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A System Analysis of the Monitoring, Scheduling & Reporting Process for Public Water System Compliance

Jacob Rusconi and Dylan Ross
Business Administration Department, BIS
Eastern Connecticut State University
83 Windham Street
Willimantic, CT, 06226 USA

Faculty Advisor: Dr. Doncho Petkov

Abstract

The goal of this research is to provide a systems analysis of a Public Water Monitoring Laboratory in the Northeast for the purpose of identifying opportunities for improvement in its procedures. The laboratory is considered as a socio-technical system in which the technical aspects of its operations are interdependent with cultural and political features. To capture the many dimensions of the problem the authors applied a systemic approach, the Work System Method (WSM) developed a few years ago by Steven Alter. It is a design science socio-technical methodology which allowed us to formulate the problem, analyze possibilities for improvement and provide recommendations for changes and justify them. As a result of our findings the authors were able to produce recommendations on how to create preconditions for a better system performance and eliminate possibilities for monitoring and reporting violations. These were reported to the management of the laboratory.

Keywords: Systems Analysis, Water quality testing, Work System Method

1. Introduction

As a leader in their industry, Premier Laboratory, Inc. wants to maintain its status as one of the top Drinking Water Laboratories in New England. In order for the organization to achieve this goal, it encourages the analysis of their current work system for Public Water System Compliance. This work system includes the scheduling, monitoring, and reporting of drinking water quality tests and results as required by the State of CT Drinking Water Section.

The Benchmark Water Monitoring, Inc. (BWMI), acquired Premier Laboratory, Inc., a Connecticut based drinking water laboratory in November of 2007, to increase its presence in the New England market of water testing. The acquired laboratory has been in existence since 1977, and was the leader in the drinking water sector due to its cutting edge technology. This technology allowed it to be a pioneer in electronic deliverable capabilities and internal tracking of water system needs and testing. Within the past few years this technology has become available and more widely used by other labs, thus eliminating the lab's competitive advantage. The development of information systems has become a low priority and with the loss of the in-house programmer the Information Systems (IS) have plateaued at a level subpar to competitors.

The Lab Scheduling, Monitoring, and Reporting (SMR) system was a very effective tool up until the past several years as the state moved toward a paperless system. The system was excellent in the automation of redundant tasks allowing the user to convert paper schedules into electronic data. This function of the system allowed for much more efficient tracking of schedules for water testing. Premier Laboratory, Inc. system currently requires too many steps forcing users to create their own sub systems, which greatly reduces standardization of processes.

The goal of this research is to provide a systems analysis of a Public Water Monitoring Laboratory in the Northeast for the purpose of identifying opportunities for improvement in its procedures by identifying the processes that are redundant, and to automate any processes that can be handled without review of a project manager. The

laboratory is considered as a socio-technical system in which the technical aspects of its operations are interdependent with cultural and political features. To capture the many dimensions of the problem the authors applied a systemic approach, the Work System Method (WSM) developed about ten years ago by Steven Alter [1,2,3,4,7].

Another reason for the selection of the WSM is that the only existing comprehensive theory that explains information systems and their usage. It is a socio-technical methodology as it pays attention not only to the technical aspects of a business or IT problem but also to the social aspects as well. Mingers and White [3] provide more information on some aspects of systems thinking and its application in Management. The result of the application of WSM is a better design of operations for the water lab and hence this work can be categorized as a design science approach [6]. The reported work is a case study for the application of WSM for defining recommendations for improvement in a given practical situation.

The systemic methodology the authors to formulate the problem, analyze possibilities for improvement and provide recommendations for changes and justify them. Using this method the authors gathered data from the laboratory through interviews with key stakeholders at the organization. Information was also collected also by observation of the work system in use. Additional data was extracted from the Laboratory Information Management System (LIMS).

The data was analyzed and summarized following the WSM template produced by Steven Alter. As a starting point, the essential characteristics of the system such as customers, products, work processes, stakeholders, information flows and technology used were documented in a Work System Snapshot. The authors were able to identify the important parameters of the system, current problems, and issues, the diverse needs of the organization and opportunities for improvement. As a result of the findings the authors were able to produce recommendations on how to run better and automate some operations of the system and to create preconditions for a better system performance and reduce the penalties received by the Public Water Systems served by the laboratory.

This paper will continue with a brief overview of the Work System Method and of the methodology that will be applied. Then the findings from the systems analysis will be presented followed by recommendations for improvement and conclusion.

2. The Work System Method – a brief overview:

This section introduces basic notions of the Work System Method and it will show the process of applying it following Alter [1,2,3,4] and Petkov et al [4,7]. The authors provide a brief WSM primer here. "The Work System Method provides a rigorous but non-technical approach to any manager or business professional to visualize and analyze systems related problems and opportunities [1]". The same source presents the most comprehensive justification for the Work System Method and how to apply it to define a work system, analyze it, formulate recommendations for improvement and guide its evolution [1].

A crucial issue is the definition of the notion of work system and how it relates to information systems. According to Alter "WSM assumes that the topic of analysis is a work system, a system in which human participants and/or machines perform processes and activities using information and technology to produce products and services for internal and/or external customers. Methods and tools that emphasize business viewpoints and issues should view such a system as a sociotechnical system and should focus on how to improve that system's performance. Almost all current work systems are IT-reliant. They rely on IT but are not IT systems [2]." The above formulation distinguishes clearly between work systems in general and Information Systems in general [4].

The WSM [1] is based on two major components: the work system framework, representing a static description of the work system, showing how a work system operates at a particular point in time and the work system life cycle, focusing how a current or proposed work system evolves over time. Detailed definitions of the elements of the work system framework are presented in Alter [1].

The work system framework (a model for organizing an initial understanding of how a particular work system operates and what it accomplishes) and the work system life cycle (a process through which a specific work system is created and changes over time through planned and unplanned changes) have complementary roles [1].

The work system framework consists of nine elements, four internal and five external [1]. The four internal elements, considered part of the work system, include processes and activities, participants, technology needed to enable completion of processes and work items, and information or knowledge base needed. The five external elements, viewed as outside of the work system yet important for understanding its purpose and operation, include strategy (both business and IS/IT), infrastructure needed to support the work system, environmental factors, product

and services, and customers (internal customers who are employed by the enterprise work system users and external, economic customers of the enterprise).

A summary of the six central components of the work system framework for a specific problem situation constitutes a convenient initial representation of a work system called work system snapshot [1, 2].

Alter [1] introduces a three step process for the analysis of a work system:

- Identify the system and problems: Identify the work system that has the problems that launched the analysis. The system's size and scope depend on the purpose of the analysis.
- Analyze the system and identify possibilities: Understand current issues and find possibilities for improving the work system.
- Recommend and justify changes: Specify proposed changes and justify the recommendation.

This process is quite natural as it corresponds to the typical problem solving process in operations research, considered to be one of the reference disciplines for Information Systems [4].

The dynamic view of a work system through the work system life cycle (WSLC) model describes how work systems change over time through a combination of planned change (explicit projects with initiation, development, implementation phases) and unplanned change (incremental adaptations and experimentation) according to Alter [1, 2].

More details and examples of applying WSM analysis are provided in Alter [1,2,3,4] and Petkov et al. [4,7]. Guidelines for analyzing work systems within the three step process described above are presented in Alter [1]. The body of knowledge on WSM continues to develop and most of the subsequent publications by Alter after 2006 introduce new dimensions of WSM research [4,7].

The WSM provides opportunity to analyze the problem in many dimensions and thus the analysis becomes systemic. The first stage helps identify the problem and define it, while the second stage provides the analysis of the problem and the possible opportunities for improvement and all that leads to the last stage when recommendations for improvement are generated and justified.

The authors applied in this investigation only the static model of a WSM, the Work System Framework including the system snapshot and the three step process of applying WSM as was defined above, which can be seen in Table 1.

3. System and Problem:

Developing the work system snapshot through interviews and data collection, the authors formulated a clear systemic picture of the system processes used at the lab. The information was collected and categorized using the WSM template. With this information in hand the authors began to diagnosis the system using their knowledge of available system, hardware, and software solutions, and the lab's requirements and goals. The information gathered during this stage is key, in order to prepare proper recommendations and justifications in the later phase of this project.

The Lab Schedule, Monitoring, and Reporting system manages a large part of Premier Laboratory, Inc.'s customer base making it crucial to operations. In order for Premier Laboratory, Inc.to succeed in its market for water testing, the ability to schedule, track, and report water system test results for State compliance in an electronic medium quickly and without error is critical. The current system does accomplish this job, but not as efficiently as management would like to see, which makes this an important dilemma facing Project Managers. The current system allows for automation of many routine tasks, but the system is cumbersome and convoluted with multiple interfaces between the users and the systems. The multiple interfaces have deeply degraded the quality of work this system produces and has also hampered Premier Laboratory, Inc.'s ability to compete in the market.

Table 1. work system snapshot

Customers	**Products & Services**
Private Residences Environmental Engineers Public Water Sources Businesses Other Laboratories Waste Water Treatment Plants	Water Sample Lab Reports to clients Meeting State of Connecticut Compliance Deadline Required follow-up sampling and testing

Major Processes and Activities
• Project Manager downloads regulations from state database and inputs data into LIMS. • Project Manager prints monthly and quarterly pick up sheets, color codes and then prints information. • Project Manager sets up appointments and gives sample pickup sheets to Scheduler. • Scheduler adds pickup sheets to existing schedule pool and assigns collections to individual Drivers. • Drivers travel route collect samples, and bring the samples back to the lab for analysis by Lab Techs. • Completed Lab report is given to Project Manager for review and client notification of exceedances. • If exceedances are found, Project Manager is required to fulfill follow-up sampling procedures. • Results are delivered to Customer and submitted via EDI to Connecticut Drinking Water Section.

Participants	**Information**	**Technologies**
Project Manager Public Water System Owners Drivers Department Manager State of Connecticut Lab Technicians	Overall Water Quality Results for Sample Period EDI to state Exceedances Monitoring Compliance Met Regulations	Laboratory Information Management System (LIMS) Microsoft Access Microsoft Excel Microsoft Outlook

In meeting with key personnel, the authors identified the Lab's status in relation to cost, technical and operational needs. These three factors are the most critical points in Premier Laboratory, Inc.'s decision-making process on what system to implement to meet their long-term goal of gaining a competitive advantage over the other Labs in their market. Based on the above information and further analysis through observation of the system, and interviews with several users of the current system, the authors have prepared the following report to discuss their findings and recommend the best possible solution to meet and exceed the needs of the Lab.

As the initial information was gathered about the Scheduling, Monitoring, and Reporting system at Premier Laboratory, Inc., the inefficiency in this area was obvious. It did not take more than five minutes of speaking with the primary users to understand the type of issue this organization was dealing with on a daily basis. Major processes flaws linked to the functionality of this work system mentioned above, affect the overall system.

The authors concluded that, the fundamentals and basis for this system were strong, but how information is shared, accessed, and managed were found to be weak. The main functionality and processes in the system were on the right path towards efficiency, but the Information systems used to complete each step could use some major polishing.

The information system that is used to manage the data required involved with water testing is called, Laboratory Information Management System (LIMS). The convoluted and complex interfaces for the user to use this system present many issues that required deeper analysis as a future project. The primary interface issue is two different versions of the LIMS system are running parallel to each other. The reason these two applications exist is due to the fact that during the implementation of porting projects in which the original LIMS was being upgraded to a to a visual .net platform; the IS Manager/Programmer resigned halfway through the project leaving Premier Laboratory, Inc. to rely on both systems simultaneously to complete all required tasks throughout the entire SMR process are required to maintain compliance with the State of Connecticut. For instance, redundant procedures in the scheduling,

monitoring, and reporting system have no benefit towards maintaining State compliance. The overall system's subsystems are tightly coupled and tightly paired creating excessive task dependency. This creates many opportunities for Premier Laboratory, Inc. to receive avoidable violations due to user errors and system flaws.

Finally, adequate metrics to measure performance and effectiveness of the system are not in place. There is little to no reporting on whether or not the system is acting, as it should be. Management and users cannot access or customize reports quickly to make decisions quickly and effectively in this deadline driven area of the industry.

4. Analysis and Possibilities:

The analysis and possibilities phase, allowed the authors to brainstorm and look at all types of solutions for this system. At this stage ideas were developed and then compared against feasibility and practical application. The authors began to fully understand the true nature and importance of this system to the lab. This is a system that is mission critical to their operation and ultimate success in their industry by allowing the lab to maintain proper certification, protect the Public's health through proper reporting to the agencies, and being profitable as a commercial entity.

The system at Premier Laboratory, Inc. is a good system, but could really use restructuring with new capabilities that provide high efficiency in its processes and also allow for automation of crucial processes. The system is limited in a big way by the paper submission of scheduling for water tests. This paper submission could easily be computerized and schedules can be automatically assigned by a computer reducing the wasted time. Aside from paper submissions, manual data entry also hampers the competitive advantage of the company.

The main problems the authors encountered while investigating Premier Laboratory, Inc.'s Public Water Systems Monitoring and Compliance Work System were the amount of steps required to process a sampling and reporting cycle to meet state compliance regulations for a specific water system. Convoluted interfaces for input in the Lab Information Management System (LIMS) create loss of credibility and revenue to both customer and the lab from monitoring and reporting violations. The opportunities to improve the work system come from removing self-inflicted monitoring reporting violations, and eliminating non-value added activities within the scheduling process. Table 2 identifies some finding and opportunities from the analysis.

The authors evaluated the Lab Sample Scheduling, Monitoring, and Reporting System at Premier Laboratory, Inc. to determine if the current system could be improved through the development of a custom open source module, or through a company-wide implementation of a new LIMS System.

The problem with the implementation of a new system is the learning curve associated with the system, and the overall cost of the system investment. The authors found that implementing a whole new Enterprise Resource System (ERP) or LIMS would be too costly for the gains that Premier Laboratory, Inc. would receive from it.

Table 2. analysis and opportunities:

Step (from Major Processes and Activities)	**Problems, Opportunities, or Issues**
Project Manager downloads regulations from state database and inputs data into LIMS.	• Could be automated
Project Manager prints monthly and quarterly pick up sheets, color codes and then prints information.	• Could be done electronically, but LIMS system is limited
Project Manager sets up appointments and gives sample pickup sheets to Scheduler.	• Could be done electronically if it could be tracked
Scheduler adds pickup sheets to existing schedule pool and assigns collections to individual Drivers.	• Could be done electronically if it could be tracked and sent to driver
Drivers travel route collect samples, and bring the samples back to the lab for analysis by Lab Techs.	N/A
Completed Lab report is given to Project Manager for review and client notification of exceedances.	• Could be automated and sent electronically
If exceedances are found, Project Manager is required to fulfill follow-up sampling procedures.	• Could be electronically notified and automatically sent to Scheduler
Results are delivered to Customer and submitted via EDI to Connecticut Drinking Water Section.	• Could be automatically sent for approval and then automatically sent to State and Client

Upon our discussion with several staff members and evaluation the system in its daily use the authors conducted a quick feasibility analysis. The results of the author's cost, operational and technical feasibility analysis allowed the authors to determine the best course of action would be to build a new module. The module would be the best option for Premier Laboratory, Inc. because the implementation would cost less to develop, it would offer a long-term solution, and the gains would give Premier Laboratory, Inc. a competitive edge in the water testing market.

5. Recommendation and Justification:

During the analysis of possibilities phase of the research, the authors reviewed the data collected through the previous steps and captured in the work system snapshot. The authors began to identify system flaws through the WSM that were then communicated effectively to the non-technical employees and managers to describe the problems and recommendations. The authors discussed the causes and evaluated if the existing steps could be improved, replaced, or eliminated with the lab Management team. With keeping the restraints of costs and available resources including software, hardware, and personnel, the authors engaged in developing and identifying opportunities for improvement and the feasibility of these proposed solutions.

Upon completion of this analysis, the authors were able to provide recommendations that were feasible and cost effective. Suggestions included specific physical work system modifications and changes in the use of resources and proposals for key information system tools and software to be implemented. These were reported to the management of the laboratory which provided a very positive evaluation of the project results.

This work system could be optimized with the replacement of the fragmented systems with the implementation of a new module built to manage all aspects of appointment setting and route scheduling. The current LIMS are not as effective as they could be, and really could use an overhaul. Our solution, the implementation of a new system that covers all necessary functions of test scheduling, would allow Premier Laboratory, Inc.to hold the competitive advantage against its competition. The problem is that so much time and effort is put into converting electronic formats to paper and manually converting back to electronic format again. The new implementation would fix this by creating a purely electronic submission and scheduling. The new module the authors plan to implement will eliminate the paper scheduling of drivers, while allowing the opportunities to collect and measure data through order tracking and analyzing route efficiency. This information collected will be used to create management reports.

These reports will be used to make decisions to reduce overtime, the amount of necessary human resources required, and remove repetitive and redundant steps. The implementation would not interrupt the current flow of analytical lab data to be transferred via Electronic Data Interchange (EDI) and create customer reports automatically. Because our implementation is a new module, it would fit right over current manual processes and make the system fairly automatic. This automation would provide all that Premier Laboratory, Inc. needs to hold competitive advantage against its competitors in the water testing market and allow Premier Laboratory, Inc. to take on more customers and avoid errors. Table 3 shows purposed recommendations to the work system.

Table 3. work system recommendations

Customers	**Products & Services**
Private Residences Environmental Engineers Public Water Sources Businesses Other Laboratories Waste Water Treatment Plants	Water Sample Lab Reports to clients Meeting State of Connecticut Compliance Deadline Required follow-up sampling and testing

Major Processes and Activities

- Project Manager (PM) downloads regulations from state database and inputs data into LIMS.
  - Recommendation: Implement a new system that is capable of automatically updating the PWS Sample Scheduling Requirements into LIMS.
- Project Manager prints monthly and quarterly pick up sheets, color codes and then prints information.
  - Recommendation: Have implemented system allow for more flexible queries and automatically tag and generate new schedules for drivers in an electronic format.
- Project Manager sets up appointments and gives sample pickup sheets to Scheduler.
  - Recommendation: New system implementation automatically will add sample pickup sheets to an electronic pool of appointments for scheduling.
- Scheduler adds pickup sheets to existing schedule pool and assigns collections to individual Drivers.
  - Recommendation: New implementation will allow scheduler to easily add and remove stops on driver's routes in an electronic format and allow geo-tagging for GPS capability.
- Drivers travel route collect samples, return samples to the lab for analysis by Lab Techs. No Change
- Completed Lab report is given to PM for review and client notification of exceedances. No Change
- If exceedances are found, PM is required to fulfill follow-up sampling procedures. No Change
- Results are delivered to Customer and submitted via EDI to Connecticut Drinking Water Section. No Change

Participants	**Information**	**Technologies**
Project Manager Public Water System Owners Drivers Department Manager State of Connecticut Lab Technicians	Water Results EDI to state Exceedances Monitoring Compliance Met Regulations	Laboratory Information Management System (LIMS) Microsoft Access Microsoft Excel Microsoft Outlook

6. Conclusion:

It may be concluded that through the systemic analysis and relevant data collection applied to the SMR system, the goal of the system analysis was achieved. Positive and practical recommendations for the opportunities revealed provided Premier Laboratory, Inc. with a place to start to regain their industry leading service.

Though frustration was seen by the users knowing there was a better way to do things, they never had the tools to evaluate and effectively communicate the situation to management. The systemic approach provided by the WSM gave the users a voice using facts and evidence to support their issues.

With this knowledge in hand, the final presentation of the results from this System Analysis to the General Manager was met with positive response. The analysis and recommendations were easily communicated in a non-technical approach that allowed for future discussions to be held about implementing the system. The system analysis also provoked the idea to apply the WSM to other lab work systems that exhibited similar symptoms to that of the SMR, such as the Analytical Report Review system to start at a future date.

As demonstrated through this research, it may be concluded that the Work System Method is a practical approach that can be applied in any discipline, by any user, to any system and will provide tangible and usable analysis for improvement of a situation.

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