Seattle's Mobile City Project

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Abstract: *The City of Seattle's pioneering Mobile City Government Project has received wide attention, since it promises greatly improved fieldwork operations in local government. Three years into operation and with another fieldwork unit in the process of adopting mobile applications, our research studies the work domains of the units involved to better understand the premises, requirements, and effects of fully mobile, wirelessly connected applications (FWMC). Fully Mobile City Government is an emerging techno-social and organizational phenomenon created by, yet also influencing, human actors who are embedded in a network of relationships and interdependencies of variables, which are in turn rooted in the work and task context of government. The project uses a work-centered analytical framework for deriving and clarifying the strategic choices in such projects via a formative model, which captures and surfaces the interaction and interdependence between major organizational variables and the work context. In this paper, we introduce the research design and report on early observations.*

Keywords: eGovernment, Digital Government, mobile Government, fully mobile wirelessly connected (FMWC), Ubiquitous computing, pervasive computing, integration, interfacing

1. Introduction

eGovernment (digital government, electronic government), it has been envisioned, will enable agile, lean, accountable, and citizen-centric government operations, which are responsive, fast, effective, efficient, and sufficiently integrated (Aldrich, Bertot & McClure, 2002; Bush, 2002; Osborne & Gaebler, 1992; Relyea, 2002; Savas, 1982; Taylor, 1986). Within this context of eGovernment, *mobile government,* as some refer to the use of mobile devices and applications over wireless networks for integrated voice/data communications and transactions, opens new dimensions to and avenues towards that vision. In this vein, fully mobile wirelessly connected (FMWC) applications are being examined and tested by governments for their potential in giving government field operations an unprecedented quality of immediacy in accessing information needed for critical ad-hoc decision making. Many FMWC applications are also sensitive to the ambience and to the needs of the individual worker. The potential utility and efficacy of these applications might significantly help advance the eGovernment agenda. Since major variables of the organizational and work context are immediately impacted, the introduction of new base technologies is highly risky. By developing an analytical and formative model, this research intends to contribute to the understanding of critical interdependencies and interactions between important variables.

The Fully Mobile City research project (mCity) is being conducted with the support of the City of Seattle Public Utilities (SPU) Divisions of Drainage and Wastewater and Water Operations in Washington State, USA. The City of Seattle was one of the earliest adopters of eGovernment concepts and has developed into a nationally and internationally recognized role model for innovative eGovernment practices (Ho, 2002; Kaylor, Deshazo & Van Eck, 2002; Kaylor, 2005). With the advent of sufficiently robust mobile Information and Communication Technology (ICT), the City began deploying and using mobile applications in its field operations (Rysavy, 1999). SPU was among the early adopters of first generation (1G) FMWC applications in its Water Operations group, where fieldworker crews were equipped with FMWC-enabled ruggedized laptops, cellular data phones, and Personal Digital Assistants (PDAs). Since the introduction of 1G-FMWC applications to the SPU Water Operations field crews, in 2002, numerous measured and intangible benefits have been accounted for – such as cost reductions, productivity increases, work process streamlining, increase of data integrity and quality, increased customer satisfaction, and reduced number of task delays among others (Bleiler, 2003). These benefits encouraged the City leadership; but SPU, as well as City of Seattle ICT management, have become keenly aware of the multiple serious challenges when moving from a single-unit, small scale, and incremental pilot, as was the case with Water Operations, towards a multiple-agency, City-wide, ambience-specific deployment of FMWC applications with streamlined and enhanced backend interoperability as well as redesigned work processes in field operations, as is found in the division of Drainage and Wastewater. This research aims at better understanding the interdependencies and interactions of major organizational variables and the work context in field units with mobile applications at the City's Public Utilities. This paper is organized as follows. We first present the relevant literatures and our analytical framework. We then pose our five main research questions and detail our research design. Finally, we discuss the expected results and report on some early observations. We present this research design in some depth hoping that other researchers might be appealed to replicate our study at other sites.

2. Literature and Theoretical Framework

Fully Mobile City Government is an emerging techno-social and organizational phenomenon created by, yet also influencing, human actors who are embedded in a network of relationships and interdependencies of variables, which are in turn rooted in the work and task context of government. Orlikowski & Robey (1991) views uses of ICT in organizations as a social phenomenon both influencing and being influenced by the material and social dimension in which they are embedded (see also DeSanctis & Poole, 2000; Orlikowski, 1992). We have expanded this theoretical approach, incorporating additional elements: (1) the *informal organization* (Katz & Kahn, 1978; Taylor & Van Every, 2000) as an important structural dimension (see also Smart et al., 2002 for the empirically established extensive 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 (see figure 1).

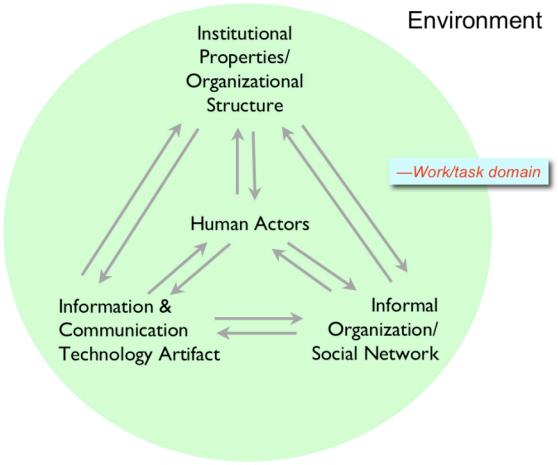

Figure 1 Extended ICT-related Structuration Framework

This extended Orlikowski & Robey framework assists in accounting for the dimensional variables and their interaction and interdependencies, which are critically missing from other research that focuses on isolating factors without acknowledging their recursive relationships. Since we are interested in a formative approach capable of informing both the academic and government practitioner communities, we linked the Orlikowski & Robey approach to the methodological lens of the Cognitive Work Analysis (CWA) framework

(Pejtersen, 1985; Rasmussen, 1986, 1994; Vicente, 1999). This work-centered methodology allows us to systematically address important cognitive tasks performed during work as well as organizational systems in the context of Mobile Government.

CWA provides a macro-level view of work in context. Its elements are illustrated in table 1 (below). They include the individuals' unit and organization culture, their goals and priorities, how they share information, as well as their personal and collective procedures and routines. This framework was originally developed to help information system designers analyze and understand the complex interactions between (a) the activities and organizational relationships and constraints of work domains, and (b) actors' cognitive and social activities and their subjective preferences during task performance. Generalizations developed through the CWA framework are based on a large number of single field case studies. This methodological framework has informed the design of information systems and organizational structures for diverse work domains such as process plants, manufacturing, hospitals, and the military.

By anchoring the study in the context of the task and work domain, we bring several analytical and relevancy-related benefits. Applying this framework will:

- Reduce 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,
- Uncover variable interdependencies and interactions in time and over time, because all variables will be studied at the same time and their interactions will be recorded and analyzed,
- Ground theoretical results in government work practice because data will be collected in the field
- Provide case-related outcome feedback because the results of the study will be based on field cases and will generate feedback that will be relevant to practice,
- Determine case-transcending findings within a formative framework because the results will be generalized through multiple cases.

Dimensions	**Issues to investigate**
1. Work environment analysis	What elements outside the organization affect its work? What are the boundaries for the work environment?
2. 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?
3. 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?
4. 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?
5. 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?
6. 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?
7. 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 outcome of applying the CWA in this study will be a formative model that will lay out the work that is being done in the research site and its interaction with its context. This formative model will guide the generation of technological and organizational requirements for the implementation of FMWC applications in city government.

3. Methods

Similar to the design of other studies situated in the work domain and employing the CWA framework (for example, in manufacturing, in hospitals, or in the military), data will be collected in situ via controlled field studies. The dimensions of the CWA framework will provide the lenses for both data collection and data analysis, which will apply the method of case-study with controlled comparisons, as explained in detail below.

The following research questions will be addressed specifically:

1. What are the social, organizational, task-related, physical, and cognitive constraints under which field workers operate?
2. What characteristics do FMWC applications/devices need to have in order to improve the existing configuration across the various domains (work, task, etc.)?
3. What would a formative model geared to guiding an organization through the transition from non-FMWC to FMWC-supported field operations need to encompass?
4. How would the utility of the model be evaluated?
5. What would make the model transferable to other government agencies in their transition from non-FMWC to FMWC uses?

The project focuses on cases in the field, where SPU field crews and crewmembers have to 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 define a case as *a task a crewmember or a supervisor performs*. Each task (for example, installing a water hydrant, allocating assignments) as performed by a participant will be considered a case. One type of task that is performed by, say, two different participants in different times and under different circumstances will be considered two cases. Similarly, a participant who carries out two tasks during the observation period will contribute two cases to the study.

Data will be collected through questionnaires, structured and semi-structured interviews, direct observation, and examination of digital and paper documents. The field crews and crewmembers will be selected from the Water Operations Division and the Drainage and Wastewater Operations from the City of Seattle, Department of Public Utilities. While crews in the Water Operations Division already use 1G FMWC applications (the pilot), the other two departments currently do not use such applications but are being considered for their introduction. This provides a locus for a well-suited work/task domain as well as a varied population for the selection of study participants.

3.1 Sampling Strategies

We are currently in the beginning stages of the research and are in the process of reviewing the literature pertaining to subject areas relevant to the project. This includes FMWC applications and uses as well as literature relating to the information behavior of fieldworkers. We have also begun analysis of the SPU fieldworker population and different fieldwork types to determine potential participants. A survey will be conducted and participants for the first round of the study will be chosen based on information obtained. Five criteria will guide the selection of these study participants and future participants from fieldwork crew members and supervisors through purposeful sampling (Denzin & Lincoln, 2000; Patton, 2002):

- *Salience of fieldwork type*: We have identified five types: (1) locating infrastructure assets in the City water system, (2) installation/renewal, (3) maintenance, (4) repair, and (5) administration. We will study all five salient types of fieldwork;
- *FMWC Suitability*: How suitable are the predominant fieldwork types for incorporating FMWC functionality? We will rank Suitability on three levels, from "modest" to "high" and study all three FMWC suitability classes;
- *FMWC Readiness*: How ready, open, and prepared for FMWC functionality are field crews and crewmembers/supervisors? We will rank Readiness on three levels, from "rather unprepared/reserved" to "well prepared/highly motivated" and study all three FMWC Readiness classes;
- *Intra- and Interdepartmental Transaction and Information Exchange*: Fieldwork tasks across fieldwork types engage field crews and crewmembers and their supervisors in transactions and information exchanges ranging from (1) intradepartmental only, over (2) moderately interdepartmental, to (3) highly interdepartmental. We will study all three classes of transactions and information exchanges.
- *Willingness to Participate*: We will study field crews and crewmembers (including field crew supervisors) motivated to participate in the study, which promises to produce more relevant data than studying field crews and crewmembers/supervisors with no, low, or limited willingness to participate.

Five to seven initial cases will be observed and analyzed. Participants will undergo an entry interview and data then collected through observation and analysis will be used to develop the initial model for the study. This stage will end with exit interviews of the participants. Each case will then be written up and shared with the participant for feedback and validation. Through this process the initial formative model will be developed and the results will be iteratively integrated into an initial model of fieldwork and fieldwork types which will include FMWC uses.

3.2 Control Groups

Field crews, crewmembers, and crew supervisors who participated in the FMWC pilot at the Water Operations Division will be invited to participate in the study as control groups. Unlike the other participants, those from this group have already been introduced to the FMWC technology. For this group, ten cases will be analyzed to develop a separate model that addresses the constraints, interactions, and interdependencies of the fieldwork and its context for workers who have been using the technology for a few years. Workers in the Division who did not participate in the pilot will be included in the general sample. A comparison between this separate model and the general one will help us understand the impact of the 1G FMWC pilot. The control-group-based model for comparison and cross-model analysis with the general model can additionally be used to help identify and shield against potential bias in the general model.

3.3 Data Collection

Based on the selection criteria specified above we will identify the field crews from which we want to select crewmembers and crew supervisors for study.

(1) *Establishing the Work Domain Context*. We will first conduct a context study, in which we will inspect available documents such as work orders and work reports, organizational charts, work manuals, requirements for the particular fieldwork type, routines, procedures and instructions, and other written work analyses for establishing an initial understanding of the field crew's work context and its specific fieldwork type;

(2) *Identifying Potential Study Participants*. Next, we will invite all crewmembers at the two SPU divisions to participate in a survey, which is designed to identify potential candidates for participation. The survey will include questions that prompt each team member to provide information about their role within the field crew and the work context, the tasks in which they are involved, their information needs, and the use of digital and mobile technology to carry out their work. We will also ask work with other organizational members and persons/institutions outside SPU, crewmembers and supervisors exchange information most frequently. The analysis of responses to the questionnaire will provide us with detailed information about the field crew's work context and its use of information and digital technology. The results from the survey will then guide the selection of crewmembers and supervisors for participation in the study. We will pick crewmembers and supervisors who belong to the same field crews but also aim to introduce into the sample a wide variety of types of tasks, information needs, and ICT uses. An initial diagram of the social networks of the crewmembers, supervisors, and the field crew from the analysis will be derived through this process.
(3) *In Situ Observations*. A researcher will accompany every crewmember participating in the study for at least one whole workday. By so doing, we will observe in situ the workflow, the elements, procedures, routines, interactions, and decisions made as well as the information seeking behavior, the information sources used, and the use of technology for the particular task from beginning to end. These in situ observations will take several weeks to complete and will be iterated until the essential elements, their interactions, and their interdependencies have been captured.
(4a) *Special Foci of Observation*: *Decision making and ICT.* Special attention will be paid to (a) seeking, acquiring, and evaluating information which leads to decisions in the field, and (b) in situ ICT uses in this context. Crewmembers can be engaged in the process by asking them to "think aloud" and share the considerations and the process leading to the decisions made or in the case that a participant is uncomfortable with the "think aloud" procedure, through retrospective analysis or commenting on notes taken.
4b) *Special Foci of Observation*: *Interchanges and interactions with back-office, supervisors, and others.* Special attention must be paid to the interchanges between the participating crewmember and her environment, particularly as they incorporate ICT and information exchange. Documents used or created in that context will also be of interest. Field crew and department meetings are also a rich source of information for observation. These will be audio taped. At the same time, we will also observe the activities of the field crew and the interactions that occur between crewmembers during those events including the uses of and references to ICT in this context.
(5) *Entry and Exit Interviews*. Study participants will be interviewed twice: (a) upon entry and (b) after completion of the in situ observations. In the entry interview, we will collect data relating to the dimensions of the CWA framework (see table 1). In the exit interview, we will review the information seeking and information sharing behavior (with special attention to ICT uses in that context) related to particular decisions made. While we will cover all dimensions in the entry interview, we will focus on dimensions 5 (decision making) and 6 (strategies) in the exit interview, since we will have collected a wealth of data on the other dimensions before.

3.4 Data Analysis

3.4.1 Overview

After transcribing the audiotapes recorded during interviews, meetings, and other data collection instances such as "think-aloud" recordings taken in situ, data will be coded and analyzed using ATLAS.ti. In an iterative fashion, we will create a model of the SPU fieldwork domain and its various dimensions by using the case study method with controlled comparisons (Fidel, 1984; Stake, 1995), which is appropriate when in situ research is conducted without clear demarcations between phenomenon under study and the embedding context (Yin, 1981, 1989).

3.4.2 Iterative Observation and Analysis Process

After data for the first case of the first field crew (that is, the first participant to carry out the first task) is collected it will be analyzed and a first formative model will be developed. This first model will delineate the work context and the opportunities for information interactions. This analysis of the first case will continue until all (1) the dimensions of CWA are fully presented, and (2) the observed information interactions are described and explained. The observation of the second case will begin after the analysis of the first case has been concluded. After the observations of the second case have been completed and transcribed, the researchers will analyze the second case. The results will be compared with those gained from the first case and will be integrated with the model of the first. That is, the second analysis will expand the model and will reflect the analyses of two cases. This iterative and cumulative process will continue until the model reflects all cases studied with the first field crew. We will then approach a second field crew and its members/supervisor and start the next cycle in the iterative observation/analysis process. The model continues to expand until it includes all cases studied in the second field crew. We will continue the process with the next field crew until the entire sample is covered. Upon completion of these cycles we will have a highly integrated and detailed model of the fieldwork context at SPU and its various fieldwork types including the constraints rooted in stationary and mobile ICT uses.

For developing the integrated model as well as for deriving the requirements based on the model as specified below, we estimate the need for observing and analyzing about 50 cases within 15 to 17 field crews, that is, an average of three cases per field crew. Previous experience indicates that about 10 cases in a particular situation capture most of the complexity involved such that we can sufficiently cover all fieldwork types.

4. Results (Expected and Preliminary)

This integrated model will comprehensively lay out the context in which SPU fieldworkers operate, use ICT (including FMWC) applications, interact internally and externally, and make their decisions. In particular, the model will explain and describe the information interactions involved in the fieldwork organization and decision-making processes. Hence, the model will present in detail the types of information, which fieldworkers create, seek, use, and share in the fieldwork process as well as the respective information formats. Along with the other elements in the model, we will examine the information types and formats used, which helps us specify the requirements for ICT applications, document design, work procedures, incentives, or other transfer modes of non-documented information. Deriving context-specific requirements enables us to identify and specify the potential uses and formats of FMWC applications for the various fieldwork types.

4.1 Early Observations

Already, at this early stage in the project we have collected some data, which we present here with the caveat that they are incomplete and preliminary in nature. These data are anecdotal. We are using them for merely illustrative purposes, and more research is necessary to validate and confirm these findings. A known issue for organizations in change processes involving new information technology also found at SPU Drainage and Wastewater Operations is a relatively high rate of change in leadership and frequent recent modifications of organizational structure. New departments and units have been created, and individuals have been transferred within the organization from one role to another. Due to retirement and other attrition, the unit leadership had to engage in hiring people from outside to fill vacancies. Some change is triggered by the organizational structure and the underlying philosophy: In order to provide all members of the field crews with the opportunity to lead, field crew lead positions are open on a rotating basis every three months. Although this rotational scheme provides a valuable opportunity for the individual workers to expand their capacity, the rapid turnover in field crew leads to organizational friction and individual experience of stress. The introduction of new technology in this context has been found an additional and disruptive burden by quite a few fieldworkers. Management has recently come to an agreement with the labor union and the scheme of rotating field crew lead positions will be extended from a

period of three months to one of six. In addition, workers in the Drainage and Wastewater Operations are older on average than those in the Water Operations where the FMWC pilot was successfully carried out. The older workforce might be more entrenched in their way of doing things and more reluctant to change from one backend system to another. An older workforce, of course, does not only present challenges to the implementation of new technology. The organizational memory that older employees carry with them is being lost before they can sufficiently train new employees or take advantage of the new logistics and planning system. The new system allows workers to manually input important information concerning location and job procedures. Since the implementation of the system has been running into difficulties the opportunity to train and require employees to use this feature is being missed.

Another potentially aggravating factor might lie in SPU management's attempt to implement several major technological and organizational changes simultaneously. For example, the decision to use mobile technology in the Drainage and Wastewater Operations also triggered the decision to replace the backend logistics and planning system at the same time. The new backend system was chosen primarily because of its superior integration with the mobile technology. However, the field crew workers, specifically the field crew chiefs and their supervisors, are obviously struggling with two those concurrent changes while maintaining their basic workflow responsibilities. This preliminary data seems to indicate that not all of the problems, which Drainage and Wastewater Operations face, might be technology specific. An aging workforce, organizational change, and introducing two major innovations at the same time, in this case mobile technology and replacing the backend system, might pose significant challenges to ultimate project success.

4.1 Outlook on Future Work Progress

As a premier principle for evaluation in qualitative research, the *principle of theory* has been articulated (Davison, Martinsons, & Koch, 2004). This study rests on the ICT-related theory of structuration (DeSanctis & Poole, 1994; Giddens, 1984; Orlikowski, 1992; Orlikowski & Robey, 1991) and connects it with the theory of organizational transformation (Watzlawick, Weakland & Fisch, 1974; Erlandson, 1993 & Fidel, 1984) in the context of eGovernment. As a methodical lens, CWA enables us to account for and operationalize the various high-level variables as well as their interaction and interdependencies. Another important principle for evaluating qualitative in situ studies is the *principle of researcher-practitioner agreemen*t, without which the research might be ill anchored (Lincoln & Guba, 1985). In addition, since the metrics used in qualitative studies vary, we rely on the *principle of result triangulation*, (Patton, 2002), which we will employ throughout the analysis process. Further, we will use the member-checks procedure to continually validate our model (Schwandt, 2001). At the conclusion of each case, the researchers will write a report analyzing the fieldwork task and decision-making process, the information interactions, and the ICT uses during the process. The participant involved will receive a copy of the report and will be asked to provide feedback to the research team about the validity of the analysis.

Techniques for controlling for and ensuring trustworthiness of findings (Erlandson, 1984) will be employed as will techniques for tempering distortions potentially introduced by the presence of a researcher, or by temporal or unusual events. Further, the collection and analysis of documents—such as work reports, work orders, exception reports, fieldwork procedures, and organizational charts—will also support the credibility of the results. Peer debriefing will also be used to enhance the credibility of the project.

Periodically (that is, about every ten cases) we will involve a different expert peer not engaged in the project for testing and for providing feedback on our working hypotheses and the emerging model. We will particularly engage eGovernment practitioners and academics to help assess the transferability of findings to other venues. Finally, we will check the completeness of the model against the emerging literature on FMWC fieldwork uses for ascertaining that no important factors are missing from the model. In this context, we will use the control groups as outlined above. In case of missing factors, we will perform additional analyses of the data.

5. Conclusion

While mobile information and communication devices (radio, Global Positioning System devices, laptops, cell phones, Personal Digital Assistants (PDAs), etc.) have been in use for some time, the rapid merger of Internet and high-speed wireless communication technologies yields a new class of uses in both field and back office work (Capra, Blair, Mascolo, Emmerich & Grace, 2002; Gorlenko & Merrick, 2003; Scholl, 2005). In government, we see this emerging class of fully mobile wirelessly connected (FMWC) applications posing unprecedented opportunities and unique challenges (1) in the work and task domain as well as in the uses of (2) information and (3) ICT, potentially leading to significant organizational transformations and also changes in social networks. Through the research highlighted above, we will (a) develop and refine an analytical framework for mobile eGovernment work design, which we will use for (b) assessing the efficacy of emerging mobile eGovernment work designs including (c) field worker acceptance and support of those designs. Finally, we will study (d) the policy choices in mobile eGovernment diffusion from a work and task design perspective, which accounts for the particular characteristics and constraints of FMWC applications and their interdependence with organizational structure, social network, and human actors. Again, we would welcome if other researchers replicated our study to facilitate comparisons between the cases, which would help deepen the understanding of the multi-dimensional problem space.

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