & Bannon, 1992; Maines, 1991).
3. Standard operating procedures (Schmidt & Bannon, 1992; Suchman, 1987, 1996).
4. "Conceptual schemes (e.g., thesauruses, taxonomies) for indexation or classification of information objects so as to organize distributed inclusion and retrieval of objects in 'public' repositories, archives, libraries, databases etc. maintained by multiple persons" (Schmidt & Bannon, 1992, p. 13; see also Star & Griesemer, 1989; Bowker & Star, 1991).

> These protocols, formal structures, plans, procedures, and schemes can be seen as mechanisms in the sense that they (1) are objectified in some way (explicitly stated, represented in material form), and (2) are deterministic or at least give reasonably predictable results if applied properly. And, these are mechanisms of interaction in the sense that they help to reduce the complexity of articulating cooperative work. (Schmidt & Bannon, 1992, p. 13; see also Spasser, 2000)

If, however, articulation is cumulative, then continued uses of these four mechanisms becomes increasingly less useful. Engaging each mechanism increases (even if the increase is slight relative to the benefit) coordination, planning, and other cognitive, social, and operational loads. In this way, responding to articulation work adds articulation work: a recursive bind. It may be that this is a slow recursion (e.g., Nardi & Engstrom, 1998) or that properly done tools and frameworks can take on this cumulative activity, focusing articulation to be directed solely at mastering the tool set or framework (e.g., Spasser, 2000; Raposo et al., 2004). The evidence from our work and that of others (e.g., Færgemann et al., 2005; Fjuk & Dirckinck-Holmfeld, 1997; Eschenfelder, 2003) suggest that articulation is additive as new ICT-based systems are engaged. One reason that computer-supported cooperative work (CSCW) scholars are the most attentive to articulation is that they see it is endemic to the distributed, ICT-intensive and collaborative work on which the contemporary approach to the knowledge-intensive work force is premised. This attention to improving collaborative software/systems is important and needs to be continued.

We further note that over the past 30 years many of the Western world's organizations have moved toward flatter hierarchies, often relying on ICTs in lieu of some managerial functions that middle managers once did. Activities such as facilitating coordination, communicating among employees, guiding workflows, monitoring employee workload and efficiency, and so on have shifted from middle management to the workers themselves. Some of these activities have been partially embedded into ICT (such as calendaring, e-mail, workflow, and project management systems). The shifting of these functions to ICTs has added articulation costs even as the (organizational) functions that served to reduce this articulation work have been removed. If articulation is cumulative, then bringing back human project managers and technical project support is a second path to pursue. For example, in the context of our study, if the various police departments each had full time IT staff, much of the articulation needed to get the JNET trial to work would not have been needed.

More broadly, if articulation is cumulative, and if ICT used to support work adds (even incrementally) to this extra work, then organizations should perhaps be willing to increase levels of hierarchy and support resources to remove some of the complexity from work and the need for individual-level articulation. Access to ICT support staff will likely mitigate the ICT take-up burdens of each worker. Without this support, workers must teach themselves. Our evidence suggests this approach increases the likelihood of abandoning useful ICT. It appears that articulation is a sociotechnical concept that defies resolution via increased uses of ICT.

NOTES

1. Public safety is a broad term, often used to refer collectively to criminal justice units, emergency medical services, fire companies, and hazardous material response organizations. Criminal justice refers to police, courts, probation and corrections officers, and their units. First responders are personnel from criminal justice and public safety organizations who typically arrive first on the scene in response to emergencies and other public safety incidents. The concept of *homeland security* is a more recent and general term that often includes activities of public safety, criminal justice, and/or first responders. For more on this, see Rudman, Clark, and Metzler (2003). In the rest of this article we focus on criminal justice personnel.

2. Manning focused on the informal take-up and uses of cellular phones by police. Informal cellular phone ownership and use is now common among police officers. The take-up and use of the cellular phone is beyond the scope of this article. Two attributes of this take-up are worth noting. First, the officers use their own (personal) cellular phones and do not consider them as part of their professional equipment. Second, this personal use has made them aware of issues with wireless coverage and reliability.

3. Ironically, the very action of using systems to reduce articulation increases articulation work to use that system. This recursive property is reported in the oft-cited Schmidt and Bannon (1992) paper, and in other more recent work (e.g., Færgemann et al., 2005; Fjuk & Dirckinck-Holmfeld, 1997).

4. For more information on JNET, see www.jnet.state.pa.us

5. Debates and issues with wireless network deployment, coverage, access, and use are beyond this article.

6. Developing and deploying integrated criminal justice systems create a vibrant and active space in the United States. There are literally hundreds (if not thousands) of such systems development or implementation efforts at this time. Two other large-scale efforts, comparable to JNET, are (1) the Capitol Wireless Integrated Network (CAPWIN, see more at www.capwin.org) and the Automated Regional Justice Information System (ARJIS, see more at www.arjis.org).

7. We employed a technical support person half-time and he was fully committed through the entire trial, maintaining the equipment. Production systems would need to be ruggedized to withstand the wear and tear of the criminal justice operational environment.

8. Given the extensive literature on policing, here we draw from but do not develop or discuss principle findings. Instead, we refer the interested reader to anthologies of such work (listed in our references). The interested reader can also find courses in crime, law, and justice offered in most sociology departments and the extensive material on the web in locations such as the U.S. Department of Justice and the International Association of Chiefs of Police.

9. CDPD is a first-generation wireless standard that was being phased out (meaning the networks supported by CDPD were being turned off) as the 3G systems were being made available.

10. The wireless service provider was paid to provide service and was supportive. Other vendors in the region elected to not participate. Anecdotal evidence suggests their service is also spotty. The principal lesson is that maps based on theoretic coverage provided by wireless service providers do not provide insight into what areas are actually covered. They do provide insight into what areas are clearly not covered.

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