ABSTRACT

Title:	THE FEASIBILITY OF USING WEB-BASED TECHNOLOGY FOR THE MANAGEMENT OF DREDGING PROJECTS
	Gustavo A Vecino, Doctor of Philosophy, 2016
Directed by:	Professor Miroslaw Skibniewski, Ph.D., Department of Civil and Environmental Engineering

The research investigates the feasibility of using web-based project management systems for dredging. To achieve this objective the research assessed both the positive and negative aspects of using web-based technology for the management of dredging projects. Information gained from literature review and prior investigations of dredging projects revealed that project performance, social, political, technical, and business aspects of the organization were important factors in deciding to use web-based systems for the management of dredging projects. These factors were used to develop the research assumptions. An exploratory case study methodology was used to gather the empirical evidence and perform the analysis. An operational prototype of the system was developed to help evaluate developmental and functional requirements, as well as the influence on performance, and on the organization. The evidence gathered from three case study projects, and from a survey of 31 experts, were used to validate the assumptions. Baselines, representing the assumptions, were created as a reference to assess the responses and qualitative measures. The deviation of the responses was used to evaluate for the analysis. Finally, the conclusions were assessed by validating the assumptions with the evidence, derived from the analysis.

The research findings are as follows:

1. The system would help improve project performance.
2. Resistance to implementation may be experienced if the system is implemented. Therefore, resistance to implementation needs to be investigated further and more R&D work is needed in order to advance to the final design and implementation.
3. System may be divided into standalone modules in order to simplify the system and facilitate incremental changes.
4. The QA/QC conceptual approach used by this research needs to be redefined during future R&D to satisfy both owners and contractors.

Yin (2009) Case Study Research Design and Methods was used to develop the research approach, design, data collection, and analysis. Markus (1983) Resistance Theory was used during the assumptions definition to predict potential problems to the implementation of web-based project management systems for the dredging industry. Keen (1981) incremental changes and facilitative approach tactics were used as basis to classify solutions, and how to overcome resistance to implementation of the web-based project management system. Davis (1989) Technology Acceptance Model (TAM) was used to assess the solutions needed to overcome the resistances to the implementation of web-base management systems for dredging projects.

THE FEASIBILITY OF USING WEB-BASED TECHNOLOGY FOR THE MANAGEMENT OF DREDGING PROJECTS

by

GUSTAVO A VECINO

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Advisory Committee:
Professor Miroslaw J. Skibniewski, Chairman
Professor Gregory B. Baecher
Mr. John H. Cable
Dr. Gerald E. Galloway
Professor Daniel P. Lathrop (Graduate School Dean Representative)
Professor Paul M. Schonfeld

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1. INTRODUCTION

1.1. Overview of the Current Dredging Industry

The operation and management of a dredging operation requires costly high-performance equipment and expensive specialized resources. A major dredging project may represent approximately $1.2 million in value of production per day. Lack of optimal information flow to owners and contractors during dredging operations introduces risk, errors, and claims. Any time lost due to errors or owners and contractors lack of information, greatly affects the project.

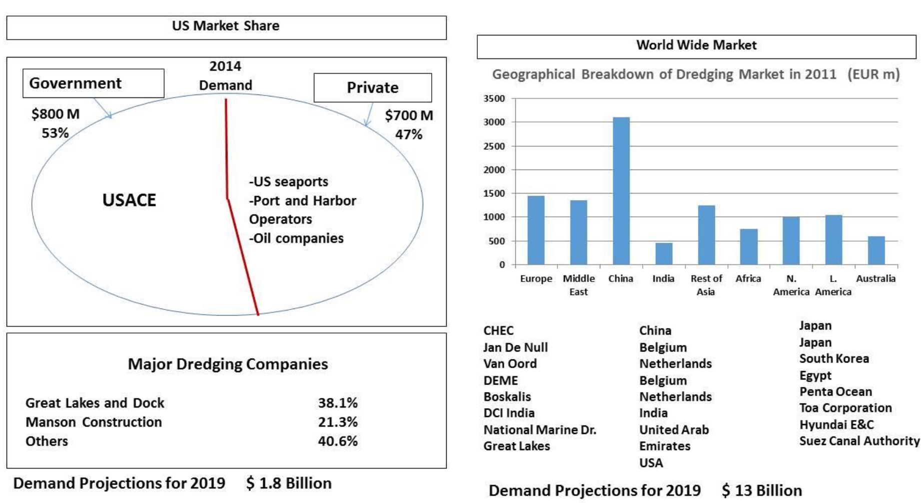
In 2013, global revenue of the dredging industry was approximately $11 billion per year and increased at a rate of 2.7% compared to 2012 (IADC, 2013). Figure 1-1 shows the worldwide dredging market ecosystem. In the U.S., the U.S. Army Corp of Engineers manages 53% of the dredging market. U.S. ports, ports and harbor operators, oil companies, and the private sector handle the remaining 47%. The projected U.S. dredging demand for 2019 is approximately $1.8 billion. The worldwide demand projection for 2019 is $13 billion (Rabobank, 2013.) Appendix B shows a list of major dredging companies worldwide.

The dredging industry has a major influence on the performance of water-borne trade and thus on the world's economic wealth, as well as on marine and coastal ecosystems. Dredging projects create and maintain navigational channels, maritime infrastructures, marine and coastal ecosystems, and civil engineering structures. To create and maintain these structures, dredging projects excavate material from the bottom of the waterbed to create and maintain channels and use the dredged material to create or maintain onshore and offshore structures. Examples of these structures are navigational channels that create passage for the maritime trade to distribute goods around the globe, e.g. the Panama Canal, the Suez Canal, access channels to maritime ports, navigational rivers, and waterways.

Currently, new supersized ship requirements are creating pressure on the dredging industry to construct deeper and wider navigational access channels to support new cargo ships that will travel the Panama and Suez canals after current expansion. The new canal capabilities to support supersized cargo ships will become effective in 2016.

Dredging equipment is costly, and projects require high levels of production. Dredging operations are often performed in remote areas by excavating large volumes of rock, sand, clay, or silt material from the bottom of a waterbed with no direct visual feedback from the dredging area. Therefore, excellent operational and managerial processes are vital. Time and productivity losses due to an inaccurate dredge position, over-excavation below the intended/design surface, or lack of optimal flow of information are destructive and extremely onerous.

Figure 1-1. Dredging Industry Ecosystem (Rabobank, 2013)



1.2. Performance Problems with Dredging Projects

Dredging projects are hampered by claims, change orders and errors because of the lack of shared information between management and the operating team (see examples in Chapter 4). This lack off effective information-sharing impacts cost, duration, and quality of dredging projects. An array of projects were investigated encountering the same systemic issues, where project cost overruns varied from 11% to 25% due to errors and claims (see Table 1-1.) From Table 1-1, it can be inferred that the average cost overrun is nearly 20%. Statistical information on cost overruns is not readily available.

Table 1-1. Projects Contract Information

Project Location	* WPMS Concept Applied	Initial Cost (M)	Final Cost (M)	Cost Increase (M)	Claim (M)	Schedule	No. of Claims	Comments
US	Yes	32	33	1	1	No	1	
US	Yes	22	22.3	0.3	6	No	1	
US	Yes	61.6	62.7	1.1	3	Yes	1	
US	No	4	4.7	0.7	0.7	Yes	1	
US	No	5	5.8	0.8	0.8		1	
US	No	4	4.7	0.7	0.7	Yes	1	
Colombia	No	150			80		3	Project was not completed
Colombia	No	10	12	2	2	Yes	2	
Colombia	No	3	3.5	0.5	0.5	yes	1	
Colombia	No	13	14.5	1.5	1.5	no	2	
Colombia	No	6	6.7	0.7	0.7			
Colombia	No	120			30	Yes	3	

* Concept Applied – Used the Project Management Frame for Dredging Projects (PMFD) without the Web-based tools functionalities (Skibniewski & Vecino, 2011).

Our estimated 20% overrun in dredging project cost may be conservative compared to the 30% overrun in construction reported by Built Environment and Transport Panel. Recent studies in the "U.S., Scandinavia, and the UK suggest that up to 30% of construction is rework, labor is used at only 40-60% of potential efficiency, accidents can account for 3-6% of total project costs, and at least 10% of materials are wasted" (Egan, 1998.)

Errors and claims can result from lack of good management processes. The errors and claims addressed in this research are not related to equipment capabilities or to means and methods. They are related to inadequate information flow during the life of the project and, to the lack of quality information or thorough knowledge of the site conditions. When this happens, project management efforts are hampered. Project control is hindered, and decision-making is delayed. In general, all management processes are affected, generating errors and claims.

For example, the competing interests of the management team and the operating team during project performance create conflicting conditions within the project environment. The management team would like to have their projects delivered within budget, on schedule, and with the quality defined in the specifications. The operating team would like to deliver the project while maximizing resources. As a project evolves over its life cycle, action and reaction of project parties due to an evolving project environment affect project performance. The results of these actions and reactions associated with the inherent technical and operational difficulties of the project affect management processes.

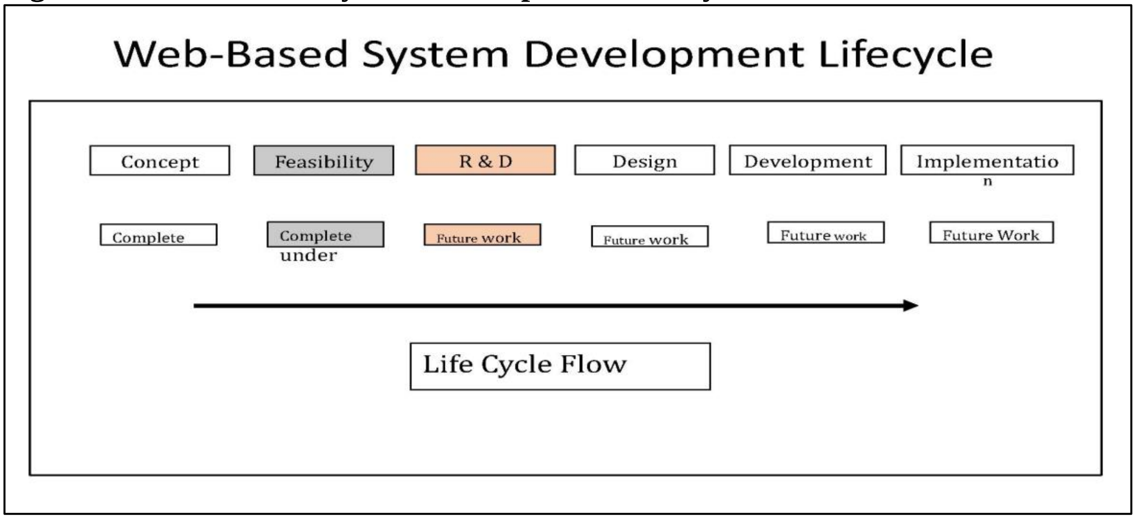
1.3. Web-based Project Management Systems for Dredging

The use of Web-based technology (explained in Chapter 3) for the management of dredging projects is new in the dredging industry. The U.S. Army Corps of Engineers started introducing it in 2006. However, to date has not been widely used. This research assessed both the positive and negative aspects of implementing a web-based project management system for management of dredging projects (WPMS). Assessing the correct implementation strategy is important before investing substantial resources to develop the system. This research used the exploratory case study methodology to assess the negative and positive aspects of implementing the WPMS.

Currently, dredging projects management systems are develop by major companies, and customized to their needs. The bulk of the industry currently uses traditional methods to convey project information and to implement management processes. Even with advanced systems, dredge information is captured and transmitted using manual logs. Proper risk management is not the norm, and owners and contractors are disconnected. Information flow cycles are delayed by days or weeks (see Section 3.2). Project control is limited, and decision-making is delayed.

As a solution, a Web-based Project Management System (WPMS) for dredging projects was developed as a conceptual framework. The American Society of Civil Engineers (ASCE) published this work in the Journal of Management in Engineering, (Skibniewski & Vecino, 2011). To materialize the concept, a prototype of the system was created. The creation of the WPMS includes the concept, feasibility, design, development, and implementation phases The concept of the system is describe see Chapter 3 and feasibility assessed in this research. The feasibility study concluded that more R&D is needed before continuing to final design (see Figure 1-2).

Figure 1-2. Web-Based System Development Life Cycle



This figure shows the feasibility study developed in this investigation within the WPMS development life cycle.

1.4. Feasibility of Web-Based Project Management Systems

This investigation assessed the feasibility of the Web-Based Project Management System (WPMS), and proved that the WPMS is viable from a project performance standpoint. However, it was discovered that users from distinct segments of the industry would be likely to resist implementation of the system due to, political, technical, and business issues. Thus, special requirements are needed during system design, and more R&D is needed before advancing to final design and implementation

WPMS Cost

The investigation revealed that the system might positively influence the organization's business competitiveness by improving performance. However, concerns about the cost of using the WPMS were raised in the responses of the experts surveyed. The cost of the WPMS was estimated and a break-even point was developed (see Figure 1-3). Table 1-2 below shows that the break-even point is achieved at a $300K project cost (or a production of 20,000 cubic yards (CY) at $15/CY). Therefore, even though this project size is considered a very small project within the dredging industry, it would pay for the cost of using the WPMS.

Based on Table 1-1, the mean value for dredging projects cost overruns is approximately 20% due to errors and claims. The objective is to reduce this cost overrun to a minimum, with a target of 0% in overrun costs. The first three projects in Table 1-1 used only the project management techniques proposed by Skibniewski & Vecino (2011). The implementation of these techniques alone reduced overruns from 20% to 2% (see Section 1.2). If the full-scale WPMS is used, the actual project cost may even be reduced from its original cost estimate, as a result of the performance improvement generated by the WPMS .

Figure 1-4 illustrates that the cost of the system diminishes quickly as the project cost increases and levels out after a project cost reaches $10M. Projects above $10M could pay the system for less than 4% of the total project cost while potentially reducing costs by more than 20%.

Figure 1-3. WPMS Cost Break-even Point

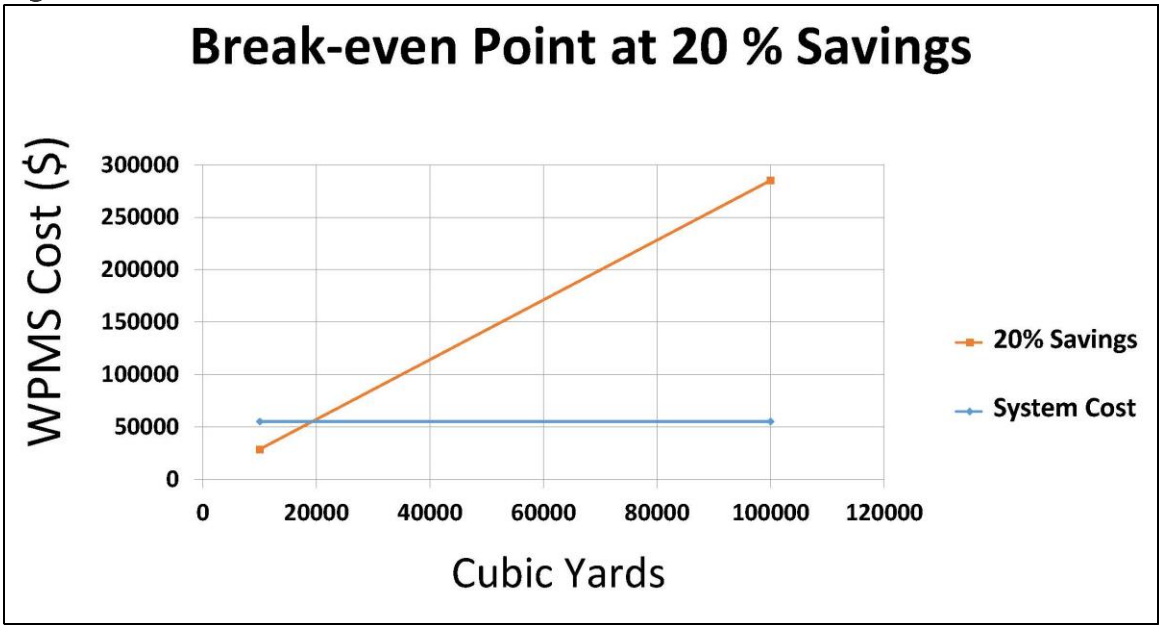
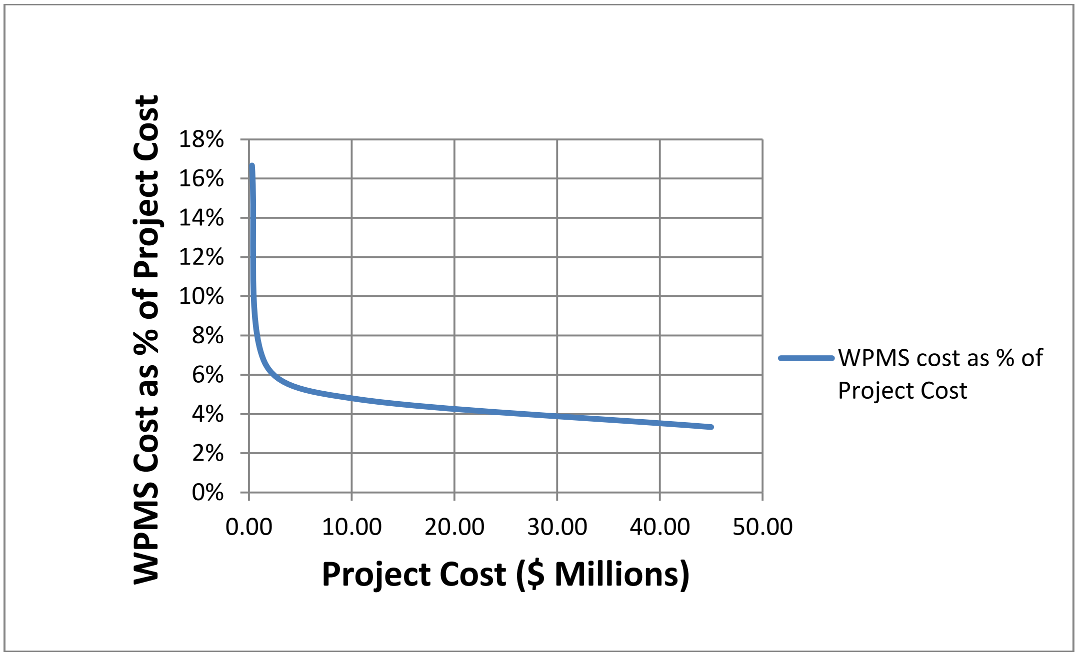


Table 1-2. Project Cost vs WPMS cost

Project Cost (in $ million)	WPMS Cost(%/Project Cost)
0.30	17%
1.50	7%
10.50	5%
45.00	3%

Figure 1-4. WPMS Cost as % of Project Cost



1.5. Research Strategy

The research assessed the feasibility of using the WPMS and analyzed the positive and negative aspects of using the system. It includes the influence of the WPMS on performance, the influence on the user's social, political, and technical environments, and the influence on business competitiveness.

The research studied three projects and surveyed 31 industry experts. The projects experts of one of the projects participated in the concept development, the definition of system requirements, and prototype design. During data collection, the experts interviewed participated in two brainstorming system-simulation sessions to discuss system performance/functionality and to respond to the research questions. The responses were used to validate the research assumptions, to assess feasibility, and decide if the system should move to the design and implementation phase.

1.6. Contribution to the Body of Knowledge

The results of this study may motivate dredging project teams to use the system to improve performance, and may also help owners and contractors understand their need to reduce complexity of dredging project management processes that affect current project performance.

The study sheds light on how owners and contractors can collaborate to create a win-win environment during a dredging operation in order to facilitate project management and improve performance. The study results demonstrate that owner and contractor informational needs must be assessed during the design phase of the WPMS in order to optimize the dredging project's operation and management.

This study shows that use of the WPMS can have a significant beneficial impact on project performance. As presented by Vecino and Skibniewski (2011) and by Raymond and Bergeron (2008), adding appropriate information system tools to automate and standardize the flow of project information may further improve project performance.

In addition, this investigation exposes the concept of combining project management techniques, Web-based technology, and communication infrastructure for the management of dredging projects so that other investigators can expand on the concept.

The study explores the use of web-based technology for the management of dredging projects, to introduce Internet of Things (IoT) concept into the dredging industry environment. IoT is intended to connect people, data, things, and processes into several organizational networks.

The system also explores the concept of continuous connectivity to the internet, even in remote areas, by using redundancy between several technologies, namely WI-FI, Cellular Networks, and Satellite Communications.

1.7. Research Context

In Section 5.1, the study established three assumptions. Assumption 1 – The use of the WPMS will have a positive influence on dredging project performance. Assumption 2 – The design and implementation of the WPMS requires considering social, political, and technical aspects of the organization. Finally, Assumption 3 – The design and implementation of the WPMS requires considering the business aspects of the organization.

The context of the study depends on the research assumptions being studied. The assumptions were reviewed for the context needed to achieve the research objective. Assumption 1 and 2 used the project as the context of analysis, and Assumption 3 used the business organization context as defined below.

To facilitate the analysis generalization a model was created (see Figure 1-10) to rationalize the interpretation of the responses from the different types of delivery systems and contract arrangement considered in this research.

Project Context

A project as defined in the context of this study is a temporary endeavor undertaken to perform dredging, and includes all the organizational units and processes directly involved in the project, including the project management team, the operating team as defined below, the equipment, and the management processes.

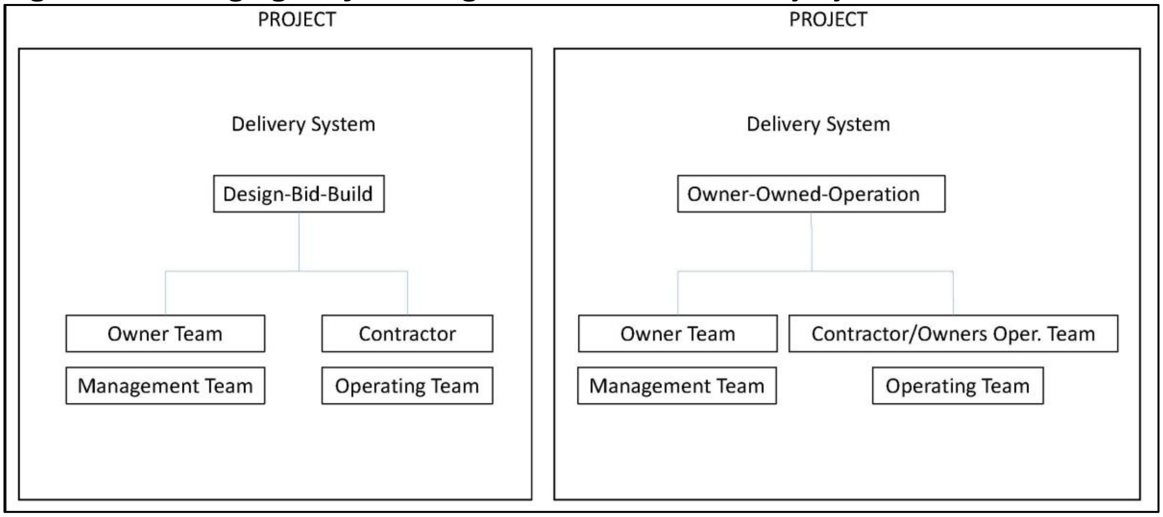
Project Management Team and Operating Team

Two basic project delivery systems will be used for the research analysis: the design-bid-build delivery system and the owner-owned-operation delivery system. The design-bid-build is the standard delivery system used for dredging contracts. It includes the owner's team and the contractor. The owner's team designs the project and the owner then hires the contractor to perform the work. In the owner-owned-operation delivery system, the owner company owns the equipment and performs the work with its own people or hires a contractor to operate the dredge. In order to characterize both delivery systems into one concept and be able to generalize from the projects studied, the research defines two project organizational components for both delivery systems: the management team and the operating team. The management team includes the owner and the owner's team, and the operating team includes the contractor or the owner's personnel operating the dredge.

Business Organization Context

The business organization context include an independent business entity that may participate in a dredging contract and will fit the definition of management team or operating team above. The business organization may be a project owner or a contractor. The management team and the operating team may be different organizations where the design-bid-build delivery system is used. The management team and the operating team may belong to the same organization where the owner-owned-operation delivery system is used. However, the owner-owned-operation delivery system may use an independent organization to operate and manage the dredges as with Project B (see Figure 1-5 below).

Figure 1-5. Dredging Projects, Organizations, and Delivery Systems Model



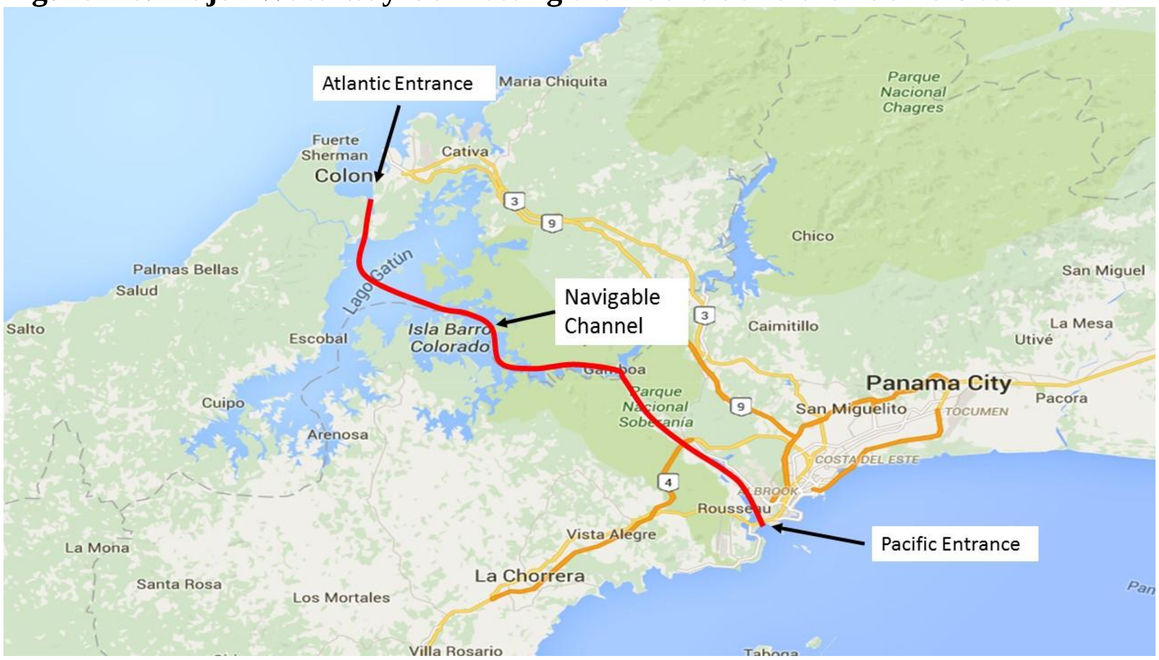
Projects Studied During the Investigation

Three projects were studied during this research. Project A uses the owner-owned-operation delivery system and is a continuous dredging operation for the maintenance of a navigational channel. Project B uses a combination of the design-bid-build and the owner-owned-operation delivery system. It is a dredging operation to recover the navigability of a river. Project C uses a design-bid-build delivery system and is a project managed by an organization responsible for the management of a large portfolio of dredging projects.

1.7.1. Project A: Major Waterway Connecting the Atlantic and the Pacific Ocean in Central America

Project A owns and operates four dredges, 24 hours, seven days a week. Project A operates a dipper dredge with a 15 CY bucket, two hydraulic dredges and a 31 CY backhoe dredge. The main objective of the dredging operation is to maintain the navigability of the channel (see Figure 1.6). Project A also used its dredges to execute the portion of the excavation needed for the channel expansion.

Figure 1-6. Major Waterway Connecting the Atlantic and the Pacific Ocean



Project A manages the dredging operation using the following organizational units: the management team includes the Dredging Division in charge of planning, coordinating, and executing the dredging operation; and the Engineering Division in charge of validating the dredge work in terms of quality and quantity, and maintains channel geometry for navigability conditions. The operating team includes the dredge captain and operators, as well as the engine, deck, and tugs crews.

Project A needs to dredge approximately 100 million cubic meters of material to complete the expansion navigational channel. In addition, Project A needs to perform maintenance dredging continually to maintain the channel navigability.

The dredging project management processes starts with the technical planning, performed by the Engineering Division. This technical planning uses preliminary hydrographic surveys as inputs to assess which part of the canal needs dredging. The Engineering Division informs the Dredging division of the technical details and the Dredging Division plans the operation and prepares the equipment needed for the operation. The equipment is located at the site and the dredging starts. During the dredging operation, the Dredging Division oversees the operation and performs quality assurance. When the dredging operation is complete, the Engineering Division is informed and they perform the validation of the excavation by doing a final hydrographic survey of the area.

Project A has had problems with unstable slopes, and these areas are under constant slope stability control. In this area, the dredging operation should be executed with care, so the dredge does not dig into the slope, which could destabilize the slope and create a landslide. Project A is investigating what tools can be used during dredging operation to prevent over dredging and slope destabilization.

Project A dredging operation project was used as a research case study. Project A is seeking to improve their dredging operation and they were interested in using their dredging operation as a case study. In 2013, Project A was visited, and the requirements and specifications for a web-based system prototype, for the management of dredging projects, were defined. In a later visit, the requirements and specifications were refined and a prototype was developed. In Chapter 3, the system prototype developed is described.

1.7.2. Project B: Recovery of the Navigability of a Major River in South America

In order to expand the evidence and extend the research context to others types of projects and delivery systems, Project B and C, defined below, were included in the investigation. Extending the research by adding two more case studies, expanded the research coverage to include other contractual, programmatic, and organizational conditions in the evidence. Therefore, allowing the generalization to the research assumptions. Project B is managed by a state-owned organization and uses a combination of the design-bid-build and the owner-owned-operation delivery systems. The management team owns two dredges and has an operating team (contractor) in charge of the managing the technical aspects of the project and the operation. The objective of the project is to recover and maintain the navigability of the river (see Figure 1-7). This project is important for the study because of the project size and complexity. The decision makers are looking for best management practices to handle their project.

Figure 1-7. Recovery of the Navigability of a Major River in South America

The project is being executed using a 20 year private-public partnership contract between the state-owned organization, and a private contractor. The project's basic objective is to maintain the navigability of 560 miles of the river, stabilize 159 miles of river channel and maintain a Satellite Navigation System. The navigability of the river is important to diversify the total tonnage of cargo being moved across the country. Currently trucks are moving approximatelly180 Million tons per year, while barges are only moving approximately 2 Million tons, due to very poor navigability.

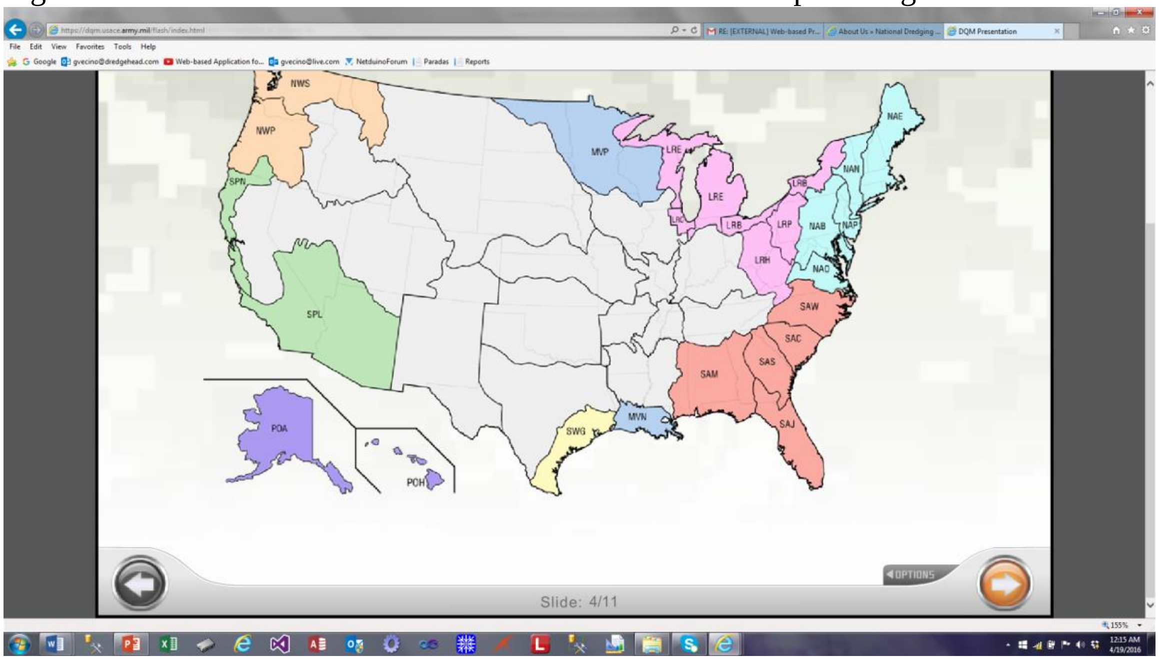
The state owned organization awarded the contract, in 2015, to the contractor who will execute the dredging operation. The state owned organization owns two dredges to be used in the contract. The dredges are operated by the contractor, which will add more dredges to the project as needed.

1.7.3. Project C: US Army Corps of Engineers (USACE) Model Project

This project model represents part of a larger portfolio of projects that primarily performs maintenance dredging and uses the design-bid-build delivery system. This project was added to the research, as a case study, given its special combination of managerial, programmatic, and organizational features. In addition, the USACE manages 53% of the dredging contracts in the US (Rabobank, 2013). The USACE, the management team in the context of this research, is experienced in the management of dredging projects. The operating team, a contractor, performs the dredging using a unit price contract. An important motivation for adding this model project as a case study to the research is because it adds new variations, in the type of contracts considered by the other two case study projects. In addition, the USACE is implementing a web-based project management system called Dredge Quality Management (DQM) (former Silent

Inspector), for their dredging projects. The evidence gathered from this model project will reinforce the research results. The DQM program is described in Section 2.4.

Figure 1-8. Coastal and Great Lakes Civil Districts of the Corps of Engineers



https://dqm.usace.army.mil/flash/index.html. April 19, 2016.

1.7.4. Research Context Summary

The three projects studied have different organizational structures, but the model (management team/operation team) used for the analysis was flexible enough to simulate the prototype and gather the evidence needed to evaluate the research objectives. This included the three projects studied and any other typical dredging project addressed during the interviews. The flexibility of the model allowed gathering of evidence from other experts in the industry. Conceptually, the model used to simulate the system included all the basic functionalities needed by a typical dredging organization to perform its activities. The three projects' operation and business processes may diverge in some aspects, but their basic functionalities are similar enough to be modeled using the WPMS and do not impede the research analysis.

2. LITERATURE REVIEW

The Web-Based Project Management System (WPMS) studied here uses project management techniques, information systems, and communication infrastructure technologies to facilitate the management of dredging projects. Because the objective of this research is to assess the positive and negative aspects of implementing the WPMS, Related theories will be discussed as the basis for the analysis.

2.1. Overview of Information Systems for Project Management

In 1962, J.C.R. Licklider, wrote a series of memos describing how networking enables social interaction. The next huge step was the development of ARPANET in 1966, which ultimately grew into the INTERNET. In 1972, the first email application was presented to the public (Internet Society, 2014).

Similarly, in 1970 Edgar Codd developed the relational model for databases Codd (1970). He developed a prototype of the Structured Query Language (SQL) in 1974 and released in 1981. Modern Web-based support infrastructures began in the late 1990s.

During the 1990s, emerging technologies converged into what is today a very powerful and versatile tool for managing information. Research related to computerized information technology and its uses in construction were evolving during those years. The majority of the literature generated during this period, and during the beginning of the subsequent decade, focuses on the influence of information technology on construction processes. During this period, different Web-based technologies were evolving. Johnson and Clayton (1998) worked on the idea that information technology facilitates management and innovation for facility administration and related construction and engineering organizations. The results of the research showed that information technology was becoming a strategic necessity because it was beginning to alter the basic economics of engineering and facility management organizations.

During the beginning of 2000, researchers began showing interest in how the Web could facilitate the management of construction projects. In 2001, Deng et al studied an Internet-based project management system called “Total Information Transfer System.” This application comprises six major functions including data exchange, information exchange, internet chat, live video-cam, search engine, and auxiliary services. Similarly, Alshawi and Ingirige (2003) discussed how web-based technology enabled management to improve quality, competitiveness, profitability, and increased value to clients.

Our literature review showed that between 2000 and 2010 web-based technology gained strength within the project management paradigm. During this period, researchers were looking at success/failure factors of web-based construction management systems (Nitithamyong and Skibniewski, 2004). Similarly, researchers investigated the justification of IT investments, benefits, and cost (Love and Irani, 2004). By the end of the 2006, researchers showed that the contribution of Web-based systems to the success of construction projects was still unknown. “…effectivenes of most PM-ASPs is not yet as high as initially expected, mainly because many important factors that can greatly impact systems performance are still left unknown or misunderstood.” (Nitithamyong and Skibniewski, 2006).

Raymond and Bergeron (2008) concluded that information systems did not lead directly to project success, but only "through its contribution to managerial work." This scientific rationale shows that not only are the technical and physical aspects of an information or computer-based system relevant to design and implementation, but the human component is critical as well. Markus (1983) studied this interaction between the system and the organization's social environment and investigated the theory of resistance to implementation. This defined the need to combine system and human interaction in this analysis.

Given Raymond's and Bergeron's (2008) rationale and Markus's studies of the interaction between the system and the organization's social environment, resistance to implementation will be included in this analysis.

2.2. Web-Based Technology for Management in Construction Projects

The literature review shows that information and studies related to the use of Web-based technology for the management of dredging projects are not readily available, but there is extensive information on studies focusing on how the scientific community addresses Web-based technology from a construction management perspective. The majority of this knowledge is applicable to dredging projects given the similarities of the organizational and programmatic nature of the disciplines.

For example, Alshawi and Ingirige studied a web-enabled project management paradigm in the construction industry. The study highlights how web-enabled project management and associated features are linked to improve quality, competitiveness, profitability, and improved value to clients. "However, it emphasizes that in order to successfully embrace web-enabled project management equal considerations should be given to technology, processes and people" (Alshawi and Ingirige, 2003).

Raymond and Bergeron studied the impact of project management information systems on project managers and on project success. The study highlights how information systems provide managers with decision-making support for planning, organizing, and controlling projects, positively influencing project performance. This study reported improvements in effectiveness and efficiency in managerial tasks related to better planning, scheduling, monitoring, and project control. Improved productivity was also attributed to timelier decision-making. However, "It is only indirectly, through its contribution to managerial work that this use contributes to project success" (Raymond and Bergeron, 2007).

Kornkaew studied how Management Information Systems (MIS) "are used by most organizations to make their operational, tactical, and strategic processes more efficient and effective" (Kornkaew, 2012). Kornkew study results show that MIS implementation confronts challenges concerning management, administration, and the human component involved in the process. Similarly, MIS implementation should focus on the project team and their teamwork. Finally, MIS implementation affects business processes which lead to changes in jobs and routines.

Doloi (2014) studied the factors influencing the implementation of web-based project management systems (WBPM) and their performance in construction projects. He found two important variables on the performance of WBPM: complexity and information streamline. Doloi (2014) found that satisfaction, transparency, accountability, and control are not strong motivators for the use of WBPM. However, "Objective rationalization of Web-based systems implementation and assessment of associated benefits in project-specific context are found to be quite fussy among the construction professionals."

Nitithamyong and Skibniewski studied factors that may potentially influence performance a of commercial Web-based project management system (WPMS) "Results indicated that "ease of use," "data quality and reliability," "system reliability," "Internet access availability," and "team attitude toward PM-ASPs" were among the factors that could influence PM-ASP performance the most" (Nitithamyong and Skibniewski, 2006).

Kim and Kankanhalli (2009) studied user resistance by integrating the technology acceptance and resistance literature with the status quo bias perspective. The status quo bias is the tendency to satay with what is available and resisting changes. The results show that switching-cost increases user resistance. Switching-cost is the cost to change to new technologies or processes. In addition, perceived value and organizational support reduces resistance.

Primavera P6 Web Access (Harris, 2012) is an Oracle project management software for construction projects, is a web-based application that allows owners and contractors to archive, share, and manage project information and documentation to plan, schedule and manage projects. The web-based capabilities allow teams to access project information in real time from any geographic location.

In addition to the planning and scheduling capabilities featured by P6 Web Access the software allows managers to manage group of projects for high level planning, such as planning resources, risk, and budget. This software is part of a large product from Oracle called P6 Enterprise Project Portfolio Management.

2.3. Software Applications for Dredging Performance Management

Blazquez, Adams, and Keillor (2001) studied the operational constraints related to sediment remediation during mechanical dredging operations. "The purpose of this paper is to help dredging contractors use their navigational dredging knowledge base to estimate costs, performance, and equipment selection for future environmental dredging projects where contaminant dispersion is a concern"

The Mclellan and Hopman (2000) study objective was to identify foreign and domestic commercial technologies that could help in reducing the overall cost of performing and managing dredging products for the USACE. These technologies were to be identified as having a high potential for increasing efficiency or productivity of dredging operations in order to be selected for evaluation using the following criteria: needs identified in USACE navigation dredging program; positive benefits versus costs; high probability of implementation; and availability of co-sponsor. The study includes several products that are related to the WPMS. The report provides ninety-one technology fact sheets of the technologies investigated. "Of the many documents and technologies pertaining to innovative technology and procedure, 11 were identified by the contractor for detailed evaluations as related to the present and long-term needs of the Corps." (Mclellan and Hopman, 2000)

- Underwater Archimedean screw vehicle.
- The PUNAISE dredging system.
- Hopper dredge recirculation system.
- DOP submersible dredge pumps.
- Pivoting gearbox.
- High-efficiency dredge pumps.
- The SedErode measurement system.
- Nearshore shelves.
- Sand separation techniques.
- River vanes.
- Detailed shoaling analyses.

A relevant technology reviewed by Mclellan and Hopman (2000) is the formerly Silent Inspector (SI) program developed by the U.S. Army Corps of Engineers. Below is an extract of the system.

Mclellan and Hopman (2000) review of the silent inspector program.

The Silent Inspector System

Category: Claims Resolution

Operating Procedures

Production Monitoring

Description: The Silent Inspector (SI) is a data-acquisition, communication, analysis, and reporting system developed by the USACE to assist in the inspection of contract dredging operations. The SI has successfully served as an inspection and management tool for numerous USACE contract dredging projects. Project management, environmental surveillance, claims reduction, and standardized contractor requirements are all addressed by the SI. The SI is fully developed for hopper dredging operations, with a system for hydraulic pipeline dredges under development. The SI system can successfully be applied to more Corps dredging projects.

To ensure that the SI is widely adopted within the Corps and its contract dredging industry partners, a Process Action Team with both Corps and industry participation has been formed. This team will recommend standards (data acquisition, data transfer, and quality assurance) that comprise the functional aspects of the SI for approval by Corps policymakers.

Reviewer: C. Woolley

Company I Organization(s): Access Restricted to U.S. Army Corps of Engineers

Projects Completed:

Location: Numerous corps dredging projects on all coasts

Information Sources:

Literature: Title: “The silent Inspector”

Author: James Rosati III

Month:7

Year:1998

LitType:Report/Proceedings

Publisher: WODCON XV, Las Vegas

Page:93

Svedberg (2013) reported how the Port of Cork in Ireland is testing a solution to track dredging operations. The vessel-tracking system includes radio frequency identification technology in order to obtain an electronic record of which areas of the seafloor are being dredged and when. This will ensure that the port continues to upgrade the portage waters at the proper time and place. “The Port of Cork—reputed to be one of the world's largest ports, geographically—services the south of Ireland. To keep its waters clear of obstructions created by silt that could impede the passage of large vessels, it is necessary to regularly clear the seafloor of sediment. The port sends its MV Denis Murphy utility vessel into the harbor daily to conduct a variety of maintenance services, including inspecting buoys and plowing the seafloor” (Svedberg, 2013).

Kellogg et al. (2016), at the University of Washington studied why “Wi-Fi has traditionally been considered a power-consuming communication system and has not been widely adopted in the sensor network and IoT space.” They introduced the use of Passive Wi-Fi using backscatter communication. This helps reduce power consumption to 10,000 times less power than traditional Wi-Fi. Passive Wi-Fi can be used by current routers, mobile phones, and tablets.

“We demonstrate for the first time that one can generate 802.11b transmissions using backscatter communication, while consuming 4-5 orders of magnitude lower power than existing Wi-Fi chipsets. Wi-Fi has traditionally been considered a power-consuming system. Thus, it has not been widely adopted in the sensor network and IoT context where low-power devices primarily transmit data. We believe that, with its orders of magnitude lower power consumption, passive Wi-Fi has the potential to transform the Wi-Fi industry" (Kellogg et al. 2016).

This technology may be important for future advancement of the WPMS technology. The WPMS concept uses WI-FI, Cellular, and Satellite communication technologies to create redundancy between these technologies and maintain the dredge connection to the Internet.

2.4. Dredging Management Software

This section assesses the management systems and tools currently used in the dredging industry. Table 2.1 compares the functionalities of current management systems in the dredging industry.

1. Dredge Quality Management Program. Appendix C, Item 1

Formerly Silent Inspector (SI), the program has undergone a name change to reflect its change in mission. The DQM program verifies, collects, and stores dredging instrumentation data for the USACE and provides tools to interpret and utilize this data for USACE dredging managers. The US Army Corps of Engineers (USACE) Silent Inspector (SI) Implementation, started in 2006, was created to perform inspection processes for quality assurance, Zichichi, Puckette and Allen (2007). Zichichi et al. (2007) studied the roles and responsibilities of the SI team, the methodology of an inspection, and the progress made by 2007 of the SI inspection process. "The SI is an automated dredge monitoring system which standardizes the collection of digital data from dredge and scows and compiles it into a centralized database" (Zichichi et al, 2007). For hopper dredges and scows, the inspection is focused on the hopper volume measurements taken using a combination of sensor and manual readings. A data logger on the equipment captures the information and transmits it to a central server using an Intranet connection.

The information captured at the dredge is transmitted via cellular network (Intranet) to a centralized database. The information collected is defined in the Dredge Plant Instrumentation Plan (DPIP) and is required by contract. Currently the system includes hopper dredges and scows monitoring. Implementations for Hydraulic dredges and mechanical dredges are under development. The system has experienced resistance from contractors due to the cost to install the equipment and concerns of exposing proprietary information.

The reliability of the data collected also has been a challenge since the implementation of the DQM. The USACE had to implement a quality control program to maintain sensors in optimal conditions and to assure the reliability of the system.

The Corps has other related Web-based applications: Dredging Information System (DIS), Operation and Dredging Endangered Species System (ODESS), and Dredge Management (DM). DIS collects the estimated incoming dredging projects to develop a national plan. The plan is to develop a schedule for the following year in advance, so that the USACE does not exceed the current dredging capacity, therefore managing the dredging market cost. ODESS is a Threatened & Endangered Species Data Collection and decision-making tool used especially in relation to the environmental impact on sea turtles. DM manages and documents detailed information of project data such as project location, equipment used, cost, dates, etc. These systems are managed discretely and the USACE is planning to integrate them into one system.

2. Automated Disposal Surveillance System (ADISS). Appendix C, Item 2

Leidos's (formerly SAIC, Inc., Appendix C) Automated Disposal Surveillance System (ADISS) is a portable dredge monitoring system developed in accordance with the USACE Dredge Quality Management Program (DQM/Silent Inspector) specifications. The system can be installed on a variety of dredge equipment including scows, hopper dredges, mechanical dredges, and tugboats. The ADISS system currently meets and exceeds the 95% data return requirement set forth by the USACE regulations. SAIC provides Silent Inspector compliant systems for the following USACE specified profiles: Tracking, Monitoring, Tons Dry Solids (TDS). In addition to transmitting data to the database, all monitoring information is stored and posted on the password-protected ADISS website for client review.

ADISS system can be configured to meet upland disposal monitoring requirements. Draft, bin, tilt sensor and GPS position data are continuously recorded at 5-minute intervals on the hopper scows. The stored data are automatically and wirelessly transmitted for processing and posting to ADISS website. Overflow email warnings are automatically sent when bin level thresholds are exceeded. During processing, bin level, draft and tilt data can be converted to bin volume and load weight to accurately determine the volume of the material loaded at the dredge site. Bin density is calculated from the volume and weight data, and is compared to the density of the in-place material to estimate the volume of material dredged. Loading position and volume data are displayed on the website to summarize the locations and the progress of the dredging.

Wireless links can be installed on each individual piece of dredge equipment on a project. Each link can transmit the equipment position and sensor status at regular intervals. This real-time data is made available on the password-protected ADISS website.

Internet dredge camera solutions can be installed to meet regulatory specifications. Pan/Tilt/Zoom cameras can be installed on individual dredges to allow real-time access to dredge activities and conditions. The camera access and controls are available on the password-protected ADISS website.

ADISS is a system developed to service contractors that need to comply with the USACE-DQM Dredge Plant Instrumentation Plan (DPIP). The service installs the sensors, monitors the data that has been collected, and submits it to the USACE for analysis. The data is submitted with a 24-hour delay from the moment the data is created. When the system is used, it increases project performance.

3. **DredgePack. Appendix C, Item 3**

DredgePack is a geographic positioning system used to positon the dredge vertically and horizontally. It is capable of controlling where the dredge is working in relation to the design section. DredgePack can be used by almost all dredging equipment. The system converts the survey data into a color-coded matrix. The survey data can be generated by single beam data or multi-beam data. The system renders a dredge in a plan and profile view, and shows the channel section and uses GPS and sensors to generate the view rendered on the operator screen. Sensors are used to track the dredge parts in movement, dredge forward/aft draft, dredge draft, and water levels. The system accepts dredging plans created in advance channel design programs.

4. Seatools. Appendix C, Item 4

CutterMate

CutterMate is a cutter head dredge monitoring and positioning system. It displays a 3D real-time data visualization that provides cutter coordinate. It uses GPS and sensors to captures the dredge features and render it on the operator screen. CutterMate helps maximize the production and precision of the dredge operation. The system can be tailored to fit specific dredge equipment, it is scalable and adaptable to suit demanding dredging control and monitoring tasks.

DipMate

DipMate is a dipper dredge monitoring and positioning system. It is an automated system that displays the dredging process in real-time. The system also helps the operator to dredge with more precision. The system also has 3D visualization capabilities and is linked to censors allowing the system to display the dredge on the computer screen. The main benefits are:

- Provides an accurate visual representation of the underwater excavation.
- Its provide the operator information he needs to optimize performance.
- It registers the dredge tip position for prof of work executed and progress
- The system is scalable to tackle future requirements.

5. Port of Cork trial solution SC2 VMS. Appendix C, Item 5

Sweberg (2013) reported that in 2013, Ireland's Port of Cork began a trial of a vessel-tracking system that includes radio frequency identification technology (RFID) in order to obtain an electronic record of which areas of its seafloor are being dredged, and when. These records will be used to for quality control and quality assurance of the vessel work. It helped identify what areas had been dredged, introducing greater efficiency into the operation. The RFID technology is used to measure movements of part of the vessel to indicate if the plow is lowered or raised.

The trial of the solution uses software and hardware from Succorfish, a British technology firm.

Figure 2-1. Vessel Used for seabed plowing

(Succorfish Web-site, March, 2015 article)

The Port of Cork is one of the world's largest ports servicing the south of Ireland. The SC2 VMS solutions will maintain the navigational channel to its specified depth by using a seabed-plowing methodology. The plowing dredge alternative lowers a large multi-ton steel bar from the vessel to the bottom of the seabed and drags it along the channel to break the cohesion of the sediment, put it in suspension, and allow the tide to sweep away the suspended material.

The system uses an automated system to capture the vessel location and the plowing activity in real time and transmit the data via a GPRS or GSM cellular connection. If the vessel travels beyond a cellular connection, the SC2 device data can store the information until coming back within range of a cellular tower, or transmit the data via Iridium satellite transmission.

Figure 2-2. Sensor on Winch to Measure the Depth of the Plow

On the stern winch drum, the project team installed three yellow passive RFID tags and an RFID reader, (Sweberg, (2013).

"Succorfish and SEA-Tech determined that RFID was the best solution to that problem. The companies installed three passive high-frequency (HF) 13.56 MHz RFID tags to the winch's drum, on which a cable was spooled and rolled either up or down as the winch raised or lowered the plow from the vessel. The tags are mounted at 120 degrees from each other, in a circle around the winch drum." (Sweberg, (2013).

Succorfish M2M, in partnership with Irish marine communication specialists SEA-TECH, delivered the project in 2015.

The Port of Cork trial exercise is a good example of using a combination of cellular and satellite communication technologies to interconnect the dredge operation with other project stakeholders in real-time. "Its success has the potential to change future operational methods, increase efficiency at ports anywhere in the world and be beneficial for future planning for marine authorities globally." (Succorfish Web-site).

6. <u>ClamVision. Appendix C, Item 6</u>

ClamVision is a CableArm, wireless integrated dredge positioning system for mechanical dredges. It gives crane operators a real-time view of the barge and the clamshell bucket position. It displays , color-coded surface created form surveyed data, and shows the position of the bucket during excavation in relation to the surface.

Clam Vision's most important features are: Cable Arm Tide Gauge with remote transmission to dredges; fully wireless data and video communications; robust ClamVision computers to handle tougher work environments; Dredge Quality

Management (DQM) (formerly "Silent Inspector," compatible for scows and dredges; and clamshell bucket depth available using pressure depth or cable counting systems. ClamVision software can be integrated into to custom job applications (from ClamVision Web-site, see Appendix C).

7. <u>WPMS Concept, Item 7</u>

The operation and management of a dredging project requires high-performance, expensive equipment and specialized resources. A typical dredging project represents approximately $1.2 million in value of production per day. Lack of optimal information flow between owners and contractors during dredging operations exacerbates the risk of diminished performance, errors, project delays, and contractor claims. As a solution to these problems, the concept of a Web-based Project Management System (WPMS) for dredging operations has been developed. Subsequently, a prototype of the system was created and it is currently undergoing evaluation by selected potential customers. Government organizations, port authorities, harbor operators, and dredging contractors have shown interest in the system. The subsequent efforts will focus on developing the commercial grade when it can undergo full-scale testing and commercial evaluation.

The Web-based Project Management System (WPMS) combines information system architecture with communication infrastructure technology to create an intelligent system for comprehensive information processing. The prototype version of WPMS includes three integrated components: 1) Real-time Information Delivery component through sensor-based system solutions to maintain the connection of dredges to the Internet, allowing two-way communication between dredge operators and remote dredging equipment, 2) Dredge-View Desktop Application to manage and process data generated by dredge-mounted sensors and to display information needed by the operator for precision-focused performance, and 3) Dredge-Log Web-based Application to allow interactive data management and customized reporting by dredge operators. WPMS is capable of capturing geo-referenced data for its daily production report. Three iterations of WPMS have been developed; and additional development continues.

Table 2.1. Current Management Systems Functionalities.

Item Number (Reference to description and Appendix B)	* System	Used with all equipment	Web-base— Permanent connectivity to the Internet even in remote areas	Real-time interaction between the dredge cutter head and the bottom surface;	Acquisition and recording of all dredging operating parameters;	Real-time volume calculation during operation	2D and 3D real-time rendering, over the internet	Multidimensional views of the dredge, depth, and waterbed surface	Seamless connectivity between the dredge and the owner or contractor	Preservation of data integrity for future analysis and forecasting.	Report Creation
1	DQM/Silent Inspector				X	X			X	X	X
2	ADISS	X			X	X			X	X	X
3	DredgePack	X			X	X		X		X	X
4	CutterMate			X	X	X	X	X		X	X
5	Port of Cork trial solution		X	X					X	X	X
6	ClamVision			X	X	X	X	X			X
7	WPMS Concept	X	X	X	X	X	X	X	X	X	X

*System references are in Appendix C, and described in this section above.

2.5. Conclusion

During preproduction and production, lack of timely information to owners and contractors generates problems during the lifecycle of a dredging project (see Chapter 4). Traditional information management processes in dredging projects do not integrate all dimensions of the operation with management needs. management team and operating team are disconnected due to the lack of real-time information flow from the dredge to other areas, for example supporting personnel offsite, contractor office, or owner headquarters. The WPMS works as a hub to connect all users under one integrated user interface and works seamlessly with all the information system tools needed during the project life cycle.

Markus's (1983) theory emphasized the need to investigate user resistance to the WPMS implementation and added a new level to the analysis of the positive and negative aspects of using and implementation the WPMS. According to Markus' Interaction Theory, the implementation of the WPMS also requires considering the social and political aspects of how the information will change the user's responsibilities and authority within an organization. Ultimately, the design and effective implementation of the WPMS rely heavily on the project team's acceptance. Therefore, the success of the design and implementation not only depend on the development of the physical components of the system, but also on the satisfaction of the users in the organization. This research includes in its feasibility analysis the user's potential resistance to the implementation of the system.

3. WEB-BASED TECHNOLOGY FOR DREDGING PROJECTS

3.1. Web-based Project Management System Concept for Dredging

The research involves a concept that combines Project Management Techniques, Information Systems, and Communication Infrastructure Technologies to frame an intelligent system (see Figure 3-1). From preliminary works, it was concluded that the system improves dredging project performance by improving collaboration and teamwork, facilitating the flow of information to all levels of management. The WPMS real-time capability creates the automated acquisition of data and the generation of information from, and to, all areas of management and operation.

For example, the system will be able to capture geo-referenced data for the daily report including but not limited to, positioning, excavation conditions, production, operating time, material, weather conditions, environmental conditions, placement site, and personnel (see Figure 3-2). Similarly, information from other areas can be collected, for example, from the engine room.

This is important, because the system uses the latest technologies to allow dual communication between the user and the equipment. Dual communication means that the system manages the information generated by users to improve the operation and captures the information generated by the equipment to alert users of any unusual situation.

Figure 3-1. Web-Based Project Management System Concept

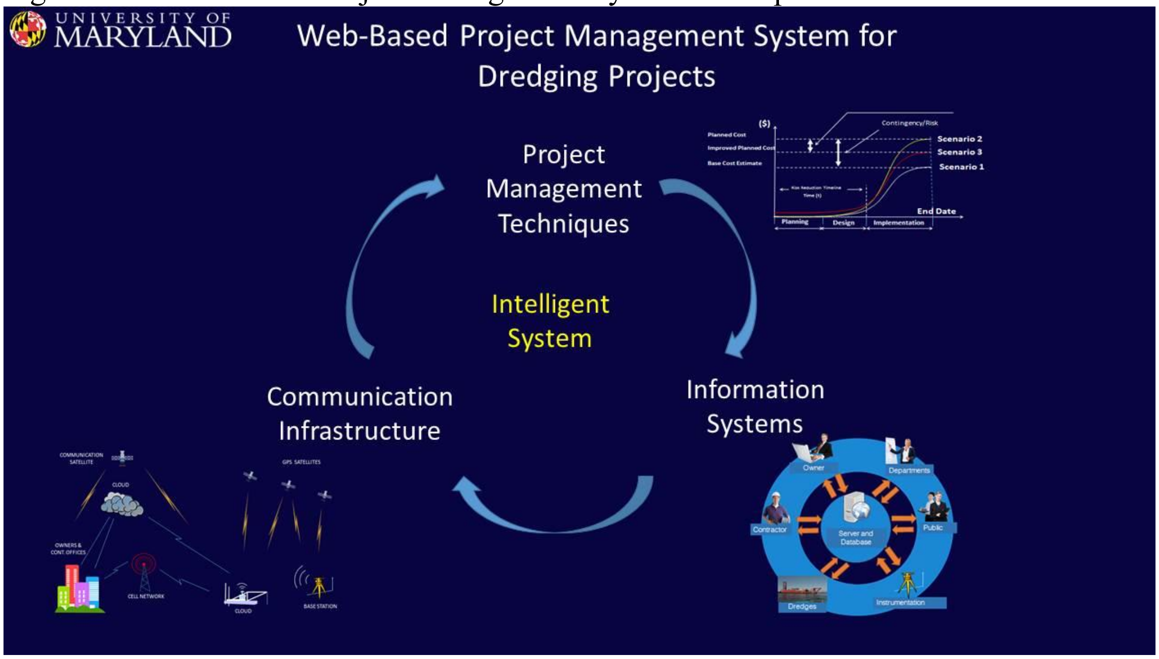
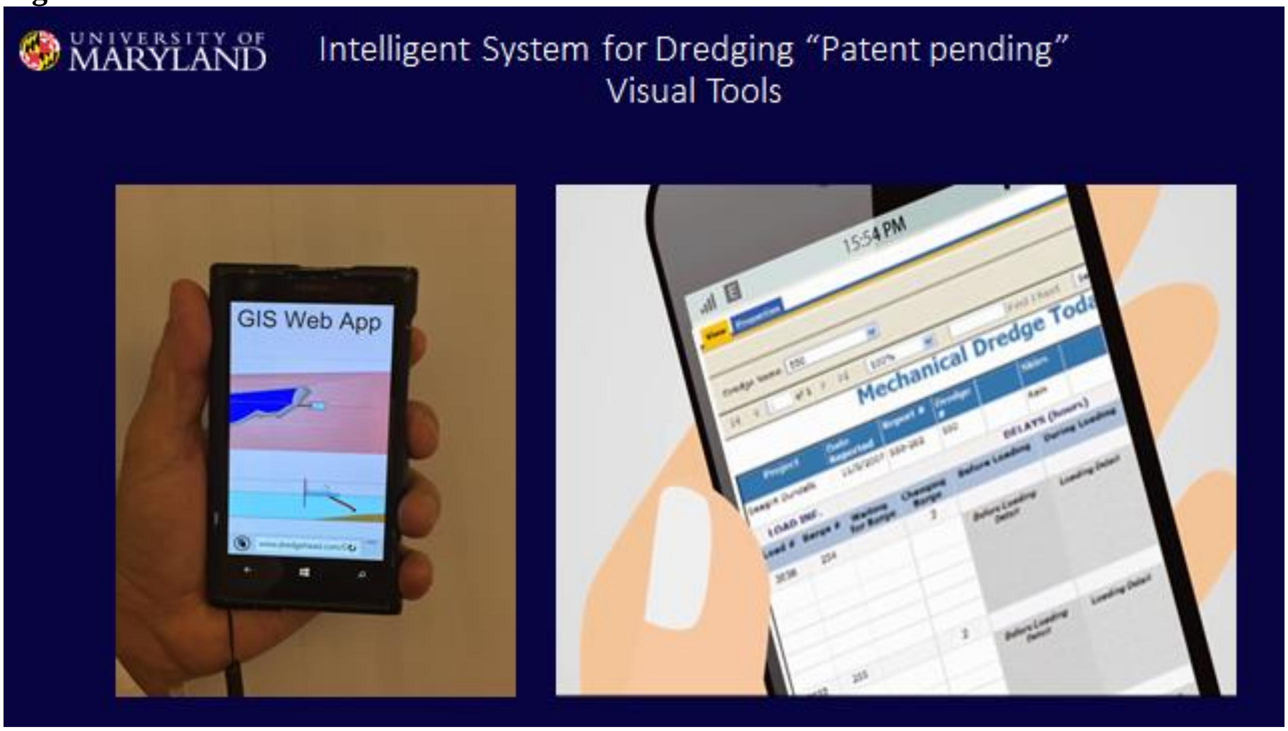


Figure 3-2. Data for the Daily Report

The system uses a combination of visual and analytical features to display information. These features make the system a powerful management tool (see Figure 3-3). The system will be able to archive and analyze the data, secure it, preserve its integrity, and redistribute the information back to its users.

Figure 3-3. Mobile Tools Used to Facilitate the Use of Information



Of the three technologies discussed above, Project Management Techniques include processes used by individuals to implement management functions. The Information System and the Communication Infrastructure Technologies are tools that facilitate teamwork, communication, data collection, and reporting. This conceptual framework is powerful because it integrates human management capabilities with the latest communication technologies to create a system sensitive to project management and operational needs and responsive to the varied and complex scenarios present during the life of the project.

3.2. Web-based Project Management System Prototype Design

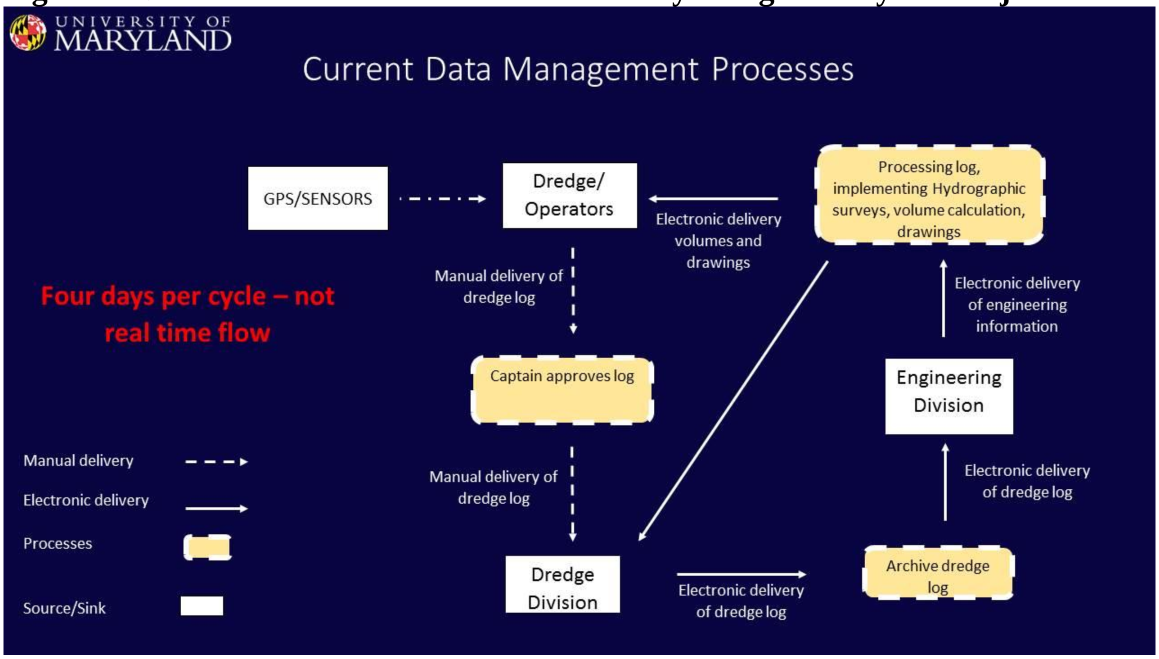
The research used the operational-prototype methodology to develop a prototype that models WPMS functionalities. In order to develop the prototype, the research was presented with the opportunity to use an organization's project environment to analyze its processes and functions and use the analysis to develop the requirements for the system prototype.

A study proposal to develop a prototype using Project A requirements and specifications (see Section 1.7) was submitted to the organization staff on November 2012. On May 27 and 28, 2013, the Project was visited to gather the requirements for the implementation of the new WPMS. On May 27, a meeting was conducted from 8:00 a.m. to 12:00 noon to explain the basic concept of the theory framework for the WPMS proposed in this research, to show examples of a preliminary prototype developed and to acquire information about the specific requirements that would customize the system intended for the project. The morning session proved to be very productive, showing synergy between the theoretical framework proposed and the project needs.

In the afternoon, visits were made to other offices involved in the dredging operation and the engineering group to gather detailed information on the processes and flow of information involved. Figure 3-4 illustrates the structure and flow of how the information is currently managed.

Figure 3-4 combines discrete actions to convey information between organizational units. This structure is not an efficient way to gather, store, analyze, and convey information to users.

Figure 3-4. Information Flow Structure Currently Being Used by the Project



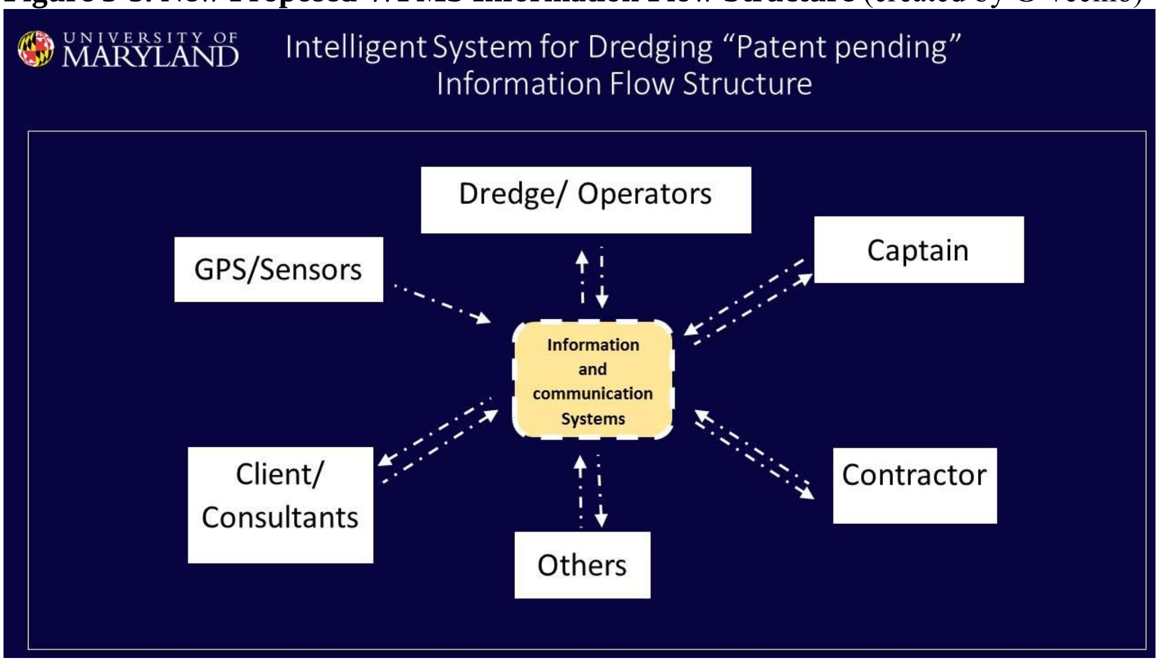
In order to improve the information flow depicted in Figure 3-4, the information generated during the dredging operation needs to be integrate it into a coherent system to add agility to the flow of information and make the process reliable.

After reviewing the current information structure, and in order to improve the flow of information, the information process model was defined and depicted in Figure 3-5. In order to achieve the functionalities needed for the information flow proposed in Figure 3-5, the design included three basic components. The first is the Real-time Information Delivery component that maintains the dredge's connection to the Internet (see Figure 3-7). The second component, DredgeView, allows the operator to excavate with precision and serves to capture the data generated by all sensors on the dredge including GPS information (see Figure 3-8 and 3-9). The third component is DredgeLog, which gathers manual information input by the dredge personnel, and serves to analyze data and to forecast and predict future project costs and performance (see Figure 3-10 and 3-11).

Four iterations of the system prototype have been implemented. Currently, the system is ready to be installed on a project for testing and field hardening.

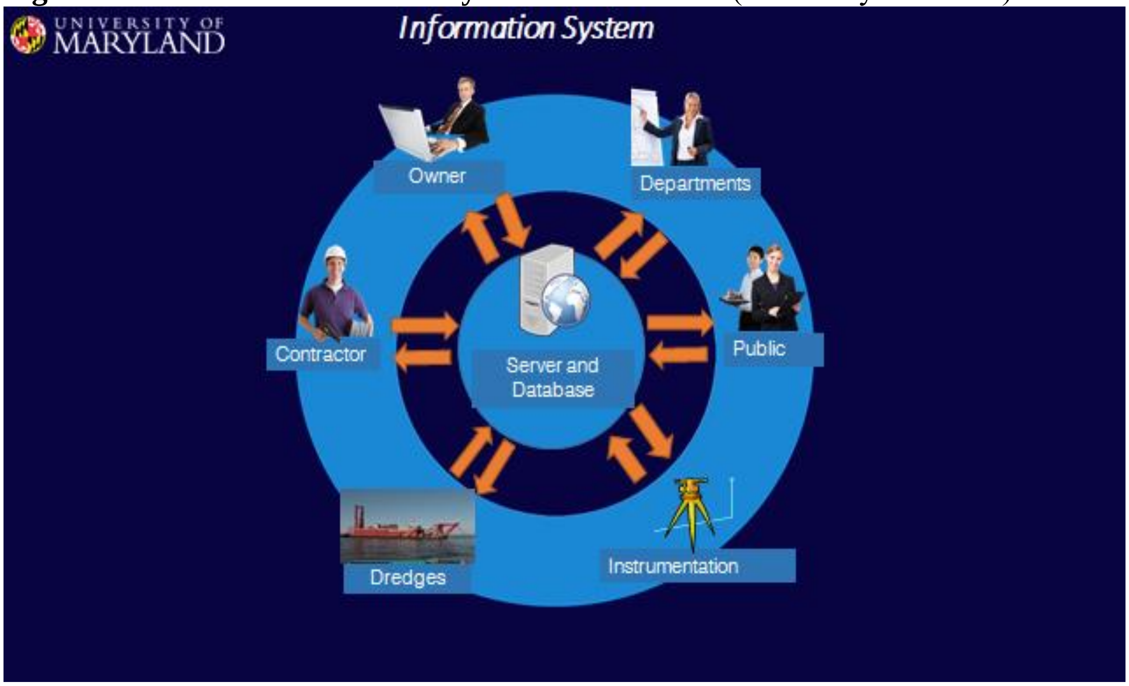
Figure 3-6 shows the Information System design that integrates equipment and users into one coherent environment, a frame within which all users and equipment can intercommunicate. The information system will standardize, centralize, automate, and distribute project information captured during the entire life cycle of the project. The Information System will facilitate the application of all management processes, from the project concept to implementation.

Figure 3-5. New Proposed WPMS Information Flow Structure (created by G Vecino)



The Information System will process the information in real time allowing reports to be generated at any time of the day and transmitted to the users. The dredge can be in a remote area, and the decision maker can see from his own office, in real time, exactly what the dredge is doing.

Figure 3-6. WPMS Information System Architecture (created by G Vecino)



Currently the WPMS includes three basic components, all of which are interconnected within the same system environment:

- The Real-time Information Delivery component maintains the dredge's connection to the Internet.
- The DredgeView Desktop Application helps the operator in the excavation process.
- The DredgeLog Web-based Application allows the input of programmatic data by the dredge personnel.

3.3. Web-based Project Management System Components

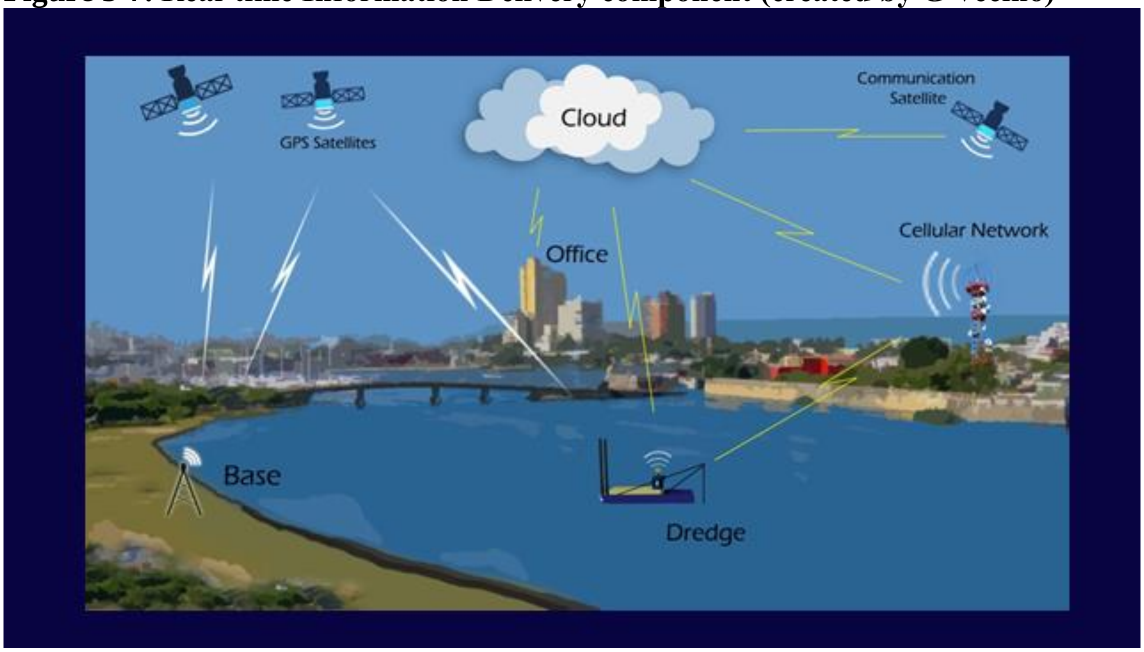
There are three basic components in the system:

Real-time Information Delivery Component

The Real-time Information Delivery component uses a series of communication technologies assembled to maintain continuous communication of the dredge with the

Internet. This feature allows decision-makers to use computers and personal digital hand-held devices to receive and manage project information from any geographic location. Figure 3-7 shows how these components are related to other elements of the system.

Figure 3-7. Real-time Information Delivery component (created by G Vecino)



The Real-time Information Delivery component uses a powerful emerging concept, the Internet of Things, a pervasive communications environment key to instrumenting infrastructures web-based communications. This component allows real time communication to any geographical locations to improve project management, project control, and decision making by self-alerting when actions are needed or unusual conditions arise.

DredgeView

Figures 3-8 and 3-9 show the DredgeView desktop interface for a hydraulic dredge and a shovel dredge respectively. This component helps the operator in the excavation processes. DredgeView manages all the data generated by the dredge and sensors, and displays all information needed by the operator on a screen. DredgeView is a visual aid for the operator to excavate with precision. It captures data from the sensors and renders the information on the screen. This component reduces excavation errors and improves performance. It renders a precise surface showing its contour lines and allows the operator to see the interaction between the cutter and the surface in real time. The image, generated by this component is transmitted in real time over the internet so managers can see, control, validate, and archive this information for analysis and evidence in future claims and other Quality Assurance processes.

DredgeView was developed using Microsoft C#, Microsoft Window Presentation Foundation (WPF), and Web Services Client technology. This component uses the data captured from the GPS and sensors to assemble the information needed by the operator on-screen and to operate the dredge efficiently. The application displays the dredge shape in real time on a monitor, including information on the dredge position and operating depth to control the dredging operation. This process also formats the information gathered and transmits it to the server database using web-services technology.

DredgeLog

The DredgeLog Web-based Application allows the input of programmatic data by the dredge personnel. DredgeLog transmits all information generated manually on the dredge to the server database using web-services technology and to the users (se Figures 3-10 and 3-11).

DredgeLog is a web-based application that runs on Microsoft Windows Server 2012, SQL Server 2012. This component captures manually-entered data at the dredge (see Section 3.4) and during validation and sends it to a centralized database. Subsequently, this information is processed, formatted, and delivered back to the users as reports.

Figure 3-8. DredgeView Component for Hydraulic Dredge

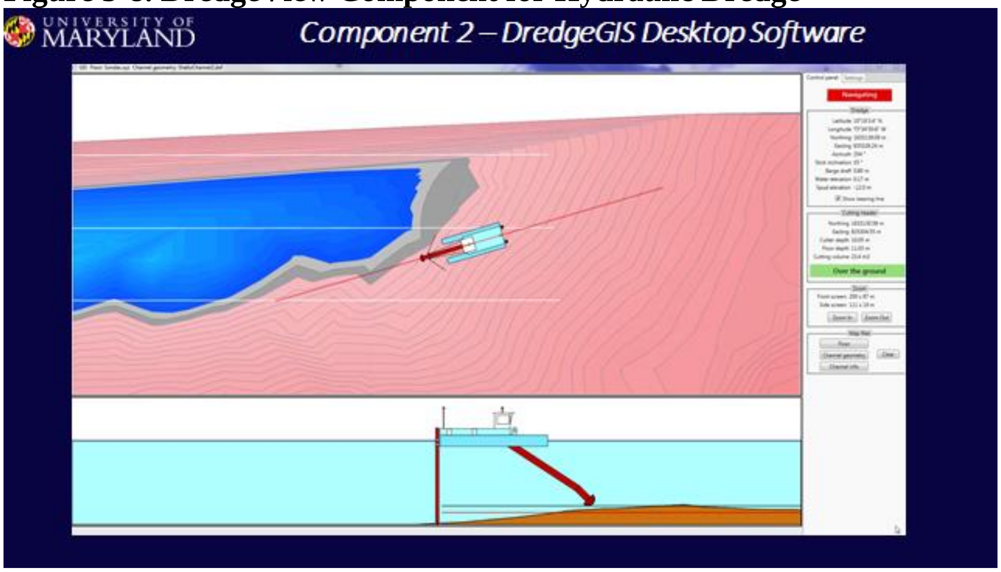


Figure 3-10 shows the operator interface. This feature uses a touch screen to allow the operator to easily log information into the system. The operator will not need to leave his chair, input the information manually on paper, or wait until later to log the information. Figure 3-11 shows a daily report, which is the result of the system processing the daily log and other information gathered by DredgeView defined above. Similarly, the system will generate weekly reports and monthly reports aggregated from the daily reports.

During operation, the captain of the dredge or other support personnel can see what the operator is doing by requesting the system to generate the daily log at a moment's notice at any time of the day.

Figure 3-9. DredgeView Component for Shovel Dredge

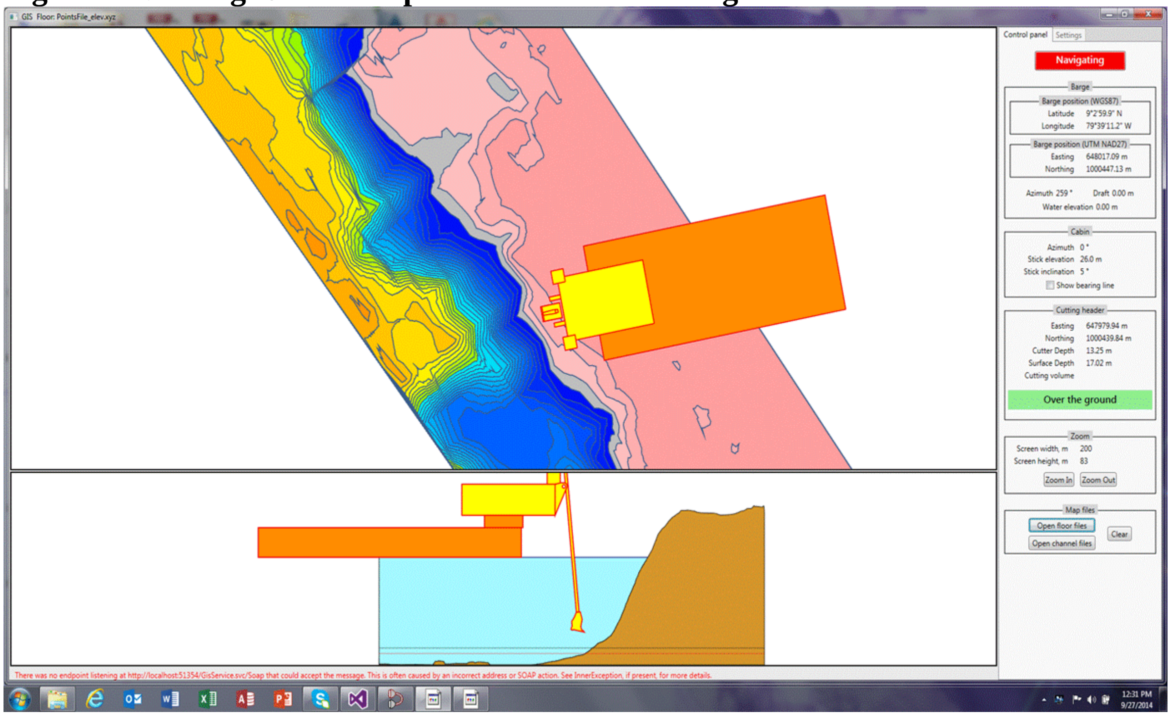


Figure 3-10. DredgeLog Web-based Application

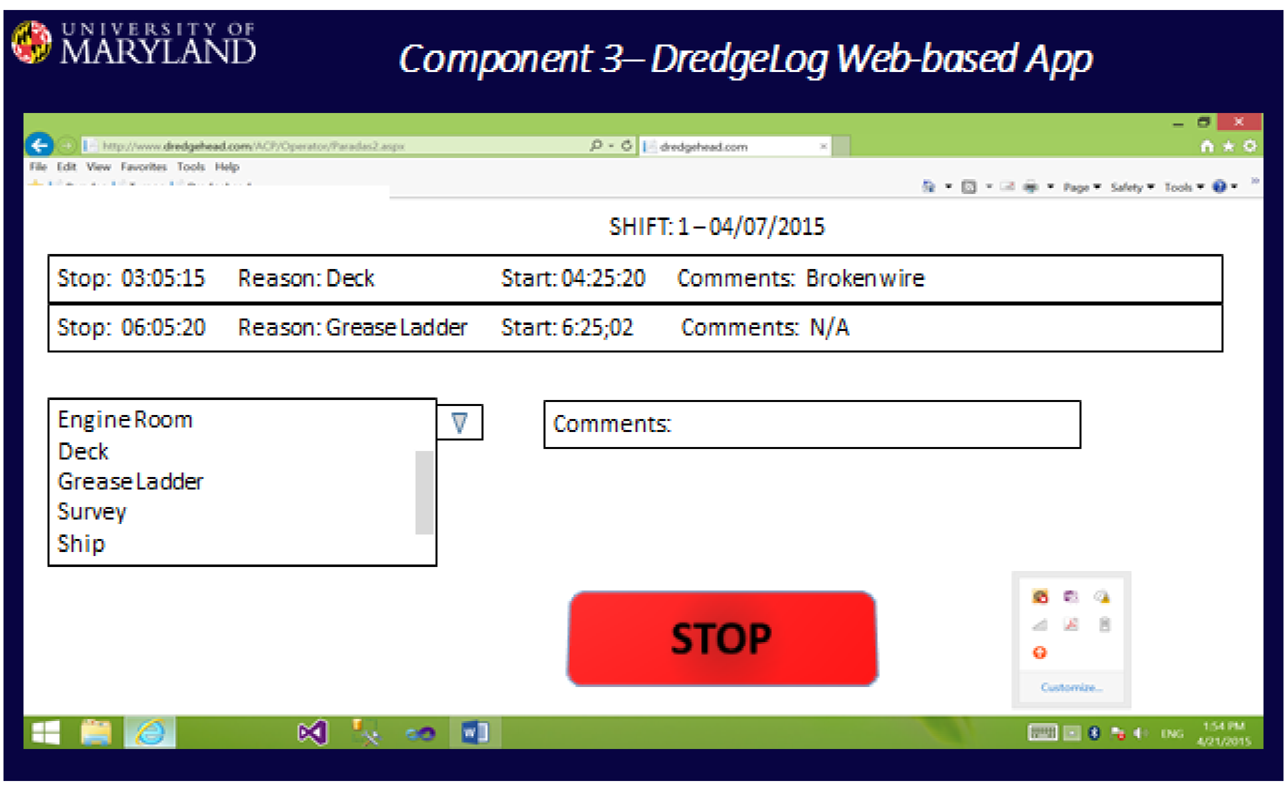
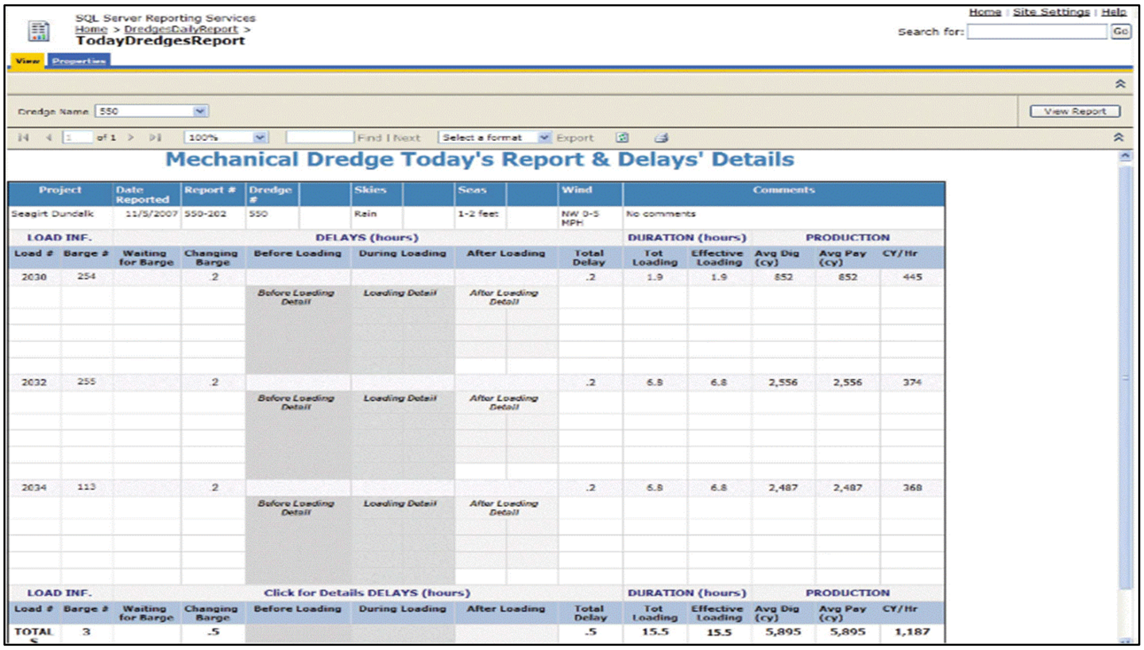


Figure 3-11. DredgeLog component – Web-based application



3.4. Web-Based Project Management System Functionalities

An array of data is captured on the dredge during dredging operation and sent to the captain and supporting divisions for validation. The data captured is transmitted in real time to two servers, one on the dredge and another at the owner/contractor headquarters, using the internet. This information is validated in real time, documented, and archived.

The data is transmitted to the server using a combined multilevel and timely array of information generated during the dredge operation. This data is then used to analyze, report, and control the current dredging operation and to forecast and predict future performance. In addition, the operation is documented and the information archived in a secure place to allow for future use.

The information delivered to the owner/contractor headquarters is delivered in several database records and includes:

a. All GIS information managed at the dredge
b. Effective dredging time and down time
c. Area dredged
d. Estimated production
e. Tugs information
f. Barge load parameter
g. Discharge site information
h. Type of material parameters
i. Material geotechnical parameters
j. Dredging depth information
k. Personnel information
l. Loading parameters

The data is processed and formatted automatically by the system and delivered back in real time as information to be validated and consumed by the end users in the form of reports.

Data Source Description

GPS/Sensor data
Dredge data
Dredging Division - Contractors
Engineering Division - Owners
Captain

3.5. Web-based Project Management System Development

The implementation of the WPMS prototype requires the installation of sensors on the dredge. Lack of resources impeded the installation of the sensors on a dredge for testing. As an alternate solution, software was developed to simulate the sensor data. This made it possible to run the desktop and Web-based applications to simulate the system features and how this system works.

Four iterations of the prototype have been developed to date. The first component was not needed for the simulation of the system; therefore, the development of this component is still in the conceptual phase. The second component has been developed and is ready to be tested on a dredge. The third component also has been created along with three databases and their corresponding user interfaces and is ready to be tested on a real project.

The first prototype was created to support a shovel or an excavator dredge operation and the third prototype included support for a hydraulic dredge. An important addition to the initial concept of Component 2 was the creation of a GPS featuring the RTK technology that could be easily integrated with the system. An operational prototype of this GPS has been created at a University of Maryland Laboratory.

The transformation methods and formulas for the geographic coordinates have been developed only for particular areas where the system has been or will be tested in the near future. The entire suite of formulas for transformation and conversion of geographic coordinates to planes coordinates needs to be completed. Similarly, the development of system Component 1 needs to be initiated and completed. Component 1 was not needed for the simulation of the system.

3.6. Implementation Scenario for Future Studies

The Dredge Quality Management (DQM) program has been reviewed (see Section 2.5), and experts involved with the use of the DQM program have been interviewed. The DQM program has been implemented since 2006. Currently, systems conforming to the DQM specifications have been installed on hopper dredges and scows. DQM requirements for hydraulic dredges may be implemented in 2016, and requirements for mechanical dredges are already being tested.

One important observation from the experts is that the implementation of DQM is experiencing strong resistance by the operating teams (contractors). Markus's theory has been proven valid in the context of this research: the implementation of a system that centralizes information, if deployed to an environment with decentralized authority, will experience resistance. This type of resistance may be present in projects with design-bid-build delivery systems that are required to use the DQM program or any Web-based management system.

A project within the aforementioned context may be used as a test for implementation, and to study how to avoid resistance to the implementation, of the DQM program in the design-bid-build delivery system scenario.

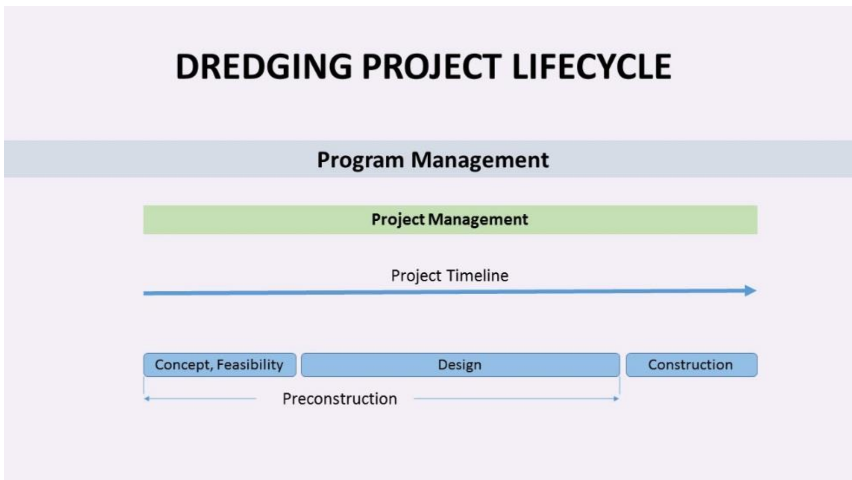
4. THE BENEFIT OF USING WEB-BASED TECHNOLOGY FOR THE MANAGEMENT OF DREDGING PROJECTS

A successful dredging project depends largely upon the optimal flow of project information to the project stakeholders. Traditional project management systems lack real-time project management capabilities. Applying web-based technology to implement real-time management capabilities brings new opportunities and leverages the management of dredging project functions and processes.

Planning and project control, documentation and communication are core functions that are best implemented in real-time during the life of a dredging project. The application of project management techniques, information system and communication infrastructure will aid the collection, process, analysis, and distribution of project information. Timely information flow to all levels of management improves decision-making and the delivery of real-time project management capabilities. Web-based technology allows all players to communicate and share project information seamlessly, eliminating geographic and time restrictions, and empowering and creating a dialog within the project community. Finally, as a result, a balanced benefit-sharing project will build confidence, transparency, and momentum - all fundamental factors in developing a collaborative environment.

The lifecycle of a dredging project is depicted in Figure 4.1. Problems inherent to traditional dredging projects undermine performance due to the lack of information-sharing between owner and contractor during the dredging project life cycle. During preconstruction, the contractor or potential contractors are isolated from the project investigations, studies, and value engineering processes. This condition places a high level of constraints on the contractor’s ability to define contract conditions and prevents the project from capitalizing on the contractor’s knowledge. Finally, during the construction phase, the flow of information between owners and contractors is inhibited and, as a result, information is unevenly distributed. Resolving the problems encountered during the management of dredging projects requires that the flow of information between the parties throughout the life of the project be greatly enhanced.

Figure 4.1. Dredging Project Life Cycle (created by Gustavo Vecino)



The lack of flow of project information to the owner during the construction phase is generally limited and as such, is inconsistent with proper project management control. The tendency is to assign the responsibility for the information management to the contractor, and work inspection is generally kept to a minimum. This tendency often has the effect of releasing the project manager (PM) from liability for changes in the scope of the project, and therefore, all the risk is allocated to the contractor. However, this lack of information gathering by the owner during the project will ultimately be counterproductive. While the owner may assume he is released from liability by having this "hands-off" approach, when the contractor later brings a claim, the owner will not have proper information to refute the claim.

Preconstruction

In a traditional project setting during the pre-construction phase, the contractor is not present in the project investigations and, therefore, he does not have thorough access to appropriate and timely information. Often, the owner's team fails to provide full disclosure of all project information gathered during the pre-construction phase in the specifications or in the contract documents, which are provided to the contractor. Due to the limited time, which the contractor has to evaluate available information, and present his bid, often the contractor is unable to discover the undisclosed information and subsequently, he may fail to present a favorable bid. Often, the PM's intention is to avoid releasing or providing information that could be interpreted differently by the contractor.

If all project information is shared between the owner team and the potential contractors (i.e., during the geotechnical investigations), the bid participants will have the correct information in order to assess the proper cost, thereby avoiding any future disputes. The contract documents and the geotechnical information are typically provided to the contractor about two months prior to the bid due date. However, to understand and master the project information, as depicted in Figure 1, the project team has more time to studies and investigate. Obviously, the disparity of access to information between project owner and the contractor, which is inherent in the current industry environment, frequently becomes problematic. Exposing project information to potential bidders during the pre-construction phase will enhance the contractor's understanding of the project, thereby improving the project bid prices and the quality of the construction process.

Construction

Similar to the difficulties present during pre-construction, during construction, the owner often struggles to gather the information needed to assess the project's performance. The owner must be able to retrieve comprehensive and accurate information from the contractor's operation in order to properly assess and track project performance. This information will also be useful for future project planning. In order to validate the accuracy of the project information supplied by the contractor, the owner will assemble a team of qualified inspectors during construction in order to scrutinize detailed information submitted by the contractor during the operation. Therefore, the owner will not be at the contractor's mercy when it comes to subsequent contractor claims. This information is important for the owner's team to be able to assess equipment performance at any given point in time during the operation. Without this information, the owner is at a disadvantage when faced with a contractor claim.

4.1. Applying Web-based Technology to the Management of Dredging Projects

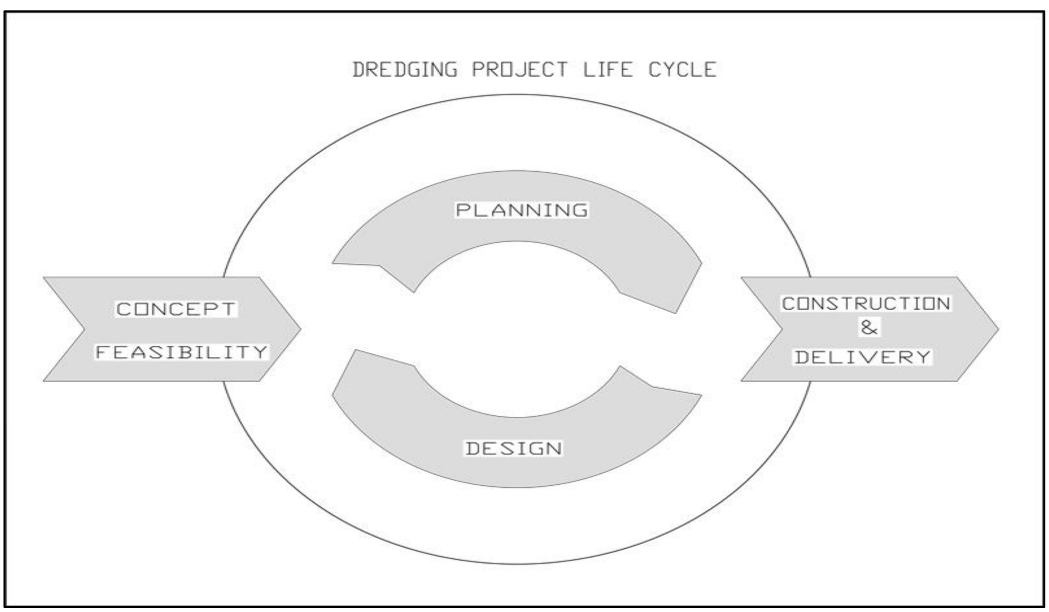
The objective of this section is to focus attention on the analysis of the processes implemented during the management of a traditional dredging project, and then assess the benefit if web-based technology had been applied. The estimated benefits and procedures are discussed below. It is important to note that each one of the phases shown in Figure 4.1 delivers very important information to the subsequent phase. The concept study phase delivers vital information in the form of defined requirements to the feasibility study phase. Similarly, the feasibility phase delivers information in the form of requirements specifications to the design phase. Finally, the design phase conveys information in the form of specifications and drawings to the dredging phase. This streamlined process maintains project consistency during its life cycle.

Figure 4.2 depicts how the information generated by the project management processes flows within the dredging project life cycle phases. This figure demonstrates how the information flows from the concept and feasibility phases to the design phase and finally to the construction and project delivery.

Pre-Construction or Engineering Phase

A project that needs federal government approval and financing is required to conduct a concept study to determine whether the project can solve local and regional problems. Based on the concept study reports, the federal government and the non-federal sponsor jointly decide whether a full feasibility study is warranted.

Figure 4.2. Information Flow



Conceptual Study – During the conceptual study, the project requirements are identified and the following project processes are implemented: project environmental impact analysis, soil investigations, equipment availability, and concept cost assessment, as well as, value engineering analysis, initial schedule assessment, and scope definition. In addition, as part of the concept study deliverables, there will be a list of recommended tasks to be implemented during the next phase in the event the project should continue to the next phase. This information is vital for an initial assessment of the viability of the project. When the concept study is completed, a higher-level decision-making team will decide if the project should continue to the next phase or not. If a go-ahead decision is granted, the project will continue to the next phase – the feasibility phase. The following studies are required by the federal government, and should be recommended in the conceptual report:

- Definition of the problems and opportunities related to water resources; identification and potential solutions.
- Estimation of the benefits and cost of the solutions to determine prospects for a feasible project; appraisal of the federal interest in potential solutions.
- Determination as to whether or not further studies are appropriate.
- Estimation of the feasibility phase cost, schedule, and budget.

Corps and non-federal sponsors must agree to share equally in the cost of the feasibility study.

Feasibility Study – during this phase, the project characteristics, and the recommended tasks defined in the concept study will be reviewed and implemented, and any additional investigations needed to assess the project feasibility will be undertaken. In this phase, it is very important to continue the value engineering assessment; this process will validate the feasibility of the project requirements and its construction methods. At the end of the feasibility study, the project initiation process will be completed and a decision will be made in regard to the project feasibility and its continuation to the design phase. The following studies are required by the federal government, and should be included in the feasibility report.

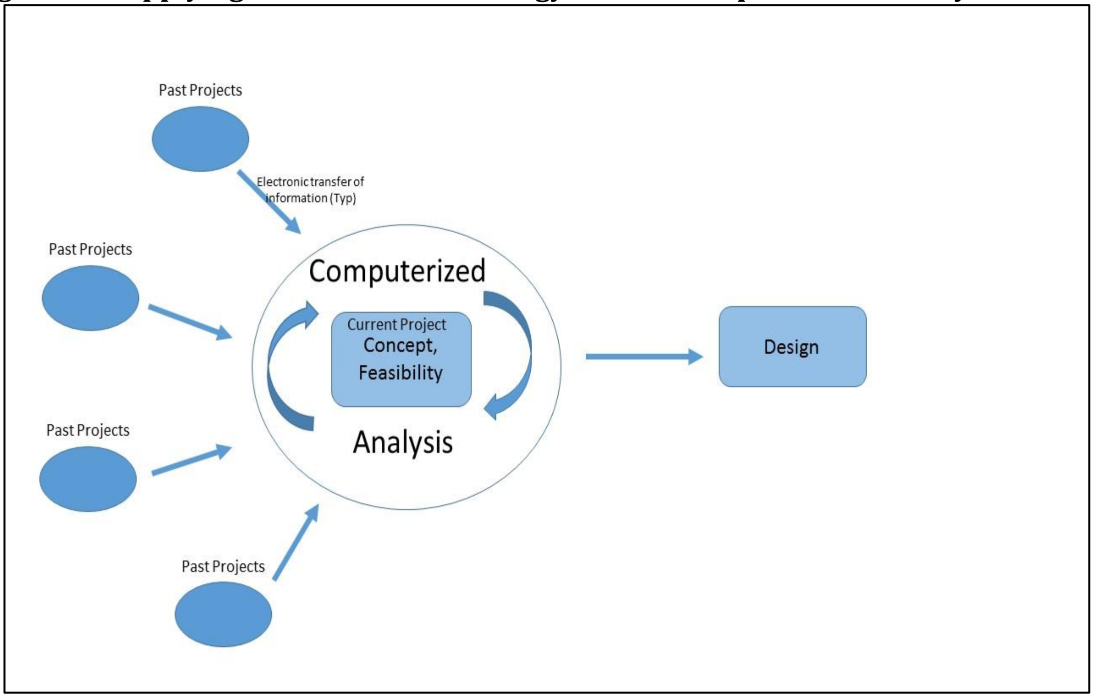
- Further planning and evaluation of alternative solutions to water resource problems.
- Detailed estimation of the benefits and costs of the alternatives to determine what plans merit federal participation.
- Preparation of a feasibility report recommending solutions to water resource problems, and subsequent Congressional authorization.
- Preparation of a letter of intent to financially participate in recommended plan implementation, as demonstrated by mutual concurrence in a draft Local Cooperative Agreement (LCA) for implementation of the project. A Letter of Intent (LOI) is to be prepared by the State or local entity.

4.1.1. Applying Web-Based Technology to the Concept and Feasibility Phases

Traditional project management processes are implemented using conventional methods to deliver information and apply project management techniques. Web-based technology accelerates and facilitates the management processes so that decision-makers can use project management strategies to their best advantage.

The concept and feasibility studies implement the same processes at different levels and are studied as one phase due to the similarity of the processes that take place. During the concept and feasibility studies, the use of web-based technology adds agility to the project environmental impact analysis, soil investigations, equipment availability analysis, and project value engineering analysis, as well as, to the conceptual cost assessment, initial schedule assessment, and scope definition. This is because it uses information previously collected and available in the system to facilitate the analysis of the information (see Figure 4.3). The project documentation will be available in real time, to all stakeholders improving responsiveness and timely decision making. Similarly, the information from the concept to feasibility to design will flow in a seamless manner under a single interface; bringing agility to the entire process.

Figure 4-3. Applying Web-Based Technology to the Concept and Feasibility Phases



After the project has been approved, it will move into the design phase. During this phase, the project design will be implemented and the requirements will be turned into the physical components of the dredging project. The following are examples of physical components of dredging projects: construction and maintenance of navigational channels and infrastructures, construction or maintenance of port and marine infrastructures, land fillings, coastal infrastructures, and environmental remediation design and specifications.

4.1.2. Applying Web-Based Technology to the Design Phase

Implementing the web-based technology during the design phase benefits the project by delivering information in real time over different geographic locations; facilitating dissemination of information between project teams. Communication between the owner's team, designer's team, and other stakeholders improve the processes that take place during design. Similarly, using web-based technology facilitates publishing and posting all project investigations and conclusions on the web –i.e. geotechnical investigations, so that stakeholders and especially potential contractor will understand the project conditions investigated during design. This will reduce project unknowns and corresponding uncertainties, at the time of the bid, therefore reducing the project bid prices. Similarly, this project management strategy reduces claims and change orders dramatically during dredging. These benefits are discussed in Section 4.1.3.

4.1.3. Applying Web-Based Technology to the Dredging Phase

The dredging operation corresponds to the construction phase in the life cycle of the project. During this phase, the project's physical implementation is executed in accordance with the project contract and specifications. As soon as this phase begins, all project management plans and strategies will need to be in place. These plans define the activities and controls that will take place during implementation. The dredging management plan will encompass the dredging operation plan, the information management plan, and the inspection plan.

During dredging the owner needs to maintain control over the information generated at the dredge. This will be achieved by using a system that will collect, archive and process the information generated at the dredge in real time, so the integrity of the information can be protected.

4.1.4. Assessment of the Benefits of using Web-Based Technology

Table 4.1. Assessment of the Benefits of Using Web-Based Technology

Projects Managed Using Traditional Management Processes		**Projects Managed Using Web-Based Management Processes**	
Activity	***Difficulty to Achieve**	**Activity**	***Difficulty to Achieve**
Planning	High	Planning	Very Low
Quality Assurance	Extremely High	Quality Assurance	Very Low
Quality Control	Medium	Quality Control	Very Low
Data Collection	High	Data Collection	Very Low
Processing Data	Extremely High	Processing Data	Very Low
Data Analysis	High	Data Analysis	Very Low
Report Generation	High	Report Generation	Very Low
Improve Production	High	Dredge Production	Low
Cost Reduction	Extremely High	Cost Reduction	Low
Duration Reduction	High	Duration Reduction	Low
Claims Reduction	High	Claims Reduction	Low
Rework Reduction	Medium	Rework Reduction	Very Low

*Classification of Difficulties: Extremely High, High Medium, Low, and Very Low

This assessment was the result of interviews conducted with industry experts during this research.

5. INFLUENCE OF THE WPMS ON THE MANAGEMENT OF DREDGING PROJECTS

The research did not challenge the financial impact of using the WPMS on dredging projects or on the organization, because the system has not yet been installed on a real project, and there is currently no data to assess the financial impact of the system. However, in Chapter 1, an analysis of the system cost was presented. The analysis revealed that the system cost is not a factor in deciding whether to use the WPMS.

Instead, the research focused on the influence of the WPMS on project performance, on the organization's social and political environments, and on the organization's business competitiveness. To assess project performance and organizational impact due to the use of the WPMS, a simulation of the system and brainstorming sessions with experts were conducted. Pertinent hypotheses for future inquiries should be developed for future investigations, when the system is tested and installed on a project. The influence of the system on project performance and on the organization's, social, political, technical, and business environments was analyzed. Prior to the final collection of evidence, prior information collected from dredging projects, literature review, and industry experts were consulted to develop the context and relevant issues related to the research objective. From this context, three basic assumptions were defined.

5.1. Influence of Web-based Systems on Project Performance

The analysis of the literature review and prior investigations on dredging projects and dredging organizations revealed that the use of WPMS technology for the management of dredging projects would influence project performance. Therefore, Assumption 1 was defined: The use of the WPMS will have a positive influence on dredging project performance. Moreover, as presented in Vecino and Skibniewski (2011) and Raymond and Bergeron (2008), adding appropriate information system tools to automate and standardize the flow of project information may further improve project performance.

The research assessed the influence of the WPMS on project performance by focusing on Assumption 1. The former assumptions helped focus the feasibility analysis on the most critical aspects of using the WPMS for the management of dredging projects and served as the focus for the research generalizations. The research used the analytical generalization technique to analyze the evidence obtained during data collection. In order to focus attention and facilitate the definition of the variables of interest for Assumption1, the following research questions were developed.

- *What is the impact of using the WPMS on the performance of dredging projects?*

Furthermore, the question above was broken into more questions to develop more variables of interest. In the research context, performance primarily depends on the team management capabilities, project control, and the decisions made to guide the project. In order to assess if the WPMS influences performance, the following questions were assessed:

- *What is the influence of the WPMS on the management of dredging projects, and how might this affect dredging performance?*

- *What is the influence of the WPMS on project control, and how might this affect dredging performance?*
- *What is the influence of the WPMS on decision-making, and how might this affect dredging performance?*

Final questions generated from the propositions:

- Would the WPMS improve project management?
- Would the WPMS improve project control?
- Would the WPMS improve decision-making?

Analysis of Assumption 1 Questions and Baseline Considerations

A qualitative baseline was defined in order to create a reference from which the responses were assessed.

- Would the WPMS improve project management? The evidence should show that the WPMS positively influences project management functions.

Baseline considerations—during the project life cycle, the people managing the project have access to real-time information of what is happening at the dredging operation, and have access to information that will let them assess project conditions, thereby improving project management capabilities. Similarly, the operator will be able to manage his operation by having a precise view of how the cutter interacts with the surface, eliminating over-dredge, or dredging outside the design area. Therefore, improving project management will improve project performance.

- Would the WPMS improve project control? The evidence should show that the WPMS positively influences project control.

Baseline considerations— during the life cycle of the project, managers have access in real time to operational and programmatic data facilitating project control functions. This allows the support team to oversee the dredge operation in real time and from any geographical location, thereby reducing errors and delays. This facilitates enhanced control of dredging projects, thus improving project performance.

- Question 6— Would the WPMS improve decision-making? The evidence should show that the WPMS positively influences decision-making.

Baseline Considerations— during the life cycle of the project, project managers have real-time access to project information, improving teamwork and coordination. This allows the management team and other stakeholders to make timely decisions, thereby reducing errors and improving effectiveness. Similarly, during the operation, the operator and dredge personnel will have access in real time to plan-views of the area dredged, geotechnical information, past performance of dredge works in the area, managerial information, and accurate real-time position systems. This will allow effective scope determination, risk assessment, construction methods, and decision-making, thus improving project performance.

5.2. Influence of Web-based Systems on the Organizations Social, Political, and Technical Environment

Additionally, as concluded from prior work, the design and implementation process will not be straightforward. The development of a system that creates a systematic and automated environment to process data, standardize functions, and improve the flow of project information to all parties will not guarantee its successful implementation or acceptance within an organization. During system design and implementation, the implementer should consider the impact of the system on the organization's social, political, and technical environments.

Assumption 2: The design and implementation of the WPMS also requires considering the user's social, political, technical environments. In order to focus attention and facilitate the definition of the variables of interest related to Assumption 2, the following research question were developed:

- *In terms of the user's social, political, and technical environments, is the implementation of the WPMS feasible?*

The question above was broken into more granular questions to develop more variables of interest:

- Would the WPMS make your job easier or more enjoyable?
- Would the WPMS compromise your job security?
- Is there any reason why you would not use the WPMS?

Analysis of Assumption 2 Questions and Baseline Considerations

A qualitative baseline defining specific events that will influence the user's social, political, and technicla was defined in order to create a reference from which the responses were assessed.

- Would the WPMS make your job easier or more enjoyable?

Baseline Considerations— the WPMS facilitates project management, project control, and decision-making functions. However, influence on the user's social, political, and technical environments in an organization go beyond what is good for the project. The subjective feelings of the users in relation to their positions and work environment must also be considered. This situation is complex and requires careful attention. If the user believes that his authority, position, or work environment is threatened, he may resist implementation of the WPMS. The implementer will investigate the reason for the resistance, and the design will consider these concerns in order to make the system flexible enough to avoid resistance.

- Would the WPMS compromise your job security?

Baseline Considerations— If the user feels that the implementation of the WPMS compromises his job, or he believes that his job may be threatened, he may resist implementation of the WPMS. Therefore, the design phase would take into consideration the requirements needed to make the system flexible enough to avoid resistance.

- Is there any reason why you would not use the WPMS?

Baseline Considerations— This question can be interpreted in various ways, depending on the responder's position within the organization. User responses will be interpreted according to each user's position within the organization. If the responder is a middle level employee, for example an operator, he may interpret the question from the point of view of losing power over managing the information or if he believes that his job may be threatened, or if he needs to learn a new technology. In the above case, the question has to do with Assumption 2. On the other hand, if the responder is a high-level employee, the response may be interpreted from the organization's business environment view. In this case, the question has to do with Assumption 3.

5.3. Influence of Web-based Systems on the Organizations Business Environment

The use of the WPMS should give an organization the advantage of being more effective and efficient, improving business competitiveness within its market. Moreover, it is anticipated that a company using the WPMS will create a healthier relationship with the project owners, bringing repeated business to the organization. However, resistance to the implementation of the WPMS was encountered in the contractor and consultant business segment. Resistance arose from contractor concerns of system cost, from their believe that the organization's sensitive information would be exposed, and because the system may influence their strategic position in the industry. This type of resistances were reactions to Assumption 3: The design and implementation of the WPMS requires considering the business aspects of the organization.

In order to focus attention on and facilitate the definition of the variables of interest related to Assumption 3, the following research question were developed.

- Would the WPMS make your business more competitive?

Analysis of Assumption 3 Questions and Baseline Considerations

A qualitative baseline was defined in order to create a reference from which the responses were assessed.

Baseline Considerations— this question is related to how the user feels the use of the WPMS will influence the organization's business position within its market. This question helped discovered if high-level management would resist the WPMS implementation. If there is evidence that the WPMS will jeopardize the organization's business position in the market, the design and implementation of the WPMS would require considering the factors creating resistance.

Final questions for Assumptions 1, 2, and 3

1. Are you a Project Owner?

2. Are you a Project Manager or Consultant?
3. Are you a Contractor?
4. Would the WPMS improve project management?
5. Would the WPMS improve project control?
6. Would the WPMS improve decision-making?
7. Would the WPMS make your job easier or more enjoyable?
8. Would the WPMS compromise your job security?
9. Is there any reason why you would not use the WPMS?
10. Would the WPMS make your business more competitive?

A questionnaire was prepared with an introductory overview of the system functionalities and its most important characteristics. The questionnaire was used to gather research data from the experts during interviews, and a survey was sent out to 84 potential users (consultants, contractors, and project owners).

5.4. Procedure to Maintain Study Quality

The research used three tests to establish the validity of the study:

- Construct validity
- External validity
- Reliability

Construct Validity – For the construct validity test, the research used the projects and expert opinion as evidence to establish a link to the research assumptions. Interviews with project staff, operational personnel, and project experts, as well as using the survey results provided multiple sources of evidence. A baseline was established which linked the evidence to the assumptions. For Assumption 1, the baseline was established by defining specific events that constitute good performance. For Assumption 2, the base line was established by defining specific events that influence the user's social, political, and technical environment. For Assumption 3, the baseline was established by defining specific events that influence the business aspects of the organization.

Good Performance

Assumption 1 established that the WPMS positively influences project performance. To assess positive performance, the baseline for good performance was established when the project is completed on time, under budget, and with the quality specified in the contract documents. The measurement used to assess project performance is how users feel the WPMS can help improve performance by improving project management, project control, and decision-making. The survey responses were used to determine if the WPMS improves project performance.

Social and Political Considerations

Assumption 2 requires considering how the WPMS influence the user social, political, and technical environment. To assess this, the baseline is when each feels confident of his/her current social, political position, or technical environment. The measurement used to assess the social and political position or technical environment of the interviewees is based on how each interviewee feels the system will affect his/her current work environment. Based on survey responses, it was determined that the WPMS would positively influence each interviewee's current social, political, and technical environment (see Section 7 for the research analysis).

Business considerations

Assumption 3 requires considering the business aspects of the organization. To assess this, it was established that the baseline for the business's current position in their market of influence is when the interviewees believe that the business is well-positioned and competitive. The measurement used to assess the company's current business market position is based on how the interviewees feel the WPMS would affect the company's strength in the market. Based on their responses, it was determined that the WPMS would influence the business's current position in the market.

External Validity – The test was achieved by proving that the study findings were generalizable to other dredging projects.

Reliability – In order to assure that if a different investigator attempts to perform the same study using the same procedures, the research documented the interviews and the data collected.

5.5. Interpreting Study Findings

The strategy used for analysis generalizes from the evidence to the research assumptions (analytical generalization). The research relied on the assumptions to identify the data collected and to define the questions that would generate evidence. The research assumptions were used for final interpretation of the evidence, and for the analytical generalization of the evidence to the assumptions. The research context established in

Section 1.7 further facilitates the analysis generalization. This is because it models the management of dredging projects in to two components: the management team and the operating team. This model works for the owner-owned-operation and the owner-contractor delivery systems considered in this research.

Table 7-1, in Section 7, summarizes the responses creating a link between the response and the research assumptions. It facilitates the generalization from the responses to the assumptions.

The generalization took the responses from the experts, from interviews with the project staff and operational personnel, and from the survey respondents, and linked it to the assumptions. The generalization was used to assess the feasibility of the WPMS. The validation of the research objective by generalizing from the empirical evidence to the research assumptions using the case study methodology demonstrated how the WPMS improves project performance and what needs to be done to solve potential resistance to implementation.

6. DATA COLLECTED TO ASSESS THE FEASIBILITY OF USING WPMS FOR THE MANAGEMENT OF DREDGING PROJECTS

6.1. Projects, Interviews, and Data Collection Methodology

The investigation collected data from three projects and surveyed 31 dredging experts (see Table 6.1 and 6.2). Since the WPMS was not deployed to the project's equipment, the WPMS functionalities were simulated during brainstorming sessions using a prototype simulator. The WPMS was simulated to the project staff and industry experts, capturing experts and staff opinion on how the WPMS would influence project performance and the organization's social, political, technical, and business environments.

The blueprint of the research subject was developed in Chapter 1 and the research assumptions and questions were defined in Section 5. The research assumptions reflected the research subject and were developed to help focus the feasibility analysis. To validate the Assumption 1, three-research questions were defined to gather the information related to the influence of the WPMS on project performance. To validate the Assumption 2, three research questions were defined to gather the information related to how the implementation of the WPMS influences the organization's, social, political, and technical environment. To validate the Assumption 3, one research question was defined to gather the information related to how the implementation of the WPMS influences the organization's business environments. Three general questions were used to define the user's position within the industry segments.

Meetings and System Simulation

In order to convey the concept and characteristics of the WPMS to project personnel and to the dredging experts, the system functionalities were presented using simulation. Based on this information, the interviewees responded to the research questions. The interviewees where selected from a professional network of contacts, from the world Dredging Contractors of America (DCA) database: (http://www.dredgingcontractors.org/about.htm), and from the World Dredging Magazine Directory (http://worlddredging.com/World_Dredging.html).

Project A interviews were held independently with each project expert, in person, at different times during the research. The interview lasted approximately 45 minutes. On February 19, 2016, a meeting was held with the Project B team using Skype; the features of the latest prototype were presented using the system simulator. The presentation and simulation lasted one hour, and the group interview lasted for thirty minutes. The questions were previously handed to each participant and questions were answered during the subsequent interviews. On February 4, a meeting was held with the Project C team using Skype. The features of the latest prototype were presented using the system simulator. Three people attended the meeting from the team, all experts. The following personnel attended the meeting: the Director of Research and two research engineers. The presentation and simulation lasted one hour, and the interview lasted for thirty minutes. The questions were previously handed to each participant and subsequently, the Director of Research answered the questions during the interview process.

Project A, B, and C engineers and personnel were interviewed on a one-by-one basis. Other experts from the industry were also interviewed. The interviews were done using video-conference software by showing the latest prototype features and asking the questions in the questionnaire. A survey was also implemented and 84 survey questionnaire distributed. The survey questionnaire included an introduction with an overview of the system along with the questions.

6.2. Summary of Data Collected

<u>Summary of Interviews and Survey</u>

The data collection is based on the interviews from the projects studied, form other experts of the industry, and from a survey. The data have been consolidated for each interviewee and survey response in Appendix A. Table 5-2 show a count of the experts surveyed by segments.

Table 6-1. Projects-Studied Experts Surveyed

CASE STUDY	NUMBER OF INTERVIEWEES	COUNTRY
Project A	7	Panama
Project B	2	Colombia
Project C	3	U.S

Table 6-2. Experts Surveyed

EXPERTS PARTICIPATING IN THE		COUNTRY
Interview	SURVEY	
6	10	U.S
2		Colombia
1		China

7. ANALYSIS OF THE DATA TO ASSESS THE FEASIBILITY OF USING WPMS

7.1. Analysis of the Project Stakeholders Responses

Tables 7-1, 7-2, and 7-3 show a summary of the results from the data collection. The tables link the assessment of the responses to the assumptions. To assess the feasibility of using the WPMS, the responses were analyzed for each research assumption independently. Assumption 1 assessed the benefits of using the WPMS on project performance. Assumption 2 assessed the WPMS influence on users social, political, and technical environments. Assumption 3 assessed the impact of the WPMS on the business position in the market.

7.1.1. Analysis of the Data to Assess Project Performance

The data collected from the first three questions correlates with the hypothesis presented in Assumption 1 (see Table 7-1). All responses agree that the WPMS will help improve project performance, with the exception of one response from a contractor arguing that the system will not improve performance because the system already exists in the current environment. This particular response does not answer the question that was asked. Therefore, this answer was not included in the results, and it was concluded that the WPMS would improve project performance.

Table 7-1. Summary of Responses for Assumption 1

	1	2	3	4	5	6	7	
ASSUMPTION 1	PROJECT A	PROJECT B		PROJECT C	INDUSTRY EXPERTS			SPECIAL CONSIDERATIONS
		Owner	Contr.		Consult	Contr.	Owner	
WPMS improves project performance	Yes	Yes	Yes	Yes	Yes	Yes	Yes	*1
	Yes	Yes		Yes	Yes	Yes		*2
	Yes				Yes	N/A		*3
	Yes				Yes	Yes		*4
	Yes				Yes	Yes		*5
	Yes				Yes	Yes		*6
	Yes				Yes	Yes		*7
					Yes			*8
					Yes			
					Yes			
					Yes			
Summary of Results	Yes	Yes	No	Yes	Yes	Yes		

*3. The "N/A" in Column 6 denotes a response that did not answer the question that was asked.

Table 7-2. Summary of Responses for Assumption 2

	1	2	3	4	5	6		
ASSUMPTION 2	PROJECT A	PROJECT B		PROJECT C	INDUSTRY EXPERTS			ESPECIAL CONSIDERATIONS
		Owner	Contr.		Consult	Contr.	Owner	
WPMS negatively influences the interviewee's social, political, and technical environment	No	No		N/A	No	No	No	* 1
	No		Yes	Yes	No	No		*2
	Yes	No			No	Yes		*3
	No				No	Yes		*4
	No				No	Yes		*5
	Yes				No	Yes		*6
	Yes				No	No		*7
					No			
					No			
					No			
					No			
Summary of Results	Mixed	Mixed		No	No	Mixed	No	

*3. "Yes" in column 1 shows middle-level management resistance to technical changes.
*3. "Yes" in Column 6 shows resistance to technical changes.
*2. "Yes" in column 4 shows middle-level management resistance to technical changes.
*2. "Yes" in Column 3 shows resistance to technical changes.
*4. "Yes" in Column 6 shows resistance to technical changes.
*5. "Yes" in Column 6 was not qualified with any specific comments.
*6. "Yes" in Column 6 shows resistance to technical changes.
*6 and *7. The "Yes" in Column 1 shows resistance to implementation because of owner intrusion in operator work, and resistance to changes.

Table 7-3. Summary of Responses for Assumption 3

	1	2	3	4	5	6	7	
ASSUMPTION 3	PROJECT A	PROJECT B		PROJECT C	INDUSTRY EXPERTS			ESPECIAL CONSIDERATIONS
		Owner	Contr.		Consul	Contr.	Owner	
WPMS positively influences business position in the market	Yes	Yes		Yes	Yes	Yes	Yes	*1
	Yes		No	Yes	N/A	No		*2
	Yes	Yes			Yes	No		*3
	Yes				Yes	No		*4
	Yes				Yes	No		*5
	Yes				Yes	Yes		*6
	Yes				Yes	No		*7
					Yes			*8
					No			*9
					No			*10
					No			*11
Summary of Results	Yes	Mixed		Yes	Mixed	Mixed		

*2. The response of “N/A” in Column 5 does not apply because the interviewee is a consultant not directly involved in contracts.
*2. The response of “No” in Column 6 is because the interviewee would not like to share dredge information with the owner.
*2. The response of “No” in Column 3 is because the interviewee would not like to share dredge information with the owner.
*3. The “No” in Column 6 shows resistance to exposing the organization’s private information, and cost concerns.
*4. The “No” in Column 6 shows resistance to exposing the organization’s private information.
*5. The “No” in Column 6 was not qualified with any specific comments.
*7. The “No” in Column 6 shows resistance to exposing the organization’s private information.
*9. The “No” in Column 5 shows resistance to exposing the organization’s private information.
*10. The “No” in Column 5 shows resistance due to cost concerns.
*11. The “No” in Column 5 shows resistance due to cost concerns.

7.1.2. Analysis of the Data to Assess the User's Social, Political and Technical Aspects of Using Web-Based Technologies

Influence of the WPMS on User's Social, Political, and Technical Environments

The investigation used the entire business organization as the scope for analysis of Assumption 2. The reason for this approach is that the influence of the WPMS on the user's social, political, and technical environments occurs at the organization level (Section 1.7) Assumption 2 includes, as the scope of analysis, all levels of personnel at the dredge and at the organization's office. It also includes the organization's business processes, organizational structure, and functional areas.

Three questions in the questionnaire were related to Assumption 2:

- Would the WPMS make your job easier or more enjoyable?
- Would the WPMS compromise your job security?
- Is there any reason why you would not use the WPMS?

Project A Responses

Project A uses an owner-owned-operation delivery system, and the project has a decentralized authority structure; each division has a certain degree of autonomy. This structure is prone to resistance when implementing a system that centralizes control over the information, altering the balance of power. The responses show that the system meets resistance at the operator level. ***The reason for resistance is that the operators feel that management is intruding in their work.*** The captain and technical personnel of the dredge did not show resistance to the implementation of the WPMS. The above result requires that during design, the implementer consider the factors influencing resistance in order to avoid resistance during implementation.

The solution to this resistance can be solved by investigating the specific reasons for the resistance and applying the solutions needed to avoid it. Markus's recommendation is that once resistance is apparent, an analysis should be performed to determine precisely why the resistance occurred and what could be done to avoid it. After determining the reason for resistance, the implementer could decide upon a course of action that may include:

- Altering the initial concept in ways that would be acceptable to the operation personnel
- Sacrificing some of the general features of the system to accommodate the operational personnel preference
- Allowing the operational personnel to participate in the design of the system
- Negotiating changes for other conditions that have value to the operating team

Project A, also showed resistance at the organization level, by middle level management. ***The resistance is because the user would be required to learn a new system, and change technical tools and methods for acquiring information.*** This result requires that the system be implemented and tested so that the users better understand the technical implications of the system.

Project B Responses

Project B uses an owner-owned-operation delivery system combined with a design-bid-build delivery system. The contract is a technical-private association between both the owner and the contractor. The project has a decentralized authority structure in that the contractor is autonomous. Dredge personnel were not interviewed due to logistic matters. Analysis of responses related to Assumption 2 (see Table 6-2) showed that resistance to implementation, was encountered at the organization level, by middle level management. ***The resistance is because the user would be required to learn to use a new system, change technical tools and methods of acquiring information, and change work methods already in place.*** This result requires that the system be implemented and tested so that the users better understand the technical implications of the system.

Project C Responses

Project C involves the management team, a government organization that uses the design-bid-build delivery system to procure dredging services, and the operating team, a contractor who owns the dredges. In the Project C scenario, resistance was encountered at the management team and at the operating team. Project C management team is implementing a system similar to the WPMS; this system is described in Section 2.4-1. ***The management team middle-level management personnel showed resistance to technical changes***. For example: they resist implementation because of the need to change the tools and artifacts they are currently using in order to capture information and to control the project. This result requires that the system be implemented and tested so that the users better understand the technical the implications of the system. Similarly, the interviews revealed that the operating team would resist the implementation. The operating team (contractor) believes the system will ***expose the organization's private information and will negatively influence their strategic position in the market***. The solution to this situation requires additional investigation.

7.1.3. Analysis of the Data to Assess the Business Aspects of Using Web-Based Technology

As shown in Table 7-3, responses related to the influence of the WPMS on business competitiveness show three types of concerns from the responders: Concern related to the security of the contractor's private information, resistance to technical changes, and concern related to the system cost.

Responses from Private Sector related to Assumption 3

The interviewees of the business private sector are either contractors or consultants. They are primarily involved with projects using the design-bid-build delivery system. Their involvement with the owner creates a decentralized authority structure being more likely to resist the implementation of the WPMS. Contractors and consultants feel the system will ***expose information that may influence their strategic position in the market***. A counter argument to this hypothesis is that the bulk of the project information handled during the project concept, design, and implementation phases is not sensitive information. On the contrary, this information should be widely distributed to all stakeholders as part of best management practices in order to mitigate project uncertainty and risks. This portion of the information contains the information used by the WPMS to improve project management, control, and decision-making. Any remaining information that may be confidential should be taken into account during the design phase so that a higher level of security can be insured. However, this issue needs to be investigated further.

The private sector also showed resistance ***because the user needs to learn a new system, and change tools and methods of acquiring information.*** This result requires that the system be implemented and tested so the users better understand the technical implications of the system. Finally, experts in the private sector expressed concerns related to the system cost. In Section 1.4 an analysis of the WPMS cost was assessed and concluded that the system cost is not an important factor in deciding on the use of the WPMS.

7.2. Analysis of the Feasibility of using Web-Based Systems for Dredging Projects

The research analyzed the feasibility of the WPMS by assessing if the system would improve project performance, if the users would resist the system, and if the system would influence business competitiveness. In addition, an analysis of WPMS cost was developed, and a summary is depicted in Section 1.4.

The WPMS's acceptance is sensitive to the type of user - high-level management, middle-level personnel, or operation personnel. It is also sensitive to all industry segments including project owners, project managers or consultants, and contractors. The investigation shows that each type of user and industry segment introduces different types of resistance to the use of the WPMS.

A summary of the factors triggering resistance are as follows: 1) The user feels that management is intruding in their work; 2) The user needs to learn a new system, change technical tools and methods of acquiring information, and change work methods already in place; 3) The user feels that the system will expose the organization's sensitive information, and will negatively influence their strategic position in the market; and 4) The users feel concerns related to the cost of WPMS.

7.2.1. Influence of Web-Based Systems on Dredging Project Performance

Assumption 1 states that using the WPMS will improve dredging performance. The research uses three key functional areas to assess if the WPMS improves project performance, project management, project control, and decision-making. The assessment of the interviewees validated the assumption based on the following considerations:

Project management— coordinates, organizes, controls, and assures that all functional areas perform as expected. The evidence shows that WPMS facilitates how project management can interconnect with all functional areas, access project information, analyze the information, use the information, and distribute the information as needed. The WPMS facilitates project management by centralizing, standardizing, automating, and distributing project information in real time and over any geographic location.

The WPMS, enhances project management capabilities by mitigating the uncertainty inherent in dredging projects, therefore eliminating the crippling influence of project errors, misunderstandings of project conditions, lack of information sharing between the management team and operating team, and contingencies in general. These issues can increase project costs and create delays. When this happens, the project owner generally pays the consequences. The WPMS capabilities facilitate team communication and problem resolution. Therefore, a project using the WPMS is more likely to experience improved performance.

The WPMS combines Project Management Techniques (PMT), Information Systems, and Communication Infrastructure Technologies to aid the project management process. Of these three components, PMT, is performed by individuals to manage the project. The other two are tools used by the individuals to perform PMT. Regarding WPMSs influence on project performance, "It is only indirectly, through its contribution to managerial work…." referring to Project Management Information Systems, "….that this use contributes to project success" (Raymond and Bergeron, 2008).

Project control— assures that the dredging operation is performed in accordance with the specifications and quality, on time, and with the resources available. The evidence shows that the WPMS allows project controls to track, validate, and support the operation in real-time. The WPMS facilitates project control by allowing the operation team to continually monitor the operation, thus allowing the project team to be aware of and correct errors.

For example, decision-making is a dynamic response from all functional areas that allows project flow. If there is a problem, a response allows the project to flow in the right track. The evidence shows that the WPMS allows dynamic responses to problems. The WPMS pushes information to the users, maintaining awareness and alerting the users about unusual situations, action items, errors, and the need to make decisions.

Conclusions

Regarding the influence of the WPMS on project performance, as explained above, the system includes not only the contribution of Information systems and Communication Infrastructure to add agility and ubiquity to project information, but also, the power that these tools adds to the project management team capabilities. The WPMS is an application of the Internet of Things (IoT) concept. "It connects people, data, things and processes in massive networks, creating vast amounts of information that, when analyzed and used intelligently, could create new innovations and efficiencies" (Sawyer, 2016).

The evidence shows correlation between the responses; the WPMS improves management, quality control, and decision-making for all organization segments. This validates the research proposition that the WPMS improves project performance.

7.2.2. Influence of Web-Based Systems on Social, Political, and Technical Aspects of Using Web-Based Technology

The research analyzed the design and implementation of the WPMS through the lens of the evidence gathered during data collection. The study shows the need for a detailed examination of the user's social and political environment for each particular organization when implementing the WPMS. In addition to social and political considerations, users will resist implementation of the WPMS because of resistance to technical changes.

Evidence collected indicates that the WPMS influences dredging project's social and political environment and that this type of resistance would be found in the owner-owned-operation delivery system. In this context, the owner's organization has decentralized authority structure and the operating team controls the data generated at the site. This creates a division of power and an unbalanced flow of quality information. Because the WPMS centralizes control over data and creates a balanced flow of information, the teams operating the dredge will resist implementation of the WPMS. The interaction theory explains that "Systems that centralize control over data are resisted in organizations with decentralized authority structures; systems that alter the balance of power in organizations will be resisted by those who lose power and accepted by those who gain it" (Markus, 1983).

In an owner-owned-operation, the management team needs to secure site information for quality assurance and quality control, while the operating team may feel that management is intruding in the operation. For example, during interviews, an operator described that the system would intrude in the operator's job. Nevertheless, in this scenario, the management team needs total control over the information so that they can assist the operation with the greatest efficiency

Resistance to change was also encountered because the user is required to learn a new system, change technical tools and methods of acquiring information, and change work methods already in place.

Conclusions

The above analysis reveals two scenarios that require adjustments to the WPMS design and implementation. The first is that an off-the-shelf system will not fit the needs of all organizations, because each organization has its own environment and business processes. In this case, the implementer will customize the system so that it is flexible enough to fit each organization. An off-the-shelf system may not be feasible given the complexity of the system requirements. The second scenario is that the system needs to be installed and tested on a dredge, so that users can better understand the technical implication of the system. The users may understand the WPMS functionalities and capabilities, but until tested, the user will not be able to assess how it differs from their current systems.

7.2.3. Influence of Web-Based Systems on Owners and Contractors Organizations

In an owner-contractor scenario (design-bid-build delivery system), the management team (owner) needs to secure site information for quality assurance; the operating team (contractor) claims that this information is proprietary. For example, the management may want to know equipment performance details during execution, while the operating team (contractor) considers this information private; project performance information is intrinsically information that belongs to the project; the owner uses it to assess contractor performance and eventually will need it in order to assess contractor claims. When the contractor claims that his performance is low due to site conditions, the owner has no base knowledge to assess the factual accuracy of this claim. From the WPMS theoretical approach, owners need to secure project-related data in order to use it for analysis, forecasting, or for project control. Conversely, information sharing can work in a contractor's favor and actually allow the evidence to support their claims.

In terms of how the system influences the organization's business, the evidence shows that high-level management resist the idea of implementing the system because they perceive it as a threat to their business sensitive information and know-how. During the investigation, when the WPMS was presented to potential users, contractors and consultants were concerned that the system might expose their private information affecting the power they have over information during the project life cycle. They did not focus on demonstrable positive attributes of the system, such as how they will be able to interact with the data generated by the system to improve performance or the impact of having real-time information available to improve project control and/or decision-making. The issue was related to losing their exclusive power over information. Their fear appears to be that sharing project data with the project owner threatens how the organization will leverage its power over information they have acquired in the past.

Over the years, some contractors and some consultants have gained experience and information that they consider proprietary. For example, this information may be related to the characteristics of soil and topography of specific areas, and the contractors may use this information during the bid process or during project execution to gain advantage over the owner. During project concept, design, and implementation investigations, the owner should discover this information and use it to benefit the project. The use of this information during implementation will have a positive value for overall project performance. Dredging projects are repetitive, and executed at the same locations repeatedly. Therefore, historic information is vital for good project performance.

Conclusions

For an owner-contractor scenario, the implementer would make sure the data collected is project-related. The information needed by the owner and the collecting methodology would be specified in the contract. However, the solution to this situation is complex and need further investigation.

7.3. Using Web-Based Systems for the Management of Dredging Projects

The analysis of the literature review and prior investigations on dredging projects and dredging organizations were the basis to define the research assumptions. These assumptions are generalizations of a typical dredging project management paradigm. Therefore, they represent the management environment for any dredging project in the industry. Moreover, in order to analyze the information gathered from different types of projects and contract delivery systems, the research created a model depicted in Figure 1.5 in Section 1.7. The model modularized dredging project, allowing the interpretation of the research responses from different contract delivery systems and project contract arrangements to be associated with the research assumptions. Table 7-2 shows how the evidence collected is linked to the research assumptions.

Table 7-2. Summary of the Analysis

ASSUMPTION	SUMMARY OF THE ANALYSIS
Assumption 1 The WPMS improves project performance.	The investigation concluded that the WPMS would improve project performance.
Assumption 2 The design and implementation of the WPMS also requires considering social, political, and technical aspects of the organization.	The investigation concluded that the WPMS would encounter resistance to implementation due to influence on the user environment. The operators claim that if the system is implemented the owner will intrude in their work. Middle level management showed resistance because they will need to learn a new system, and change tools and methods used currently to collect project data.
Assumption 3 The design and implementation of the WPMS requires considering the business aspects of the organization.	High-level executives showed resistance because the system will expose private information influencing the strategic position of the organization in the market of influence.

8. SOLUTIONS TO RESISTANCE TO THE USE OF WEB-BASED TOOLS IN DREDGING PROJECTS

8.1. Solutions to Resistance to the Use of Web-Based Tools for the Management of Dredging Projects

Assessing the feasibility of using Web-based technology for the management of dredging projects is a new topic in the scientific community. It has not been defined by a formal investigation therefore; an exploratory case study investigation was conducted. Evidence was gathered by reviewing available literature and qualitative approaches such as formal interviews with case study project experts, staff, operating personnel, and other experts of the industry, as well as implementing focus groups at the case study project organizations. In addition, a website and a forum were created to attract worldwide feedback, and a survey was distributed to 84 industry experts, see Appendix B. This investigation highlights important matters that need to be addressed in further investigations in order to allow the Web-based technology to fit in to the dredging industry paradigm.

The main questions asked in order to address the uncertainty of continuing the design and implementation of the Web-based system was is the Web-based technology feasible for the management of dredging projects? Evidence showed that the technology would improve project performance. This conclusion is positive and does not need further considerations. In addition, implementation of the technology would encounter resistance to implementation due to influence on the user's social, political, and technical environment. This resistance will hinder the implementation of the Web-based technology, but can be solved by using Markus's Interaction Theory (Markus, 1983). Finally, the majority of the contractors and some consultants in the dredging organizations will resist the use of the system because it will influence negatively their strategic position in their market. This resistance needs further formal investigation.

The second and third findings are related to how a Web-based system influences the users' position within the organization and how the system influences the organizations' position within the dredging market. According to Markus's Interaction Theory, the second finding has to do with political and organizational learning and changing variants of the theory. The third finding has to do with the interaction between the system and the organization. In order to encounter solutions for the resistances, the second and third findings will be studies under the lenses of Markus's and Keen theories, and TAM model.

8.1.1. Resistance due to Political and Technical Factors

In analyzing resistance, the evidence shows resistance related to political and technical aspects.

Resistance due to Political factors on the Users

For an owner-owned-operation delivery system operators showed that, they would resist the Web-based system implementation. According to Markus's theory, this situation has to do with the influence on the political aspects of the users position within the organization. "Here the resistance is explained as a product of the interaction of the system design features with the intra-organizational distribution of power…" (Markus, 1983). In the dredging industry the operators work gravitates around the most important task, which is production. In a traditional dredging operation, the operator is responsible to excavate and report all parameters related to performance, namely down times and its causes, operating times, and production. Similarly, he is responsible for the production, and excavating within the design section. The operator generates and manages important portion of the information generated during a dredging project. This situation gives the operator great power over the information he manages.

Consequently, other intra-organizational areas that need the information generated and reported by the operator to generate analyses and reports has less power over this information and relay on the operator to collect the information. The implementation of the Web-based system will change how this information is generated, transmitted, and utilized, reducing the operator's power in the generation and manipulation of the information. This creates operator resistance to implement the Web-based system, amplified by the organization "social inertia that damps out the intended effects of technical innovations" (Keen, 1981). This resistance is strong and has significant influence on the likelihood of a successful implementation.

Solution to Resistance due to Political Factors

The operator will resist the implementation because he will lose power over the generation and manipulation of the information. Centralizing the information is paramount in improving project performance, so there is very little to negotiate here in terms of changing the design of the system. On the other hand, a good alternative would be to educate operators on how the system may improve their productivity, leading to smaller workloads, ultimately reflecting better overall performance. In addition, in order to achieve this objective effectively, the system should be installed and tested so the operators can learn the benefits of the system.

Solution to Resistance due to Technical Factors

Resistance due to technical factors such as systems and methods to collect information was encountered at the middle-level management of all user segments studied in the industry.

Positioning Systems

Middle level management of all segments expressed concerns in changing the tools they are currently using to position the dredge. The new system concept reduces complexity related to the integration between the geographic position systems (GPS) and the software. Currently, complexity is originated due to the configuration of the GPS and the software capturing the information from the GPS. The GPS needs to be manually configured for applicable geographic areas, computer ports connection, communication protocols, and a host of parameters needed. Current users have mastered the use of the current GPSs in the market and expressed concerns in changing to a new GPS because they fear they will need to learn a new system. Installation and configuration of GPS systems are currently implemented by a group of technician. This group generally incudes hydrographic surveyors and engineers with knowledge in topography, and geodesy.

The hydrographic positioning software used to capture the GPS information is a visual interface between the user, the GPS, and the system processing the information to render the geographical locations on a computer screen. This software also needs configuration to connect to the GPS, and to load different files needed to load georeferenced plan views and information needed by the operator during the dredging operation.

The new positioning system concept will include a plug and play feature capable of automatically integrating with the positioning software, for example, identifying the current geographic area automatically amongst other facilitative capabilities. The objective is to automate all configuration tasks so that less human interaction is necessary.

Collection of Programmatic and Managerial Information

Similarly, current manual systems to collect programmatic and managerial information on the dredge are in place and users fear accepting changes because they would need to learn a new system. Current manual systems include filling paper forms to collect information from the operator room, the engine room, and deck operations. This approach creates an extended lifecycle for the information flow. The information generated at the dredge is delivered manually to managers and decision makers for inspection, validation, and returned to the dredge for feedback. The lifecycle of information flow from the moment the information is generated to the moment the feedback returns to the dredge is approximately 4 to 10 days. Collecting information manually using paper forms is problematic and creates opportunities for errors in the management of the operation. For example, an operator logs stop time and start times to estimate downtime and operating times; likewise, he will log the reason to stop including any additional comments. Sometimes, he may be busy and forget to log the information. Others may wait to the end of the shift to input the log information from memory. Inconsistent logging of information is problematic, causing false expectation during analysis and skews the work assessment. This may also hamper planning, and cost estimates, and basic information needed for risk assessment. Incomplete information may create inaccurate assessment of the work conditions. Mainly the material being dredged, dredge location, weather conditions, equipment performance, and volume of material dredged.

Clearly, current methods of gathering dredging project information lack accuracy. The Web-based technology enhances the data collection methodology, adding agility to the information flow so it can be generated and utilized in real time. This investigation showed that the Web-based technology would improve dredging performance.

Web-based technology has the capability of simplifying data collection. It allows automatization of the collection process by virtually eliminating the human interaction. The collection process happens concurrently with the actions required by the operation and users may not even notice that the information is being collected. For example, the stop and start of the dredge during operations due to different operational reasons may be captured by a sensor when the engine RPMs reaches or are reduced from a certain limit. Similarly sensors measuring when the dredge pump pressure, RPM, or electrical power, reaches or are reduced from a certain limit may capture the stop and start.

In conclusion, during action group and brainstorming meetings with project personnel during the concept refinement and requirements definition, it was evident that the Web-based system will simplify the collection of information, reducing workload for operators and personnel on the dredge. However, during the interview, the same individuals still showed some degree of resistance to the implementation of the Web-based systems. The degree of resistance shown is enough to halt the implementation of the system given that these individual have power over how the information is captured.

8.1.1.1. How to Overcome Political and Technical Resistance

How to overcome resistance to political and technical factors? Up to this point Markus's Resistance Theory has been used successfully to identify and explain resistance to implementation. For this research context, Markus's theory is weak in discussing the solutions needed. Instead, Keen (1981) Theory of Information Systems and Organizational Changes was used to classify resistances and seek solutions. "Tactics for managing changes rely on incremental, facilitative approaches." (Keen, 1981). Keen argues that small changes are need to introduce information systems that will affect organizational systems and that it should include "coalition –building and careful attention to political mechanisms." This investigation introduces the Web-based Project Management System (WPMS) framework, which includes tree basic components that will achieve the goals established in the conceptual framework. These three components if integrated would work to deliver the functionalities needed to apply the Web-based technology system to the management of dredging projects. However, they may be used independently as standalone components to deliver their own functionalities. The case is that trying to make here is that introducing each components independently, one-by-one, may facilitate the acceptance of the integrated system as proposed by Keen.

8.1.2. Resistance due to impact on the Organization Position in the Market

The research evidence shows that high-level executives from some sectors of the contractors and consultants segments will resist the implementation of the Web-based systems. They argue that the system will influence negatively their strategic position in their market. The specific reasons is that the system will expose the company private information. In Section 7 a counterargument was articulated to challenge the contractors and consultants position. The counterargument explains that the information managed by the system is project specific and that if sensitive information is needed it can be managed with higher degree of security available with any Web-based system. However, according to Markus's discussion of the political variants of his theory of resistance, the use of Web-based technology in the context of dredging projects "embodies a distribution of…" interorganizational "power amongst the key actors affected by this design." (Markus 1983). In this latest citation to Markus the word "intraorganizational" was changed to "interorganizational." This is because Markus discussion considers individuals as key actors within the organization. In this context, the challenge of power is between organizations and not between individual or groups within an organization. This means that interpreting Markus intention and applying it to the dredging industry owner-contractors relationship, interorganizational power is an attribute of organization to get their "way in the face of opposition or resistance.." When high-level executive resist the implementation of the Web-based technology they are reacting to a redistribution of power caused by the system between organizations.

8.1.2.1. How to Overcome Contractors and Consultants Resistance

The key to a possible solution is to identify specifically what is causing the reaction of the contractors and consultants to resist the implementation of the Web-based system. In order to achieve this objective inference of the causes will be explored. The major achievement of implementing Web-technology, according to Keen's idea, is to cope with uncertainty. The reason is to provide the project team with useful information so they can better handle the complexity of project management and operation. The information flows from within and from outside the organizations. In the case of contractor resistance, this information flows across organizational boundaries in a nonrandom way. This creates a redistribution of power over how the information is handled. It is widely known that contractors and consultants have more control over internal project information than owners do. Given the nature of design-bid-build delivery system in the dredging context, the responsibility of delivering the project is on the contractor. This gives the deceptive suggestion that the owners just need to sit back and let the contractor manage the information. The above situation give contractors power over the information making them resist when they are confronted with systems that centralizes the information.

Keen incremental, facilitative approach seems to be the best counter resistance approach when dealing with contractors and consultants resistance. Keen recommends asking the following questions:

1. Who owns the data?
2. Who will share it?
3. What will be the perceived impact of redistribution on:
    a. evaluation;
    b. influence and authority;
    c. communication?

Keen also recommend the following questions to develop a strategic model for change:

1. What happens when consensus is impossible?
2. How can large-scale projects evade social inertia?
3. What authority mechanisms and organizational resources are needed to deal with the politics, data, and counter-resistance?
4. What is the role of management?

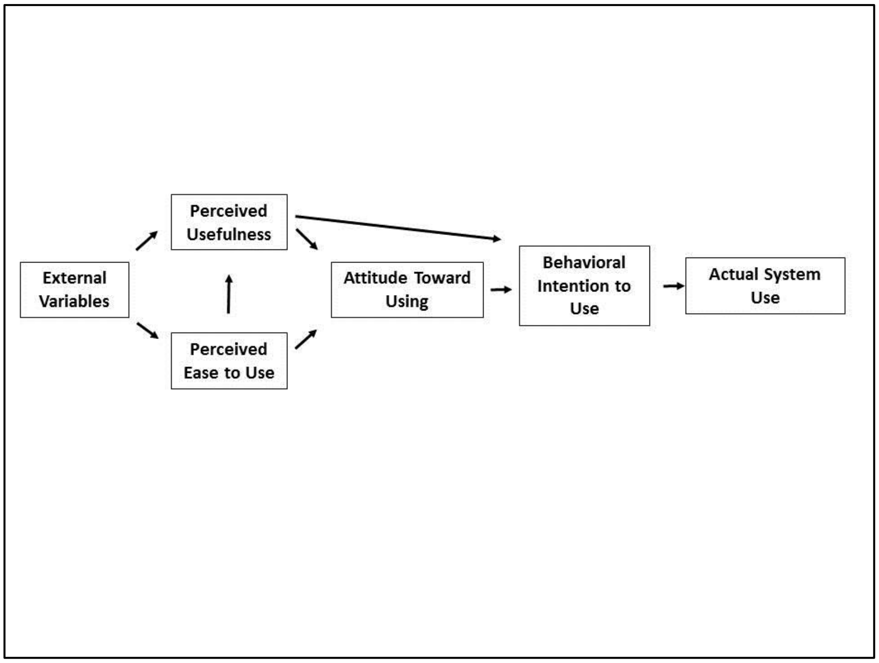
Finally, Keen recommends incremental changes, aim for simplicity of design and precise objectives, stablishing a meaningful steering committee, and authority.

8.2. Generalization of the Solutions to Resistance to the Use of Web-Based Systems for the Management of Dredging Projects

Keen (1981) Information System and Organizational change theory was used to classify the resistances derived from the analysis of the data collected. In this Section, the Technology Acceptance Model (TAM), Davis (1986) will be used to find the solutions needed to overcome the resistances. TAM is used to predict acceptability of an information system see (Figure 7-1). A summary of the solutions is in Table 7-1.

The TAM Model starts looking at the external variables using two factors, system perceived usefulness and perceived ease to use to determine the user attitude, behavior, and acceptance toward using the system. The TAM model will be used to determine solutions to resistances to implementation encountered during data collection. Based on the Web-based system concept proposed by the research and the resistances encountered during data collection a modification to the variables creating the resistance will be assessed in order to overcome resistance. The analysis will use the TAM model acceptance factors perceived usefulness and perceived ease of use to assess resistance and find a solutions.

Figure 8-1. TAM Model Logical Flow



Operators argued that the system would be used to intrude in their work. This reasoning will create resistance to the implementation. However, according to TAM model if the operators perceive that the system is useful the will change their attitude and behavior and will be more likely to accept the system. Moreover, if the system is easy to use the operator will find it more useful and will perceive that the system will improve his performance. Similarly, middle-level management feels they would need to learn a new system because the tools and methods of collecting information would change. Because of this, they showed resistance to the implementation of Web-based systems. Using the TAM model reasoning and creating a system easy to use will skew the user attitude and behavior toward acceptance of the system. ***Therefore, it may be concluded that introducing incremental***

changes using simplified ease to use systems is the best tactic to overcome resistance to implementation of Web-based technology for the management of dredging projects.

High-level executives showed resistance because the system will expose private information influencing the strategic position of the organization in the market of influence. In this case resistance is not cussed by intra-organizational conflict between actors and the system but by conflicts of power between organizations. Therefore, a modification to the TAM model will be used (see Figure 7-2). The modified TAM model uses two new acceptability factors: improved relationship with owners and repetitive contracts to assess the resistance and find a solution. The formal TAM method uses changes to the system design to modify the external factors causing resistance. The modified TAM uses tactical changes to the external variables to overcome resistance. Improving the relationship between owners and contractors has positive impact on both organizations. Because the Web-based system levels the power over the information between the owners and contractors, a better relationship should be expected. In a traditional owner-contractor relationship arrangement, giving the owner the information he needs to manage the project would give him confidence, and he would more likely be willing to negotiate changes and contractors claims. In addition, the owner will let repeat contracts with contractors that make him feel comfortable during project execution.

In conclusion, tactical facilitative approaches and incremental changes may be needed to improve owner contractor relationship. In addition, careful assessment of the information that will satisfy both the owners and contractors may be need.

Figure 8-2. TAM Model Logic Flow, Modified

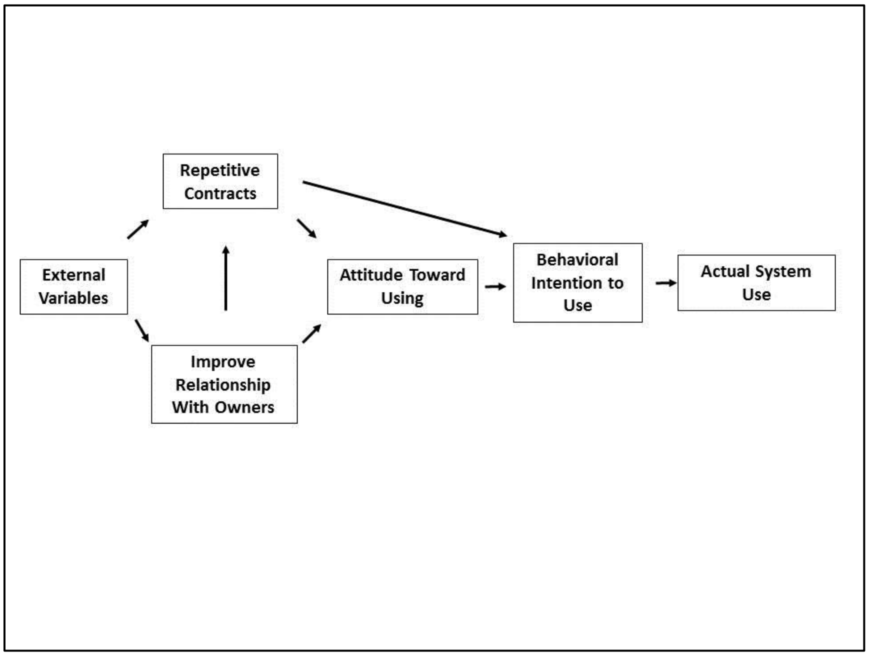


Table 8-1. Classification of resistance and Solutions

CLASSIFICATION OF RESISTANCE USING KEEN (1981) THEORY	SOLUTIONS TO RESISTANCE TO THE USE OF WEB-BASED SYSTEMS FOR THE MANAGEMENT OF DREDGING PROJECTS USING DAVIS (1986) TAM MODEL
Political and technical resistance to the used of web-based systems for the management of dredging projects	Introducing incremental changes to current management processes using simplified easy to use systems is the best tactic to overcome political and technical resistance to implementation of Web-based technology for the management of dredging projects.
Resistance due to impact on the organization position in the market (contractors and consultants resistance)	Tactical facilitative approaches and incremental changes to improve owners-contractor relationship, and careful assessment of the QA/QC information that will satisfy both the owners and contractors are important factors to overcome contractors and consultant resistance to implementation of Web-based technology for the management of dredging projects.

9. CONCLUSIONS, FUTURE WORK AND CONTRIBUTION TO THE BODY OF KNOWLEDGE

The results of the investigation demonstrate that the WPMS system based on the conceptual framework used in this research may improve dredging project performance. In addition, the results show that some users in the owners, contractors, and consultant segments may resist the system. This resistance is due to social, political, technical, and business concerns. In some cases, these users believe that the system may expose their exclusive expertise and other private information. In other cases, they feel that it may alter their strategic position in the market. The resistance issues were assessed and strategic solutions need to be implemented before moving to the design phase. Strategic scenarios are needed in order to articulate solutions to resistance to the implementation of Web-based technologies in dredging. Section 3.5 defines an implementation scenario for future studies.

The WPMS is a system that, if introduced in the dredging industry, may change the owner-contractor relationship paradigm. This study confirms the idea that the WPMS can revolutionize management of dredging projects. It proves that the WPMS will improve project performance. Moreover, large organizations from the contractor and owner sectors have developed non-web-based tools with similar functionalities. Apparently, this is an ideal situation, because it does not create conflict between the project parties. Still, this type of solution does not convey the benefit the project, or the owner, will receive with a web-based solution.

Worldwide dredging market projections for 2019 are $13 billion (Rabobank, 2013). An estimated 20% average cost increase due to errors and claims (see Section 1) will result in $2.6 billion in project costs increases. The owner may incur the bulk of the $2.6 billion in cost increases. Deploying the WPMS within the Dredging industry may certainly be worth future investigations, specifically because, in addition to reducing project costs, it will improve communication between owners and contractors, reducing owner's resistance to claims, and dredging companies may leverage their opportunities to retain more jobs.

Project Performance Considerations

Regarding the influence of the WPMS on project performance, as explained above, the system includes not only the contribution of Information Systems and Communication Infrastructures to add agility to project information, but also, the power that these tools add to project management team capabilities. The WPMS is an application of the Internet of Things (IoT) concept. "It connects people, data, things and processes in massive networks, creating vast amounts of information that, when analyzed and used intelligently, could create new innovations and efficiencies" (Sawyer, 2016).

The evidence gathered during the study has demonstrated the contribution of the WPMS to project performance. The evidence shows a strong correlation between the responses and the research assumptions, proving that the WPMS improves management, quality control, and decision-making for all organizational segments. This validates the research proposition that the WPMS improves project performance.

Social, political technical and business considerations

The research demonstrates that within the dredging industry, the WPMS will experience resistance to implementation. Therefore, resistance needs to be resolved in order to advance to the design phase. In several different scenarios, resistance was encountered during the interviews. Resistance was encountered due to loss of authority from operating team personnel, and due to changes in current technical arrangements from middle-level management. Similarly, resistance was encountered due to influence of the WPMS on the strategic position of an organization.

Social and Political Resistance

Loss of authority can generate resistance due to the WPMS influence on the user's social and political environment. The research encountered that this situation was evident within the personnel operation of the dredge. In an owner-owned-operation delivery system, the management team needs to secure site information for quality assurance and quality control; the operating team feels that management is intruding in the operation. The solution to this resistance can be solved by investigating the specific reasons for the resistance and applying the solutions needed to avoid it. Markus's recommendation is that once resistance is apparent, an analysis should be performed to determine precisely why the resistance occurred, and what could be done to avoid it. After determining the reason for resistance, the analysis could suggest upon a course of action that may include:

- Altering the initial concept in ways that would be acceptable to the operation personnel

- Sacrificing some of the general features of the system to accommodate the operational personnel preference
- Allowing the operational personnel to participate in the design of the system
- Negotiating changes for other features that have value to the operating team

Resistance to Technical Changes

Organizations may have traditional equipment, tools, and systems in place to solve their dredge excavations, project control, and information flow needs. Changes to these situations may require learning to use the new tool or system and uncertainty within the project team. This may generate resistance to change the status quo. This encountered resistance is at the middle- management level. In order to solve this type of resistance in the WPMS environment, the system should be developed, installed, and tested so that those resisting the system may better understand the technical and economic implications of the system.

Other Considerations to Solve Social, Political Technical Resistance

Using Keen (1981) theory, and Davis (1989) Technology Acceptance Model (TAM) (see Chapter 8) it was concluded that introducing incremental changes to current management processes using simplified easy to use systems is the best tactic to overcome political and technical resistance to implementation of Web-based technology for the management of dredging projects.

Business Resistance

The research shows that high-level management of a segment in the contractors and consultants organizations may resist the implementation of the WPMS. The reason may be due to the strategic position of contractors and consultants in the industry. In this case, contractors and consultants may leverage the lack of an efficient system to manage dredging projects to maintain their strategic position. The solution to this type of resistance may not be simple and may need more investigation. Another cause of resistance may be due to the fear that the organization's private information could be exposed by the system. For an owner-contractor scenario, the implementer would make sure the data collected is project-related. The information needed by the owner and the collecting methodology to be used may be specified in the contract.

Other Considerations of Business Resistance

Using Keen (1981) theory, and Davis (1989) Technology Acceptance Model (TAM) (see Section 8) tactical facilitative approaches and incremental changes to improve owners-contractor relationship, and careful assessment of the QA/QC information that will satisfy both the owners and contractors are important factors to overcome contractors and consultant resistance to implementation of Web-based technology for the management of dredging projects..

Summary

Resistance due to social and political considerations may be avoided by investigating the specific reasons for the resistance and introducing incremental changes to current management processes using simplified easy to use systems. Resistance due to technical changes may be avoided by installing operational prototypes on a dredged for testing, so that those resisting the system may better understand the technical and economic implications of the system.

On the other hand, organizations resistance due to the perceived influence of the WPMS on the strategic position of the organization in the industry may require tactical facilitative approaches and incremental changes. In addition, careful assessment of QA/QC information that will satisfy both the owners and contractors may be need.

The system components may be developed independently so that different segments of the industry can use them. Then, when they feel comfortable with the system components, the users will be ready to accept the integration of the system.

9.1. Investigation Results

A preliminary WPMS analysis is complete and feasibility assessed with the following findings:

5. The system would help improve project performance.
6. Resistance to implementation may be experienced if the system is implemented. Therefore, resistance to implementation needs to be investigated further and more R&D work is needed in order to advance to the final design and implementation.
7. System may be divided into standalone modules in order to simplify the system and facilitate incremental changes.

8. The QA/QC conceptual approach used by this research needs to be redefined during future R&D to satisfy both owners and contractors.

9.2. Future Work

Research and development is needed for the system installation on a project, in order to test it and assess its economic impact on the organization, and gain users confidence in the system by understanding its potential. In order to achieve these goals, the following R&D activities are needed:

- Develop a prototype of Component 1— Real-time Information Delivery to achieve continuous dredge connectivity to the Internet as define in Chapter 3.
- Complete the GPS geographic coordinate's transformations method for all areas of the world.
- Develop system components to work independently, so that different segments of the industry may use them, and to facilitate incremental changes.
- Continue the development of the new GPS (RTK) prototype and integrate it to the system.
- Investigate other foreign markets for resistance to implementation.

a. Contributions to the body of Knowledge

- The research work included the development of preliminary specifications for web-based systems that manage massive repetitive volume of projects geographically distributed such as dredging works.

- The results of this study may motivate dredging project teams to use web-based systems to improve performance, and may also help owners and contractors understand how to reduce complexity of dredging project management processes that affect current project performance.
- This investigation reveals the concept of combining project management techniques, information systems, and communication infrastructure for the management of dredging projects so that other investigators can expand on the concept.
- The investigation explores the use of the web-based technology for the management of dredging projects and provides potential users the knowledge of the requirements and limitations of implementing the system.

APPENDIX A – ACRONYMS AND DEFINITIONS

A.1 Acronyms

ASCE	American Association of Civil Engineers
IS	Information System
WPMS	Web-based Project Management System
USACE	U.S. Army Corps of Engineers
DPIP	Dredge Plant Instrumentation Plan
T&E	Threatened and Endangered Species
UMD	University of Maryland

A.2 Definitions

Status Quo Bias	The resistance to change the current status: can be technical, managerial, informational, organizational, as well as to change business process.

APPENDIX B— DATA COLLECTED FROM EXPERTS

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
1	Owner	Director of Operations	2/23/2016	Government	

Questions	Answers
Would WPMS improves project management?	Yes, the WPMS will make our dredge more productive, eliminating errors and improving operator ability to make better decisions. The system pushes the information to the users, alerting of unusual situations, and informing on project conditions.
Would WPMS improves project control?	Yes, continuous connective to the Internet allows the support team to validate dredge position, design parameters, and operational conditions.
Would WPMS improves decision-making?	Yes, the continuous connectivity to the Internet will management and the support team to validate the work on the fly, and make correction in real time.
Would the WPMS make your job easier, or enjoyable?	Yes, WPMS will improve my ability to manage the dredge operation. The automatic generation of reporting, and analysis of past data, give me more time to manage based on swift and better quality information.
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes, It improves production reducing costs, and improves the personnel job environment making them more productive.

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
2	Owner	Owner Representative (CO)	2/23/2016	Government	

Questions	Answers
Would WPMS improves project management?	El sistema podrá mejorar la gerencia de proyectos de dragado y las operaciones
Would WPMS improves project control?	Al contar con mayor información en detalle y de manera rapida permitira un mejor control
Would WPMS improves decision-making?	Debe contribuir a la toma de decisiones en un rango menor de tiempo. Sin embargo, se sugiere hacer consultas previas con los encargados de las operaciones y en algunos casos validar con otros especialistas.
Would the WPMS make your job easier, or enjoyable?	Por supuesto. Esto permitiría mantener y compilar información de manera continua, compartir y crear colaboración con otros equipos de trabajo y poder destinar esfuerzos a otras actividades o proyectos importantes en simultaneo
Would the WPMS compromise your job security?	Por el contrario, permitiría atender más trabajos en el mismo tiempo y oportunidad para desarrollar otras habilidades. Esto lo considero una herramienta. Los proyectos y las operaciones son dirigidas por las mentes
is there any reason way you would not use the WPMS?	En lo particular y siendo utilizado para el trabajo en equipo con la apertura suficiente para que las partes involucradas puedan explicar los datos que se generan y que no se interpreten para búsqueda de responsables y aplicar sanciones. En campo pudiera generar alguna incomodidad o afectar el clima laboral. Requiere trabajo de compromiso entre gerencias y campo para evitar interpretaciones. También, la exposición de localización de equipos e información de operaciones en internet accesible en cualquier dispositivo debe estar manejado von controles de acceso y de seguridad
would the WPMS make your business more competitive?	Por supuesto. Brindaría la oportunidad de estar a la par de empresas de primera en la industria

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
3	Owner	Division Chief Information Officer	2/23/2016	Government	

Questions	Answers
Would WPMS improves project management?	yes
Would WPMS improves project control?	yes
Would WPMS improves decision-making?	yes
Would the WPMS make your job easier, or enjoyable?	yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes, need to learn a new technology, and install new equipment.
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
4	Owner	Project Engineer	2/23/2016	Government	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	no
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
5	Owner	Captain	2/23/2016	Government	

Questions	Answers
Would WPMS improves project management?	yes
Would WPMS improves project control?	yes
Would WPMS improves decision-making?	yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
6	Owner	Operator	2/23/2016	Government	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	No, the system will intrude on the operator's work.
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes,
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
7	Owner	Operator	2/23/2016	Government	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	No, compromises privacy
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes, will need to learn a new system
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
1	Owner	Dredge Division Manager	2/12/2016	Government	

Questions	Answers
Would WPMS improves project management?	yes
Would WPMS improves project control?	Yes, the real time feature will do.
Would WPMS improves decision-making?	Absolutely
Would the WPMS make your job easier, or enjoyable?	Yes, it will make my job easier.
Would the WPMS compromise your job security?	no
is there any reason way you would not use the WPMS?	Cost may be an issue
would the WPMS make your business more competitive?	Yes, it has a positive influence of the business in the current market

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
2	Contractor	Contractor Representative	2/12/2016	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Will need to learn a new system. Also have concerns regarding on cost
would the WPMS make your business more competitive?	Private information may be exposed

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
3	Owner	Owner Consultant	2/12/2016	Government	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	I a consultant, but it will improve the project work environment. The system assist engineers in generating reports, and information; releasing engineers form this repetitive task.
Would the WPMS compromise your job security?	I am a consultant, but in my opinion, the system will not compromise personnel job security.
Is there any reason way you would not use the WPMS?	NO
Would the WPMS make your business more competitive?	Yes, it will improve productivity.

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
1	Owner	Research Group Director	1/4/2016	Government	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes, the WPMS will help people engage in the management process. It alert users of unusual situation during operation, diminishing the likelihood of making mistakes, for example: excavating outside the design section.
Would WPMS improves decision-making?	Yes, decision-making will improve because operators, management, and support personnel receives information form the site in real time. This add agility to the flow of information and involve all users in the decision-making process.
Would the WPMS make your job easier, or enjoyable?	N/A
Would the WPMS compromise your job security?	N/A
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
2	Owner	Dredge Division Director	3/8/2016	Government	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes,
Would WPMS improves decision-making?	Yes,
Would the WPMS make your job easier, or enjoyable?	N/A
Would the WPMS compromise your job security?	N/A
is there any reason way you would not use the WPMS?	Yes, we are implementing our own system
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
1	Owner	Owner	2/12/2016	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
2	Consultant	Consultant	2/15/2016	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
3	Contractor	Project Manager	2/17/2016	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
4	Consultant Inspector	Inspector	2/18/2016	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	N/A

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
5	Consultant	Consultant	3/9/2016	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Only issue would be costs
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
4	Consultant	Consultant	3/11/2016	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
1	Project Manager	Project Manager	2/7/2016	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	No
would the WPMS make your business more competitive?	Yes.

Industry Expert

Interviewee	**Organization Type**	**Interviewee Job**	**Interview Date**	**Institution Type**	
2	Contractor	Owner	1/12/2016	Private	

Questions	**Answers**
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Yes
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Contractor will resist because they will need to share operational information with the owner.
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Interviewee Job	Interview Date	Institution Type	
1	Contractor	Project Manager	10/7/2015	Private	

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	No answer
Would the WPMS compromise your job security?	No answer
is there any reason way you would not use the WPMS?	Yes
would the WPMS make your business more competitive?	Yes.

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
1	Contractor		3/1/2016		

Questions	Answers
Would WPMS improves project management?	N/A
Would WPMS improves project control?	No.
Would WPMS improves decision-making?	No.
Would the WPMS make your job easier, or enjoyable?	No.
Would the WPMS compromise your job security?	N/A
is there any reason way you would not use the WPMS?	Yes
would the WPMS make your business more competitive?	No

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
2	Consultant		3/1/2016		

Questions	Answers
Would WPMS improves project management?	Yes. For those who do not presently have such a system (It has already been developed privately)
Would WPMS improves project control?	Yes - as above
Would WPMS improves decision-making?	Ditto
Would the WPMS make your job easier, or enjoyable?	
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes - your cost could be too high
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
3	Consultant		3/8/2016		

Questions	Answers
Would WPMS improves project management?	Yes. Real time information of a full range of data, from anywhere, gives a manager an advantage over other systems, and gives him flexibility to be away from the office.
Would WPMS improves project control?	Yes. It will allow monitoring of performance and proactive management instead of reactive.
Would WPMS improves decision-making?	Yes. Access to data and built-in analytics, and collaboration is key to optimal decision making.
Would the WPMS make your job easier, or enjoyable?	Yes and yes. When you are more successful, you enjoy more.
Would the WPMS compromise your job security?	In my position no. A more successful operation is one that is more competitive in the marketplace which leads to job security.
Is there any reason way you would not use the WPMS?	No. Not as described
Would the WPMS make your business more competitive?	Yes. See above.

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
4	Consultant		3/8/2016		

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	
Would the WPMS compromise your job security?	not necessarily
is there any reason way you would not use the WPMS?	only cost or reliability of the system
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
5	Contractor		3/9/2016		

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	No, would need to learn new technology
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes, the system expose the company information
would the WPMS make your business more competitive?	No, same as above

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
6	Contactor	Project Manager	3/9/2016		

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Not
Would the WPMS compromise your job security?	Yes
is there any reason way you would not use the WPMS?	Yes
would the WPMS make your business more competitive?	No

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
7	Contactor	Project Manager	3/9/2016		

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Not
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes, data security
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
8	Consultant	Project Manager	3/10/2016		

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Not
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes, data security
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
9	Consultant	Project Manager	3/10/2016		

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Not
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes, cost concerns
would the WPMS make your business more competitive?	Yes

Industry Expert

Interviewee	Organization Type	Survey	Interview Date	Institution Type	
10	Consultant	Project Manager	3/11/2016		

Questions	Answers
Would WPMS improves project management?	Yes
Would WPMS improves project control?	Yes
Would WPMS improves decision-making?	Yes
Would the WPMS make your job easier, or enjoyable?	Not
Would the WPMS compromise your job security?	No
is there any reason way you would not use the WPMS?	Yes, cost concerns
would the WPMS make your business more competitive?	Yes

APPENDIX B— DREDGING ORGANIZATIONS DIRECTORY

COMPANY	TITLE	NAME	EMAIL	PHONE	FAX
American Marine Constructors, Inc.	President	Kevin Culbert	kevinc@americanconstco.com	(253) 254-0118	(253) 254-0155
American Marine Constructors, Inc.	CEO	Steve Brannon	steveb@americanconstco.com	(253) 254-0118	(253) 254-0155
Callan Marine, LTD	Co-Owner	John Sullivan	jsullivan@callanmarineltd.com	(409) 762-0124	(409) 762-1915
Callan Marine, LTD	VP & General Manager	Maxie McGuire	mmcguire@callanmarineltd.com	(409) 762-0124	(409) 762-1915
Callan Marine, LTD	Co-Owner	Todd Sullivan	tsullivan@callanmarineltd.com	(409) 762-0124	(409) 762-1915
Cashman Dredging and Marine Contracting Co., LLC	Senior Vice President	Frank Belesimo	fbelesimo@jaycashman.com	(617) 890-0600	(617) 890-0606
Cashman Dredging and Marine Contracting Co., LLC	CEO	Jay Cashman	jay@jaycashman.com	(617) 890-0600	(617) 890-0606
Cottrell Contracting Corp.	Chairman of the Board	Ben G. Cottrell IV		(757) 547-9611	(757) 436-4659
Cottrell Contracting Corp.	President & CEO	Ben G. Cottrell V	benv@cottrellcontracting.com	(757) 547-9611	(757) 436-4659
Cottrell Contracting Corp.	Executive Vice President	Jimmy Cottrell	jmc@cottrellcontracting.com	(757) 547-9611	(757) 436-4659
Cottrell Contracting Corp.	CFO	Tracy Brooks		(757) 547-9611	(757) 436-4659
Cottrell Contracting Corp.	VP of Safety	Patricia Heltsley		(757) 547-9611	(757) 436-4659
Cottrell Contracting Corp.	Chief Estimator	Franklin Hall		(757) 547-9611	(757) 436-4659
Cottrell Contracting Corp.	VP of Engineering	Michael Kay		(757) 547-9611	(757) 436-4659

Cottrell Contracting Corp.	VP of Equip Maint & Design	William Stone		(757) 547-9611	(757) 436-4659
Cottrell Contracting Corp.	VP of Operations	Elford Clemmons		(757) 547-9611	(757) 436-4659
Dredge America, Inc.	President	Dan McDougal	dan@dredgeamerica.com	(816) 330-3100	(816) 330-3103
Durocher Marine, a Division of Kokosing Const. Co, Inc.	Vice President	Joe Van Antwerp	jvanantwerp@durocher.biz	(231) 627-5633	(231) 627-2646
Durocher Marine, a Division of Kokosing Const. Co, Inc.	Estimator	Mark Henrikson	mhenrikson@durocher.biz	(231) 627-5633	(231) 627-2646
Dutra Dredging Company	CEO	Bill Dutra	bdutra@dutragroup.com	(415) 258-6876	(415) 721-1377
Dutra Dredging Company	Executive Vice President	Denise Dutra	ddutra@dutragroup.com	(415) 258-6876	(415) 721-1377
Dutra Dredging Company	President & CEO	Harry Stewart	hstewart@dutragroup.com	(415) 258-6876	(415) 721-1377
Dutra Dredging Company	Dredging Division Manager	J.C. Krause	jkrause@dutragroup.com	(415) 258-6876	(415) 721-1377
Dutra Dredging Company	Project Manager	Will Wallgren	wwallgren@dutragroup.com	(415) 258-6876	(415) 721-1377
Gahagan and Bryant Associates, Inc.	Vice President	Clay Bryant	cmbryant@gba-inc.com	(813) 831-4408	(813) 831-4216
Gahagan and Bryant Associates, Inc.		Dennis Urso	dcurso@gba-inc.com	(813) 831-4408	(813) 831-4216
Gahagan and Bryant Associates, Inc.		Ed D'Angelo	edeangelo@gba-inc.com	(813) 831-4408	(813) 831-4216
Gahagan and Bryant Associates, Inc.	President	Grady Bryant	gbryant@gba-inc.com	(813) 831-4408	(813) 831-4216
Gahagan and Bryant Associates, Inc.		Martin Snow	msnow@gba-inc.com	(813) 831-4408	(813) 831-4216
Gahagan and Bryant Associates, Inc.	Sr. Executive Vice President	Witt Barlow	wbarlow@gba-inc.com	(813) 831-4408	(813) 831-4216
General Construction Company	Vice President	Jeff Arviso	Jeffrey.arviso@kiewit.com	(253) 943-4200	

Goodloe Marine, Inc.	President	Betty Goodloe	jagbettie@aol.com	(813) 633-1321	(813) 633-1337
Great Lakes Dock & Materials	President	George Bailey	gbailey@greatlakesdock.com	(231) 728-4172	(231) 728-4173
Great Lakes Dock & Materials	Vice President	Joe Bailey	jbailey@greatlakesdock.com	(231) 728-4172	(231) 728-4173
Great Lakes Dredge & Dock Company	VP, Government Relations	Bill Hanson	whhanson@gldd.com	(630) 574-3000	(630) 574-2909
Great Lakes Dredge & Dock Company	CEO	Jonathan Berger	jwberger@gldd.com	(630) 574-3000	(630) 574-2909
Great Lakes Dredge & Dock Company	Pres of Dredging Operations	David Simonelli		(630) 574-3000	(630) 574-2909
Great Lakes Dredge & Dock Company	Senior VP, Operations	Kyle Johnson		(630) 574-3000	(630) 574-2909
Great Lakes Dredge & Dock Company	Sr. VP, Estimating & Bus Dev	Stephen Pegg		(630) 574-3000	(630) 574-2909
Great Lakes Dredge & Dock Company	VP, Hydraulic & Mech Dredging	Chris Gillespie		(630) 574-3000	(630) 574-2909
Great Lakes Dredge & Dock Company	VP, Hopper Dredging	Paul Lamourie		(630) 574-3000	(630) 574-2909
Great Lakes Dredge & Dock Company	VP, Chief Estimator	Russ Zimmerman		(630) 574-3000	(630) 574-2909
Gulf States Dredging, LLC	President	David Davis	david.davis@gsdcompanies.com	(281) 459-1500	(281) 459-1596
Gulf States Dredging, LLC	CFO	Matt Sitka	matt.sitka@gsdcompanies.com	(281) 459-1500	(281) 459-1596
Hendry Corporation	President & Treasurer	Aaron Hendry	ahendry@gulfmarinerepair.com	(813) 241-9206	(813) 241-9215
Inland Dredging Company	President	Jim Mohead	jmohead@inland-dredging.com	(731) 285-1995	(731) 288-0262
Inland Dredging Company	VP & COO	Richard Jackson	rjackson@inland-dredging.com	(731) 285-1995	(731) 288-0262
L.A. Hubert, Jr., LLC	President	Skip Hubert	hubert@earthlink.net	(504) 400-2955	(504) 393-7937

Luedtke Engineering Company	President	Kurt Luedtke	KurtLuedtke@charter.net	(231) 352-9631	(231) 352-7178
Luedtke Engineering Company	Secretary, Treasurer	Paul Luedtke	PaulLuedtke@charter.net	(231) 352-9631	(231) 352-7178
M.C.M. Marine Inc.	President	Darwin M. McCoy	jmccoy@mcmmarine.com	(906) 632-4316	(906) 632-7766
Manson Construction Co.	Chairman of the Board	Frederick Paup	fpaup@mansonconstruction.com	(206) 762-0850	(206) 764-8590
Manson Construction Co.	President & General Manager	Eric Haug	ehaug@mansonconstruction.com	(206) 762-0850	(206) 764-8590
Manson Construction Co.	Executive Vice President	Marcus Stearns	mstearns@mansonconstruction.com	(206) 762-0850	(206) 764-8590
Manson Construction Co.	Senior Vice President	Jim McNally	jmcnally@mansonconstruction.com	(206) 762-0850	(206) 764-8590
Manson Construction Co.	Vice President	Dan Hussin	dhussin@mansonconstruction.com	(904) 821-0211	(904) 992-0811
Manson Construction Co.	VP Hopper Dredging	Henry Schorr, Jr.	hschorr@mansonconstruction.com	(904) 821-0211	(904) 992-0811
Marine Tech, LLC	President	Ted Smith	tsmith@marinetechduluth.com	(218) 720-2833	(218) 525-9574
Marinex Construction, Inc.	President	Ham Johnson	kalbers@marinesconstruction.com	(843) 722-9083	(843) 722-9085
Mike Hooks, Inc.	President	Mike McMahon	dredge@mikehooks.com	(337) 436-6693	(337) 433-8701
Mike Hooks, Inc.	Vice President	Ashley M. Kerns	ashley@mikehooks.com	(337) 436-6693	(337) 433-8701
Mike Hooks, Inc.	Dredging Superintendent	Mike Kerns	mjk@mikehooks.com	(337) 436-6693	(337) 433-8701
R. E. Staite Engineering, Inc.	President	Ray Carpenter	rayc@restaite.net	(619) 233-3697	
R. E. Staite Engineering, Inc.	Vice President	Katha Carpenter	kathak@restaite.net	(619) 233-3697	
R. E. Staite Engineering, Inc.	Operations Manager	Chad Carpenter	chadc@restaite.net	(619) 233-3697	

RLB Contracting, Inc.	CEO	Debbie Boyd	Debbie@rlbcontracting.com	(361) 552-2104	(361) 552-2110
RLB Contracting, Inc.	President	Randy Boyd	randy@rlbcontracting.com	(361) 552-2104	(361) 552-2110
Ryba Marine Construction Co.	Vice President	Zac Morrish	zmorrish@rybamarine.com	(231) 627-4333	(231) 627-4890
Southern Dredging Company, Inc.	Chairman	H. George Dent, Jr.	george.dent@southerndredging.com	(843) 559-7500	(843) 559-0566
Southern Dredging Company, Inc.	President & Treasurer	David Dent	david.dent@southerndredging.com	(843) 559-7500	(843) 559-0566
Southern Dredging Company, Inc.	VP Operations	Lewis Frampton, Jr.	lewis.frampton@southerndredging.com	(843) 559-7500	(843) 559-0566
USACE		Jeff Lillycrop	jeff.lillycrop@usace.army.mil		
USACE		Jeffrey A. McKee	jeffrey.a.mckee@usace.army.mil		
USACE		Linda S. Lillycrop	linda.s.lillycrop@usace.army.mil		
USACE		Mark Pointon	mark.pointon@usace.army.mil		
USACE		Shawn Kiernan	skiernan@marylandports.com		
Vorex Marine Construction, Inc.	President/CEO	Blaise Fettig	blaise@vortex-sfb.com	(510) 261-2400	(510) 261-2444
Vorex Marine Construction, Inc.	VP Operations	Eric Van Zuthern	evanzuthern@vortex-sfb.com	(510) 261-2400	(510) 261-2444
Weeks Marine, Inc.	Chairman of the Board	Dick Weeks	mweeks@weeksmarine.com	(908) 272-4010	(908) 272-4740
Weeks Marine, Inc.	President	Rich Weeks	rsweeks@weeksmarine.com	(908) 272-4010	(908) 272-4740
Weeks Marine, Inc.	Executive Vice President	Eric Ellefsen	ewellefsen@weeksmarine.com	(908) 272-4010	(908) 272-4740
Weeks Marine, Inc.	Sr. VP & GM, Dredging Div	J. Stephen Chartry	sjchartry@weeksmarine.com	(985) 875-2500	(985) 875-2570

Weeks Marine, Inc.	Corp & Government Relations	Mark Sickles	mdsickles@weeksmarine.com	(703) 608-2837	

APPENDIX C— DREDGING SOFTWARE COMPANIES DIRECTORY

ITEM	ORGANIZATIONS WITH SYSTEMS CURRENTLY IN THE MARKET
1	**DQM/Silent Inspector** USACE Mobile District Contact: Vern Gwin, Ph: 251 690 3467, email William.v.gwin@usace.army.mil 109 St. Joseph Street, Mobile, AL 36602 Ph: 251-690-2511
2	Leidos, Inc. Attn: Steve Pace or Marc Wakeman. 221 Third St - Building A. Newport, RI 02840. http://www.adiss-afiss.com/contact.html
3	Hypack, Address: 56 Bradley St, Middletown, CT 06457 Phone: (860) 635-1500. http://www.hypack.com/new/sales/products/dredgepack/tabid/60/default.aspx
4	CutterMate and DipMate Seatools, Edisonstraat 67, 3281 NC Numansdorp. The Netherlands, PO box 7433, 3280 AE Numansdorp. The Netherlands Tel. +31 (0) 186 68 00 00. 24/7 Service number (outside office hours) Tel. +31 (0)186 65 00 75 e-mail: Info: info@seatools.com; Sales: sales@seatools.com; Support: support@seatools.com Seatools, USA Inc., 5090 Richmond Ave., Suite 234, Houston, Texas 77056 Tel. +1 (0) 866 7153296
5	SuccorfishM2M, The Barracks Building, Clifford's Fort, North Shields Fish Quay, Tyne & Wear, United Kingdom, NE30 1JE. Call: +44 (0) 191 447 6883 Email: sales@succorfish.com
6	ClamVision CABLE ARM, INC WORLD HEADQUARTERS 3452 West Jefferson Ave. Trenton, Michigan USA 48183 phone: (734)676-6108; fax: (734)676-1345 email: info@cablearm.com

7	University of Maryland – e-Construction Group, Miroslaw Skibniewsky and Gustavo Vecino. See Chapter 3.

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Zichichi et al., (2007). An Overview of the Silent Inspector (SI) Inspection & Certification Process for Hopper Dredges and Scows. Salvatore A Zichichi, Trapier Puckette, and Brenda P Allen. Corresponding author: 843-377-0286, e-mail: sZichichi@evanshamilton.com.