Mobile Government Fieldwork: A Preliminary Study of Technological, Organizational, and Social Challenges

Raya Fidel, Hans J (Jochen) Scholl, Shuhua (Monica) Liu, and Kristene Unsworth
The Information School, University of Washington
Box 352840, Seattle, WA 98195-2840, USA
1.206.685.9937
{fidelr, jscholl; shuhual; kruns}@u.washington.edu

ABSTRACT

With its *GoMobile* project, the City of Seattle is pioneering the utilization of fully mobile wirelessly connected (FMWC) technology applications in fieldwork operations with the aim of significantly improving its operational effectiveness and efficiency as well as its quality of service. Our study analyzes and assesses the efficacy of this prototypical mobile Government project. Preliminary findings, based on the study of one division, show that beyond the expectable technology hurdles numerous unforeseen challenges in the organizational and social context emerge, which when taken together can present staunch and tall obstacles to arriving at the intended outcome. Our study uses a work-centered analytical framework for deriving and clarifying the strategic choices in such projects via a formative model. Our narrative model captures and surfaces the interaction and interdependence between major organizational variables and the work context. In this paper, we report on our early observations and high-level findings.

Categories and Subject Descriptors

K.4 {**Computers and Society**}: K.4.2 *Social Issues* – K.4.2 *Organizational Impacts* – K.4.4 *Electronic Commerce/Electronic Government/Digital Government/mobile Government*
D.2.11 {**Software Engineering**}: - Software Architectures - *Domain-specific architectures.*

General Terms

Design, Human Factors, Theory

Keywords

E-Government, Digital Government, mobile Government, Fully Mobile Wirelessly Connected (FMWC), Ubiquitous Computing, Pervasive Computing, Integration, Interfacing, Work Content, Workflow, Work Context, Business Process Analysis, Cognitive Work Analysis, Cognitive Systems Engineering, Information Systems

1. Introduction

Due to the assumed high potential for improving field operations through high immediacy and increased accessibility of critical information needed in on-site decision making, governments around the world evaluate so-called *fully mobile wirelessly connected* (FMWC) [16] information and communication technologies (ICT). FMWC applications are sensitive to both the environmental ambience and the needs of individual fieldworkers. In the public sector, the expected utility and efficacy of these ICT might significantly help advance the e-Government agenda. However, major variables of the organizational and work context are immediately impacted, so that the introduction of mobile technologies must be considered with great caution.

Our study aims at better understanding the interdependencies and interactions of human actors, major organizational variables, and the work context in field units with FMWC ICT in local government. The study case is the City of Seattle or, more specifically, its Seattle Public Utilities (SPU) unit. For many years, the City of Seattle has been known for its leadership in Digital Government and for its innovative capacity with respect to the utilization of novel ICT (cf., [20, 25, 26]). When choosing The City of Seattle as our study site, we did so for basing our research on an undoubtedly rich, advanced, and experienced environment of Digital Government practice. We inferred that this would help confer our results and model high credibility, significance, and relevancy.

With regard to mobile government, the City identified the potential benefits of mobile ICT for its field operations relatively early [4, 38, 30]. In its public utilities Water Operations Division (WOD), the City launched a mobile pilot project in 2001, which provides fieldworkers and crew chiefs wireless access to SPU's backend asset management and logistics applications as well as Geographical Information Systems (GIS). According to the SPU-internal post-implementation review [5] the measured productivity gains and service improvements in that pilot were so significant that SPU leadership decided to quickly expand the wireless ICT utilization into other SPU divisions. However, while the mobile ICT adoption was "straightforward" [30, 2] in the WOD pilot, it soon enough became clear to SPU leadership that the pilot might have represented an ideal case, whose generalizability might be limited even within WOD. In fall of 2005, the *GoMobile* project was expanded to the Drainage and Waste Water Division (DWWD). Our field interviews and observations commenced some half a year after the launch of the mobile ICT deployment at DWWD.

The paper is organized as follows. We first present the relevant literatures and our analytical framework. We then pose our four main research questions and detail our research design. Finally, we report on our results. However, since these results pertain to one unit of a total of three to be studied within this three-year NSF-sponsored research project, we expect much more detailed results regarding all variables and their interactions in the near future. Or, said another way, here we are presenting higher-level results, which will be qualified by further detail study. We conclude from our findings that the introduction of FMWC ICT

in local government might be far more complex and difficult than initially anticipated by government leaders and academics alike. Hence, we propose further directions of research, which have the capacity to answer some of the new questions that our study is discovering.

2. Literature and Theoretical Framework

2.1 FMWC and Mobile Government

While much emphasis in the digital government literature has been placed on government-to-citizen (G2C) and government-to-business (G2B) interactions, far less studies have focused on government-to-government (G2G) and internal effectiveness and efficiency (IEE) phenomena [40]. Ironically, however, the most enduring and effective impacts brought about by digital government might be found in the latter two (ibid). The usage of FMWC ICT in government, which some authors have been quick to buzzword "mobile government" [28], or even "ubiquitous government" [1, 3] may greatly serve the mission of digital government [1] by offering "a new level of immediacy, effectiveness, and convenience in the mode of service delivery" [40].

In FMWC ICT the two base technologies of the Internet and of wireless connectivity have been merged. Also, versatile and robust mobile devices geared for universal uses make possible a new class of applications, services, and information flows in government. These new applications serve nomadic users and hosts and expand the reach of those services [6]. Once fully developed and backend-integrated, these new classes of applications and information flows may reshape and transform the information and transaction landscape in Government [39].

Mobile applications fall into two broad classes: (1) information and transaction support for traditional types of work in the field and the back office, and (2) information and transaction support for novel types of work in the field and the back office. As Gorlenko and Merrick point out, FMWC ICT can further be distinguished with regard to their mobile suitability as essential, adapted, or unsuitable [16].

Mobile applications in government, hence, provide six distinct situations:

(1) An *existing* type of field- or back-office work is enhanced and reorganized when supported by an *essential* FMWC ICT;

(2) An *existing* type of field- or back-office work may be found supportable by an originally stationary application whose use is now extended to the mobile environment via an *adapted* FMWC ICT;

(3) An *existing* type of field- or back-office work may be found *unsuitable* for the utilization of a FMWC ICT;

(4) A *novel* type of field- or back-office work is supported by an *essential* FMWC ICT;

(5) A *novel* type field- or back-office work is supported by an *adapted* FMWC ICT; and

(6) A *novel* type of field- or back-office work is found to be unsupportable under any environmental condition or in any social context [39].

When empirically studying the work domain and the uses of FMWC ICT in it, this taxonomy appears helpful in distinguishing the work types and the constraining types of

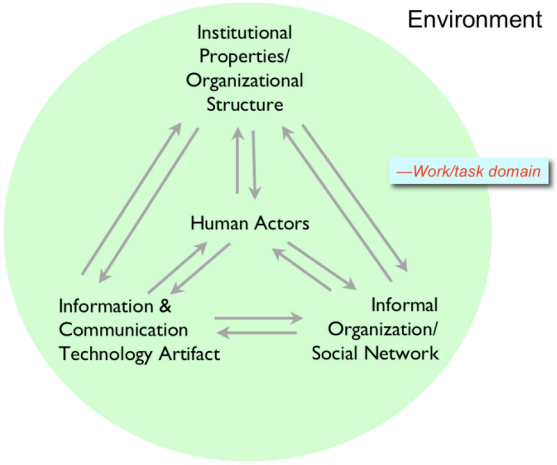

Figure 1 Extended ICT-related Structuration Framework

stationary and FMWC ICT.

However, in order to avoid a techno-centric analysis and interpretation, we hold that further analytical instruments and concepts need to be invoked when hoping to more fully understand the potential and implications of FMWC ICT on government field and back office) operations. Such instruments and concepts need to include government work in their analysis.

2.2 Work Analysis

Various theories have been used for studying the dimensions of digital government work. For example, high-level business processes such as public-sector procurement and revenues have been analyzed by means and methods also used in the private sector [34, 35]. These studies were based on the process analysis and change literatures [7, 9, 10, 18, 19] and the work flow analysis and redesign literatures [8, 42, 45]. While early business process redesign studies portray the innovative application of information technology as cornerstone of any process and workflow redesign [14, 17, 21-23], newer studies acknowledge that factors other than information technology may play important and sometimes unpredictable roles in that context [27, 29, 37]. Common to most traditional work analysis studies is an emphasis of the functional and technical sides of the problem under study. Factors of cognitive, social, and organizational action, interaction, and constraints remain widely unaccounted for.

Following the ideas of Giddens' theory of structuration [15], Orlikowski & Robey suggested to view the uses of ICT in organizations as a social phenomenon, which is both influencing and being influenced by the material and social dimension, in which they are embedded [33], see also [11, 32]. Below we will refer to this framework as the Orlikowski-Robey framework (ORF). Building on this theoretical approach, we propose to expand ORF by incorporating (1) the informal organization [24, 43] as an indispensable structural dimension (see also [41] for the extensive empirically verified influence of this dimension); (2) the work/task domain as the basis for organizational and social interaction, and (3) an environment that shapes and

constrains all other elements ([13, 36, 44], see figure 1). These latter two dimensions along with the others have been analytically captured through a framework known as Cognitive Work Analysis (CWA). We are linking the ORF structuration perspective with the CWA framework.

2.3 The ORF/CWA Framework

Our combined ORF/CWA structuration framework assists in accounting not only for important variables not addressed in other frameworks (including ORF itself), but also for the interaction and interdependencies between the variables, which are critically missing from other research that focuses on merely isolating factors without acknowledging their recursive relationships [31]. Our combined ORF/CWA structuration framework encompasses a work-centered methodology, which allows for systematically addressing important cognitive tasks performed during work as well as organizational systems in the context of Mobile Government.

The CWA part particularly helps develop and establish a macro-level view of organizational work done in context. Table 1 (below) provides an illustrative account of its elements. With this approach we have a well-structured and proven framework for analyzing and understanding the complex interactions between (a) the activities and organizational relationships and constraints of work domains, as well as (b) human actors' cognitive and social activities and their subjective preferences during task performance. At the same time, the CWA framework of inquiry covers the variables and relationships specified by ORF.

Dimensions	**Issues to investigate**
Work environment analysis	What elements outside the organization affect its work? What are the boundaries for the work environment?
Work domain analysis	What are the goals, priorities, and constraints of the work domain? What are the functions and physical processes? What tools are employed?
Organizational analysis	How is work divided among teams? What criteria are used? What is the nature of the organization? What are the organizational values? How is work divided among team members?
Activity analysis in work domain terms	What are the current tasks? What are the goals of the fieldwork activities? Constraints? The functions involved? The technology used?
Activity analysis in decision making terms	What decisions are made? What information is required? What information sources are useful? What information is used? What information is created? What information is shared? Among whom? What information in disseminated?
Activity analysis in terms of strategies that can be used	What strategies are possible (e.g., browsing, the analytical strategy)? What strategies does the actor prefer? What type of information is needed? What information sources does the actor prefer?
Analysis of actor's resources and values	What is the formal training of the actor? Area of expertise? Experience with the subject domain and the work domain? Personal priorities? Personal values?

Table 1 Cognitive Work Analysis Framework

The ORF part allows for understanding more deeply the multi-directional constraining influence of interacting variables. The institutional structure constrains both the ICT artifacts and the human actors' work context, but likewise do human actors and ICT artifacts shape the institutional structure in action. Moreover, while the ICT artifacts constrain the human actors' work context, the human actors also constrain the use of the ICT artifact.

Through the linkage between ORF and CWA we not only enrich both analytical lenses, but we believe we provide a more comprehensive explanatory whole. In the tradition of both frameworks we base our analysis in the combined approach on a relatively large number of single field case studies (note: this will be the case once this research has advanced beyond its current preliminary stages).

Anchoring our study in the context of the task and work domains, yields several analytical and relevancy-related benefits. Applying this framework

- Reduces single-variable or factor bias because the framework analyzes various dimensions simultaneously, and no single variable or dimension is selected for study over the others,
- Leads to recommendations that address technological, organizational and social facets of government work practice,
- Uncovers variable interdependencies and interactions in time and over time, because all variables can be studied at the same time and their interactions have been recorded and analyzed,
- Grounds theoretical results in government work practice because data have been collected in the field
- Provides case-related outcome feedback because the results of the study are based on field cases and can generate feedback that likely is relevant to practice,
- Determines case-transcending findings within a formative framework because the results can be generalized through multiple cases.

2.4 Specific Research Questions

The outcome of applying the combined ORF/CWA framework in this study is a formative model that lays out the work that is being done at the sites of study and its interaction with its context. This formative model has the capacity to guide the generation of technological and organizational requirements for the effective implementation of FMWC applications in local and city government.

While the formative model provides an overall synopsis of strategic choices, some specific research questions were of particular interest and are emphasized in this paper:

(R1) From a *work/task perspective*, what are the current constraints on the fieldwork, and how do the FMWC ICTs influence those constraints?

(R2) From an *organizational perspective*, what are the current constraints on the fieldwork, and how do the FMWC ICTs influence those constraints?

(R3) From a social (network) perspective, what are the current constraints on the fieldwork, and how do the FMWC ICTs influence those constraints?

(R4) From a human-actor perspective, what are the current constraints on the fieldwork, and how do the FMWC ICTs influence those constraints?

In the next section, we briefly discuss the particular case study method that we used for addressing the general and specific research questions.

3. Method

We utilized the case-study method with controlled comparisons [12], which informs the dimensions of the combined ORF/CWA framework. We focused on cases in the field, where SPU field crews and crewmembers access and use information, and then take action based on the information (for example, provide information themselves, make decisions, or carry out work orders).

Because the approach is work-centered, we defined a case as a task a crewmember or a supervisor performs. Each task (for example, installing a water hydrant, allocating assignments, drying up a flooded residential basement, or inspecting a catch basin) as performed by a participant was considered a case. One type of task that was performed by two different participants at different times and under different circumstances was considered two cases. Similarly, a participant who carries out two tasks during the observation period contributed two cases to the study.

The instruments we used were: open-ended, semi-structured interviews, field observations, and analysis of both paper and digital documents. In the field interviews, we asked very specific questions pertaining to (a) the worker's, crew chief's, or manager's *personal characteristics* (for example, how long have you been working for the city, what is your position, etc), (b) the *task domain* (for example, what job do you do in your position, for what are you responsible, what activities are involved, what do you need to know, where and how do you get this information, what tools do you use, what is accomplished when you finish the job, what directions do you receive, how do you know when you have done a good job, etc.), (3) the *organization* (for example, how do you decide what method/procedure to use to do the job, who do you normally work with, who decides what work you do everyday, who decides when the work is done, how is work divided, what is your routine during the day, how do you communicate among yourselves, who evaluates the work you do, who decides how the work is to be done, etc.).

Beyond the structured data collection via the questionnaire we also allowed for semi-structured parts during the interviews, we conducted direct observations, and examined digital and paper documents. For this first part of the study, we selected the field crews and managers were selected from DWWD. While crews in the WOD already use FMWC ICT (the pilot), DWWD had just started transitioning towards those tools. In the later parts of our research project, we will cover all SPU fieldwork divisions including the veteran users of FMWC ICT. A second cycle of interviews will take place in each division after the initial cycle to observe changes made over time. This will provide for diversity in the work/task domain as well as in the studied population.

This part of the study is based on ten cases in the DWWD. We interviewed managers, crew chiefs, and crewmembers. We transcribed and coded each case based on a code book after which we folded the cases into a formative model. In the next section we present our high-level findings, which are limited as mentioned by the number of cases and divisions studied so far.

4. Findings

4.1 Setting

The City of Seattle, located in the Northwestern corner of the contiguous continental United States is a vibrant economic, academic, and cultural hub with a population of some 2.6 million in its metropolitan area [2]. This area is also home to innovative and globally operating organizations such as Boeing, Microsoft, Amazon.com, Starbucks, Nordstrom, Washington Mutual among others. Seattle Public Utilities (SPU) is a publicly owned organization serving some 1.3 million customers with water supply, sewer, drainage, and solid waste services (ibid). For providing those services, SPU relies on an evolved system of pipes (with some 1,800 miles of pipelines), reservoirs (with two watersheds and three wells), and disposal and recycling stations (ibid). The Utility provides the area with some 150 million gallons of water and prides itself for an estimated recycle rate of 42 percent (ibid). It also maintains some 1,500 miles of combined sewer and sanitary pipelines with about 46,000 catch basins, services over 200 miles of ditches and culverts, and operates 69 pump stations (ibid). The Utility has to cope with the unique combination of a bustling metropolitan area, which is encircled by both Alpine mountain ranges, the waters of Pacific Ocean, and numerous lakes, rivers, and waterways.

In its field and maintenance operations, SPU has three field divisions, Drainage and Wastewater Division (DWWD), the Solid Waste Division (SWD), and Water Operations (WOD). The results presented here are based on data collected from DWWD. This division is responsible for the maintenance and management of the drainage system within the city by addressing storm–related issues, water quality, and flooding problems accordingly. It is a dynamic work environment dealing not only with customer needs and general maintenance but also with unpredictable weather conditions and other environmental constraints.

In 2001, SPU Field Operations launched its *GoMobile* project, which deployed FMWC ICT to field crews and supervisors. Field Operations Management had four goals in mind, when *GoMobile* was first introduced: (1) Direct work/worker supervision in the field, (2) improvement of decision-making capabilities in the field, (3) improvement of quality and timeliness of field data reporting, and (4) increase (high quality) information provided to field crews [4]. Beyond those explicit and measurable goals, management also expected further benefits from the project such as (a) increased productivity and efficiency, (b) reduced operating costs, (c) improved availability of information, and (d) a more inspired workforce (ibid). *GoMobile* uses International Business Machines' (IBM) MAXIMO® as backend logistics and asset management system and its mobile component (Mobile MAXIMO®). As mentioned before the project was successfully piloted in WOD, encouraging management to expand *GoMobile* to another division, DWWD.

DWWD has two geographical districts, and each includes a manager, crew chiefs, and crewmembers (or workers). Work generally falls into two types of maintenance: Corrective Maintenance and Preventive Maintenance. The first type primarily encompasses responses to problems that had occurred, and the second involves routine inspection and maintenance. DWWD has experienced difficulties in organizing work for the last several years. For example, in the last seven years, five different managers were in charge, and yet a new one was assigned during the period of our observation. In addition, standard procedures are lacking, and workers turnover is relatively high. Training for work at DWWD requires formal training, but most importantly, it necessitates training on the job with an experienced worker. Workers in the Division feel that DWWD customers are their own customers, and aim at providing the best service to Seattle residents. At the same time, most of them find the new technology unhelpful.

4.2 Technology (FMWC ICT and Others)

With MAXIMO® DWWD introduced a new asset and service management system in October of 2005. According to SPU officials, in WOD, MAXIMO® has successfully been used for years to help manage equipment, maintenance related information, work requests and planning, and material. At DWWD, the system is replacing a legacy system referred to as HANSEN. The devices used to access the new system are both ruggedized laptop computers (for managers and crew chiefs) and handheld computers and referred to as "handhelds" (for fieldworkers). Though they are mobile, at the DWWD they are currently not yet wireless as in the WOD. SPU Field Operations Management is planning to change this situation in the near future, and aims at providing wireless handhelds to all workers at DWWD. The required technology is already available, but the pace of the conversion will also be determined by budget constraints.

MAXIMO® is administered by the Assets Information team for the Utility. Crew chiefs, managers, and crew schedulers all have access to the main system interface. In addition to the others, workers who are in charge of the handheld devices for each crew have access to the mobile MAXIMO®. To use the main system interface requires formal training, which is particularly important for the crew chiefs. DWWD trained only the crew chiefs who were in that position at the time of system implementation. New crew chiefs have not received formal training and thus learn how to use the system from the previous ones and through trial by fire. Workers primarily use the work order facility, which gives specific job related information, provides the facility to report observations from the field and tracks worker time and equipment use or maintenance for each job.

4.3 Challenges to Technology Adaptation

The obstacles to the successful implementation of MAXIMO® surfaced when the technology did not fit the work, its organization, and the values typically held by the workers. The fact that such a system cannot account for informal processes and implicit knowledge is the major source to these obstacles. Below are some examples of how these challenges have materialized at the time of our study in the DWWD.

4.3.1 Work Support

One of the main venues for MAXIMO® to support work is to provide the information needed to complete a task. Workers at DWWD, however, felt that some information the system provided was irrelevant, while relevant information was missing.

Workers prepare to go to a site with a work order on their handheld, supplemented by a description of the procedure necessary to accomplish the job, and a list of the equipment that it requires. While it is reasonable to assume that this information will help workers in planning and executing a job by saving their time and providing information they may not have, workers in DWWD don't find this information helpful. The equipment that is listed is not specific or comprehensive enough. Were workers to use the list, they would need to complement it, based on their knowledge of the work. From their experience, workers know that a job cannot be planned to a high level of precision before they are on site. It happened not infrequently that when a problem that is defined one way, reveals itself to be another upon an examination of the site. In such cases, the procedure presented to them by the system might not be relevant.

This situation is not uncommon because much of the information workers need to complete their job successfully is tacit information. They need to see the color of the water, smell it, visually inspect the water checking for debris, tap objects and listen to the sound produced, or to measure the rate of flow before they can identify the exact problem and figure out what specifically needs to be done. Because the design of information systems has not acknowledged the importance of tacit knowledge and has not considered how to complement and support it, MAXIMO® cannot assist workers in this regard. In fact, it reduces work efficiency and increases workers' frustration because it prescribes procedures, and time frame to complete a job based on these procedures, without consideration of the vital role that tacit knowledge plays.

Two types of information that are relevant to work—work and site history, and site map—are missing at this time. Because there are no historical data available related to specific jobs and sites, when workers go out to complete a job they have to depend on their past experience at the site. This is particularly an undesired situation for DWWD because almost half of the workers are in their first one and half years working for the city and lack such experience. A GIS system is integrated into MAXIMO® but workers can get maps only on paper. Often they

have to write comments on a map, record on it if corrective operations are required and what they are, or simply update the map. While workers are used to working with paper, an access to a GIS system will eliminate the need to transfer the information from the paper map, and may afford more flexibility in choosing maps once at a site.

SPU is aware of these deficiencies and is looking for ways to resolve these issues. At this time it seems that no unproblematic solutions are available. Histories of jobs and site have been recorded on MAXIMO®. This information, however, is largely incomplete because it includes records only since October 2005, when the system was introduced. While workers can describe their experiences with sites and jobs with which they are familiar, SPU is apprehensive about collecting this information because it cannot check its validity. The usefulness of being able to display and interact with maps on handheld computers is also uncertain because of the small size of their screens.

4.3.2 Organization of Work

The most obvious obstacle to the adaptation of technology to support the work done in DWWD is the lack of standard procedures and stable leadership. To be useful, the technology design would need to be based on work procedures, and for the system to be able to incorporate those requires that the procedures are clear and consistent. The lack of stable management impedes the process of technology adaptation because the continuity that is required to support the process—including procedures for training, role allocation, and evaluation—are missing. But MAXIMO® presents additional challenges to the organization of work at DWWD.

While MAXIMO® aims at streamlining the flow of work, it cannot easily account for the informal side of work organization. For example, it cannot easily accommodate for work that is initiated by workers when they are on a site; a work that is beyond the work orders given to them for the day. The number of such work orders given to a worker for per day is determined by the estimated time it would take to finish the job, and other considerations. Clearly, the system cannot predict situations in which workers, when working at a site, realize that additional work is required. As a result, MAXIMO® handles such circumstances inefficiently.

Before MAXIMO® was installed, workers could do the additional work required and fill in a work order when they completed the job. With the MAXIMO® system, every work order needs to be approved. As a result workers cannot attend to the problem before the work order they fill is approved. While the system provides functionality for prompt procedure, most workers do not know how to enact it or find it too difficult to use. As a result, the approval process takes some time and may require the worker to go to the site a second time.

A similar issue arises when workers assess conditions in general. In addition to corrective and preventive maintenance, each worker is assigned a specific sector of the city he or she is responsible for proactively keeping an eye on all aspects of the area, and particularly paying attention to the situation along certain roads in the sector that are prone to flooding and mud slides. This is an unwritten rule of sorts and it is not included on any actual work order. As a result, this extra work would not count even when workers spend time to accomplish it. In addition, if workers notice that work needs to be done they fill out a request for work order, wait for it to be approved, and then go back and do the job. This procedure deters workers from being proactive and as a result is likely to cause inefficiencies in the long run.

Another aspect of work organization that experiences difficulties is the organization of the workflow. Crew chiefs are responsible for filtering and assigning work orders to workers. The position of crew chief at the DWWD is rotating among the workers. This arrangement was initiated by the union to make it possible for each worker to be trained in leadership. Filtering and assigning work orders, however, requires certain skills that can only be obtained through training. Because not all workers acquired these skills, not all crew chiefs can carry out their responsibilities effectively. This creates sometimes a bit of a messy situation, inefficiencies, and a sense of frustration among workers.

4.3.3 Workers Values

Workers in the DWWD like to contribute their knowledge and experience to the job, and most of them value being creative and proactive. This is disregarded by the system which leaves very little space for worker initiation. Workers feel that the system attempts to control their work: it prescribes the procedures they should follow in the field; it makes it difficult to make changes when needed (such as attending to another, unplanned job when a job is completed early); it makes it cumbersome for workers to initiate a work order when they spot a problem; and it ignores informal work—work that is done without a work order and is usually initiated by a worker—regardless of how important it might be. The system then makes it very difficult, and sometimes impossible, for workers to contribute their own knowledge and experience or to be proactive.

Receiving no feedback to comments and suggestions typed into MAXIMO® is another source of frustration to workers. They are required to enter information to MAXIMO® that includes specific job-related procedures, notes concerning work that may need to be done in the future, and corrections to information already in the system. Most workers are interested in filling this function; this is a part of their contribution to the DWWD work. There is no feedback to workers about this information, however, and they cannot know if it is ever used to influence future work, or even to correct mistakes already in the system. As a result, workers prefer paper because there is a physical trail and the act of handing off one piece of information to another person. The expectation is that by doing so something will get done or at least acknowledged. Workers can still use paper forms at this time. For the future, SPU is visioning a mode of worker-system interaction through a touch screen only. This will make the interaction efficient, sift out irrelevant information, and make data more accessible. Workers can enter only pre-determined data elements but not elements that are considered irrelevant, and these elements are already organized in fields for retrieval. While technically sound, the effects of such mode of interaction on workers' sense of creativity and ownership should not be ignored.

5. Discussion

In summarizing our findings regarding the *specific research question R1*, that is, what are the current constraints on the fieldwork *from a work/task per*spective, and how do the FMWC ICTs influence those constraints, we found fieldwork at DWWD characterized by high task specificity, detail complexity, and

high work variability. A work order that instructs a fieldworker to repair or maintain a given SPU asset may require widely different tasks and steps to be performed depending on work history, specific modifications, or the specific location of the asset. As a result, neither the maintenance nor the repair work enjoys the luxury of straightforward plannability. Consequently, the fieldwork job at DWWD requires a relatively long apprenticeship type of preparation beyond the formal training. A large portion of a DWWD fieldworker's job proficiency rests on tacit knowing (with regard to both the what and the how). In contrast, the newly implemented FMWC ICT is seemingly based on assumptions that field tasks and work follow straightforward, unambiguous, and highly standardized routines. Hence, fieldworkers currently regard the FMWC ICT as an inconvenient reporting tool, which adds little value, but on the contrary, is blamed for reducing their productivity. In addition, critical geographical information is not yet available via the FMWC ICT, such that critical information is dispersed over multiple media without an easy mechanism to integrate. From a managerial perspective, the current work/task situation at DWWD is unsatisfactory, since the expected improvements and benefits (see section 4.1) have not yet materialized.

With respect to the *specific research question R2*, that is, what are the current constraints on the fieldwork from an *organizational perspective*, and how do the FMWC ICTs influence those constraints, we found that a high turnover rate in the division's leadership in recent years might have limited a hands-on managerial oversight and direction in a critical and deep change process, and hence be attributable to a lack of routines, procedures, when adapting workflows and processes as is the case with the new FMWC ICTs at DWWD. Part of the problem might fuerther root in the enormity of the change, since for the sake of using FMWC ICTs at DWWD also the backend legacy system had to be replaced at the same time resulting in massive organizational changes both in field and back office routines. The partial re-interpretation of the DWWD fieldworkers' role as given by the new system and the perceived lack of sufficient training for the new role and system have so far resulted in suboptimal results also from an organizational perspective. Particularly the expected benefits in terms of productivity gains and cost reductions have not been observed so far at DWWD in striking contrast to the WOD pilot.

Regarding the *specific research question R3*, that is, *social (network)* perspective, what are the current constraints on the fieldwork, and how do the FMWC ICTs influence those constraints, we see a growing tension between the informal organization at DWWD and the new, far more structured, and streamlined formal organization, which the FMWC ICT is beginning to impose. Fieldwork at DWWD is largely unstructured for reasons detailed above. Crew chiefs and field workers filled the gaps, which the formal organization had produced. This gave the crews much free reign, but also put a lot of responsibility on their shoulders. The in large part unplannable nature of the work had necessitated a relatively strong and functioning informal organization. With the new systems, the informal organization would play a different, less important role. However, it needs to be seen, to what extent the new system will able to structure and streamline the tasks and workflows at DWWD. We are not able to answer this question at this point in our investigation.

With respect to the *specific research question R4*, what are the current constraints on the fieldwork from a human-actor perspective, and how do the FMWC ICTs influence those constraints, we observe that fieldworkers and crew chiefs at DWWD expose a remarkable commitment to and pride in their work. They see themselves as important actors in keeping the metropolitan area of Seattle functioning. Also, we found great willingness to use FMWC ICTs in their daily routines. However, so far the fieldworkers' expectations in the new technology were not met; on the contrary, fieldworkers seemed to be concerned about the systems' lack of functionality to support the specificities and complexities of their work. We noticed a growing and openly expressed discontent with the system, which fieldworkers perceived as not adding value, but rather additional reporting burden without offering feedback or other benefit. While certain worker dissatisfaction in the early stages of new technology deployment may be rather the norm than the exception, it may be worthwhile for SPU management to scrutinize more deeply to what extent the new system lacks critical functionality in support of unstructured, ad-hoc, and non-routine work.

With regard to our taxonomy of FMWC ICT, so far we have found only type 2 applications (adapted FMWC ICTs based on existing stationary applications) at DWWD. Essential FMWC applications, which expand and enhance an existing field or back office work, or even help create completely novel types of field or back office work have not been discovered. We believe that at DWWD a high potential for the latter might be identifiable, once fieldworkers and crew chiefs begin to embrace the technology and give input for adding functionality, which in their views more aptly supports their work and information needs.

6. Conclusion

We conclude this discussion and this paper by pointing at the relatively low number of cases, which we were able to accumulate so far (some 20 percent of the overall study). What we present here is preliminary in nature. We are in the process of expanding our investigation to other geographical areas of DWWD as well as to other SPU divisions. At this stage it is premature to provide recommendations or to discuss the findings in light of current theories. It will be most informative to analyze the successful transition towards fieldwork mobility at WOD in contrast to the more complicated transition at DWWD for understanding the differences.

From the perspective of our current understanding, we would not be utterly surprised if we find FMWC ICTs generally more challenging to implement and adopt than less complex ICTs. Based on our current understanding, it would neither surprise us, if we found that human actor (that is, fieldworkers, crew chiefs) involvement in the orchestration of such major transitions involving FMWC ICTs is more essential than in less mission-critical organizational areas.

Finally, FMWC ICT are no different from stationary ICT with regard to their situationality: A success in one organizational unit does not necessarily predispose the success in any other unit.

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