On my honor as a University student, on this assignment I have neither given nor received unauthorized aid as defined by the Honor Guidelines for Papers in TCC Courses.

Signed __________________________
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GLOSSARY

**Certification** – Certification is the process by which the International Monitoring System authorizes a station to begin reporting data to the International Data Center. Stations must meet a variety of requirements to prove the data will be accurate and reliable.

**Comprehensive Nuclear Test Ban Treaty** - The Comprehensive Nuclear Test Ban Treaty is a treaty signed by most nations in a special session of the United Nations to completely end the testing of nuclear weapons around the world. The treaty has not yet been ratified.

**Computerized Maintenance Management Systems (CMMS)**- A CMMS is an information system designed to track all areas of maintenance in one easy-to-use application.

**Data Warehouse**- A data warehouse is a tool, which organizes data to use in decision making processes. A data warehouse is usually a computer-based application such as a database with user interface.

**Graphical User Interface (GUI)**- A GUI is an interface that utilizes visual aspects to make it user friendly. The interface allows users to access information from a computer or machine by using visual screens.

**Information System**- An information system is a process that uses data in prediction, decision-making, or understanding.

**International Monitoring System** - The International Monitoring System consists of various types of data collection stations that report their data back to an International Data Center. The Comprehensive Nuclear Test Ban Treaty created this system.

**National Data Center** - The US National Data Center receives all data from radionuclide and the other technologies from the field stations and supplies the data to the International Data Center. It is co-located at the Air Force Technical Applications Center in Florida, the its primary function is to support the US monitoring and verification capabilities.

**Radionuclide**- A radionuclide can be radioxenon noble gases or particulate debris and is a result of nuclear testing.

**Radionuclide Aerosol Sampling Analyzer (RASA)**- The RASA is piece of equipment used by most radionuclide monitoring stations to detect and quantify radionuclide particulate debris in the atmosphere.

**Radionuclide Maintenance Monitoring System**- The Radionuclide Maintenance Monitoring System will be created through this thesis project. It is an information system that will be customized to the needs of the Radionuclide Monitoring System.

**Radionuclide Monitoring System** - The radionuclide network consists of 80 stations with sensors to detect radioactive isotopes in the air and 16 laboratories for analysis.
State of Health - State of Health information is data sent to the National and International Data Centers concerning the overall status of the machine. This daily data set includes readings such as temperature, humidity, and details about the RASA.

Verification - Verification is a process set up in the Comprehensive Nuclear Test Ban Treaty to ensure that no nuclear testing is being conducted by any signatory nation.
EXECUTIVE SUMMARY

The Comprehensive Nuclear Test Ban Treaty banned all nuclear weapons testing and was signed into law September 1996. It set up various monitoring stations across the globe; their purpose was to detect nuclear detonations and report them to the international governing bodies. The radionuclide stations test the atmosphere for particles and gases given off during a nuclear weapons explosion. In order to ensure that nuclear test monitoring is accurately performed, the tools used must be monitored and maintained. This thesis project developed a plan to ensure proper maintenance of the radionuclide monitoring system. Through the gathering of requirements and scenarios, the selection of the best software, and a conceptual design to aid further customization of this software, the capstone team aimed to fulfill the maintenance needs of the radionuclide system.

A centralized maintenance system is necessary to maintain radionuclide stations all across the globe. A web-based system allows users from the level of individual station operators to those responsible for the whole system to interact and monitor the station. This system includes a web-based graphical user interface (GUI) supported by a multidimensional database, including information involving part inventories, station histories, preventive and predictive maintenance, maintenance procedures, and technician scheduling. Many of these features can be found in software packages called Computerized Maintenance Management Systems (CMMS). Our team researched these products and determined the best suited one for this project. The selection process narrowed the products down by comparing the systems on a variety of performance areas and rated them according to their performance.

This thesis project also designed an interactive database that traced the functionality of the maintenance monitoring system for radionuclide monitoring. This database, designed using
Rational Rose, a computer software package, will be used as a tool when the actual CMMS is being implemented. The design documentation includes all information about the functionality, structure, and usage of the CMMS. The implementation tool organizes all areas of the maintenance system into a hierarchical object oriented environment. This organization will make customization of the commercial CMMS product easier for those unfamiliar with the radionuclide monitoring system requirements. Once our design is implemented, the stations will be linked in a maintenance monitoring system and the monitoring of radionuclides can continue with little to no downtime caused by improper maintenance.
I. INTRODUCTION

The Comprehensive Nuclear Test Ban Treaty, signed on September 24, 1996, was an international agreement brokered by the United Nations and designed to ban testing of nuclear weapons [1]. One of the problems of the treaty is how to accurately monitor and enforce the treaty. To solve this problem, the treaty created a Radionuclide Monitoring System to monitor the atmosphere in order to detect nuclear testing. The development of the Radionuclide Monitoring System is only one step to a successful implementation of the treaty. A maintenance network is necessary to ensure the stations are monitoring reliably and accurately. The treaty refers to this monitoring as verification, a process to ensure that no nuclear testing is being conducted by any signatory nation. My thesis project focused on the selection and design of an information system to monitor maintenance for these stations, in order to bolster the verification of the treaty.

The system was designed to support the eighty radionuclide monitoring system stations by tracking all maintenance procedures, spare parts inventories, current state of health of the station, as well as many more maintenance tasks. These monitoring stations were designed to detect small amounts of radionuclides, chemical compounds that are released into the atmosphere when nuclear weapons are tested [2]. To ensure the radionuclide monitoring system continues to perform its duties the IMS must adopt and properly implement a Computerized Maintenance Management System (CMMS) that can handle all the maintenance needs.

Individual stations must be certified by the International Monitoring System, a governing body that strictly regulates the stations. The main requirement in this certification process is to ensure maintenance is properly tracked and recorded. The certified stations send the results of the daily monitoring to a central data warehouse referred to as the International Data Center. Located in Vienna, Austria, the Data Center analyzes the data to determine if testing has
occurred. Each station contains a Radionuclide Aerosol Sampling Analyzer (RASA) that captures particulate from the atmosphere and test for radionuclides. The analyzers then send information to the data center concerning the amount of radionuclides present as well as the state of health of the machine. The state of health data contains information about the RASA and the other areas of the station including current temperature and other information that ensures the station is operating within specifications. If the state of health data is out of the specified range for the station, steps are then taken to fix the error and messages may be sent to either maintenance technicians or the spare parts depot. The flow of information is represented in Figure 1.

Figure 1. The flow of information for typical maintenance needs.

In order to ensure certified stations operate within the guidelines determined by the treaty, the station must track and record all maintenance activities. This thesis project began the process by evaluating commercial maintenance monitoring products that could encompass all areas of system maintenance. After initial research into maintenance monitoring it became apparent that there are many commercial Computerized Maintenance Management System
(CMMS) products available that are capable of handling the monitoring systems needs. A CMMS is a commercial software package that not only tracks maintenance but can also initiate maintenance tasks through automated alerts. The software packages offered by a variety of vendors were researched, analyzed, and the final recommendations were presented to the client.

The Capstone team determined the exact functionality required of the CMMS through a requirements-gathering phase, then used these requirements to select a CMMS. The team also mapped out the potential maintenance procedures, which the CMMS must perform to ensure the monitoring system is operating within specifications. The thesis project developed a design for an additional information system that will aid in the implementation of a commercial product chosen. The design lays out the possible maintenance problems that can occur and how the system should react. Created in Rational Rose, a software design tool, this implementation aiding system develops a hierarchical look at the CMMS and organizes the CMMS functions under an object-oriented design. This conceptual design will help during implementation by laying the groundwork for the additional computer programming necessary to customize the CMMS to the radionuclide monitoring system.

Veridian Pacific Sierra Research contracted the research and design of the maintenance monitoring system to a Capstone team consisting of Alexander Linthicum, Christopher Seacord, and myself. Because this project is part of a Capstone team’s work, each member will focus on one area of the project. I handled client management, evaluating the CMMS products, and understanding the operation of the existing network of stations.

This document provides the details of the project and its results. The chapters that follow include a review of relevant literature, to examine other current research on this topic. The materials and methods section of this document discusses the process the project took create the final design and selection of the information system. The results of the project will be summed up in detail, as well as, suggestions for future steps.
II. REVIEW OF RELEVANT LITERATURE

The radionuclide maintenance monitoring system that I designed involves several different fields including maintenance tracking, information systems, foreign policy, and general systems engineering. Maintenance monitoring has been in effect for many years and recently there has been a trend toward implementing these systems in large-scale computer-based databases. Methodologies used to design and implement information systems have been defined and can now be applied to the growing maintenance system industry.

A. Maintenance Monitoring

A brief mention of the history of maintenance monitoring in found in Bryan Weir’s article “An Impartial View of CMMS.” Weir states that maintenance tracking began as manual notes kept by maintenance personnel in an attempt to organize the procedure; they acted as little more than a record of performed maintenance. Over time, the manual method was replaced by a complex computer system used only in hospitals for critical equipment [5]. The first computer maintenance systems slowly evolved into Computerized Maintenance Management Systems (CMMS), which viewed the software program as a tool that electronically handled the paperwork associated with maintenance, according to Pan Demetrakakes in “Mind Over Maintenance” [6]. The maintenance crew would simply use the computer to record the jobs that had completed instead of using the old method of physically writing out a form. CMMS have evolved into complex maintenance tracking that have more functionality than tracking completed tasks.

In addition to simply tracking maintenance the new CMMS handle predictive and preventative maintenance, equipment histories, labor scheduling, spare parts inventories, and report generations [6]. Predictive maintenance is the analysis of data trends of a particular
machine to determine methods of predicting failure. By storing the data regarding machines and parts logical patterns can be discerned and used for latter predictive maintenance.

Pan Demetrakakes in “Mind Over Maintenance” describes in detail the process of maintenance using the CMMS as a tool [7]. Understanding the maintenance will aid in selecting the best CMMS is the subject of much research by maintenance managers. In his article “Why CMMS Fail,” Bob Long suggests sending a list of system requirements to an array of CMMS vendors and asking them to review the list and reply only if their product can perform all the desired functions [7].

Many predictions have been made about the future of the CMMS. Tom Singer synthesizes the views of experts in the field. They hypothesize that the maintenance tracking industry will use the internet. This Internet-enabled maintenance allows easier tracking for multiple users at multiple sites ideal for large companies or enterprises. In addition to broad access, the Internet allows the new CMMS industry the ability to integrate e-commerce into their software packages. Companies will eventually be able to purchase parts directly from the vendor through the CMMS [9]. For this thesis project our team utilized a CMMS software package Radionuclide Monitoring System to fulfill the requirements set by the Comprehensive Nuclear Test Ban Treaty.

B. Comprehensive Nuclear Test Ban Treaty

The United Nations (UN) adopted the treaty September 26, 1996. The treaty was a positive step toward nuclear disarmament. It reduced nuclear weapons arsenals and banned nuclear weapons testing [1]. In order for the UN to enforce it, forty of the previously selected forty-four nations of the world must ratify the treaty. The United States, Russia, China, along with other world powers
are included in these forty-four nations whose ratification of the treaty will result in the full implementation of the comprehensive treaty. Although the United States signed the treaty, it has not yet ratified it. Therefore, the US is not yet held accountable for its nuclear testing.

Verification is the process created by the comprehensive treaty to determine if nuclear weapons testing are being conducted. To determine if testing has occurred the International Monitoring System and as the network of monitoring stations were created. Eighty radionuclide-monitoring stations and sixteen laboratories comprise the radionuclide monitoring system; in addition, there are 170 seismic monitoring stations, designed to determine nuclear testing. Lynn Sykes in an article regarding verification of the comprehensive treaty discusses how the radionuclide monitoring system is an important piece of the international monitoring system because it is the only technology that can positively identify a nuclear test. The seismic monitoring system has a greater sensitivity than the radionuclide technology but scientists may easily confuse it with a small earthquake or a non-nuclear weapons test. Nuclear weapons release a unique Xenon isotope (Xe) into the atmosphere and the radionuclide monitoring system station can detect this isotope in small quantities and be able to confidently determine if a nation has conducted a test. The combination of these international resources will meet the verification goals of the comprehensive treaty.

The ratification process the United States in undergoing has been held up in the Senate by concern over the verification process outlined in the treaty. This main concern is belligerent countries may be able to develop and test weapons without the United States’ detection, even with a strict verification process. The same concern has either doomed or curtailed the effectiveness of previous test ban treaties. If an adequate maintenance system can be
established to ensure each station is monitoring the radionuclides effectively, it may lessen
concern for the verification process.

The history of the comprehensive treaty is clearly outlined by the Comprehensive Test
Ban Treat Site in their summary of the key events that led to the this latest treaty. On July 16,
1945 the first nuclear test explosions occurred. Ever since there has been a great demand from
the public to regulate these tests for public safety. One of the first treaties to affect testing, the
Limited Test Ban Treaty (LTBT), was signed by the U.S., Britain and the Soviet Union on July
25, 1963 and was ratified by the US Senate. Other treaties that follow include the Nuclear Non-
Proliferation Treaty (NPT) (signed 1968) and the Threshold Test Ban and Peaceful Nuclear
Explosions Treaties of 1974. The first talks concerning a Comprehensive Test Ban Treaty began
in 1977. These negotiations finally led to the signing of a new CTBT on September 24, 1996
during a special session of the UN in New York. The last steps remaining for the comprehensive
treaty of 1996 is the ratification of the treaty by the nuclear powers. If the treaty is not ratified the
treaty will not be able to enforce its verification process or have any impact in the limiting of
nuclear tests and negotiations for a comprehensive treaty would begin again [10].

The latest political debate surrounding the treaty may be more than national security
concern. Many top political officials cite a partisan senate as the reason the comprehensive treaty
has not been ratified. Al Gore, former Vice President of the United States, stated in a press
conference in October 1999, “They [Senate Republicans] started a fire of political partisanship
they could not put out—ultimately leaving the fate crucial international treaty in the hands of
those who would play politics with nuclear weapons [11].” The debate on nuclear testing
continues, and the fate of the comprehensive treaty is still unknown.
C. Systems Engineering

In order to ensure the verification process of the comprehensive treaty is accurate and reliant the maintenance monitoring system created by this project must reflect the needs of the system. Using the methodologies of systems engineering the design of information system will be a robust, flexible system that meets the verification needs set out in the comprehensive treaty. The Capstone team selected and designed this information system based on the needs that users and stakeholders have for a maintenance system. Requirement Elicitation is a process in which to gain information from the necessary people and turning this information into a design for a system. This process is done through research of the existing system, and interviews with stakeholders and users [12].

Another method often used in systems engineering is Use Case modeling. I. Jacobson described Use Case modeling as a responsibility-driven, object oriented design method that helps capture the functionality required by the system and clearly defines how the systems and its users must interact. The capstone team is developing several different scenarios to express different ways a user may interface with the system, by tracking the events needed to accomplish these tasks, the analyst can develop requirements. Use Case Modeling is an alternative method of gathering the requirements of the system [13]. An analyst then uses the requirements gathered through elicitation and use case modeling to create an information system called a data warehouse. Welbrock gives one definition of data warehouses in his chapter “Strategic Data Warehousing Principles.” Data Warehouses are decision making support tools that utilize the availability of information. This system allows the user to view the data that will address his/her need [14].
Applying the previous research and work down in the fields of maintenance monitoring, nuclear-weapons disarmament, and information systems, this thesis project blended the three fields to create and useful product.
III. MATERIALS AND METHODS

A. Background Research

The Capstone team developed the framework of the project by understanding all areas of the project in order to gather requirements that encompassed all needs of the system. The team began by researching the certification and verification outlined by the Comprehensive Nuclear Test Ban Treaty. The team used the actual treaty and related documents to understand the purpose of the radionuclide monitoring system. The team gathered information on the daily functions of each station. We read articles published by scientists who created the Radionuclide Aerosol Sampler Analyzer (RASA) to provide an actual picture of the maintenance needed, the maintenance procedures of individual field monitoring station, and industry maintenance techniques.

B. Requirements Gathering

Research and additional interviews with stakeholders aided in the generation of system requirements. The requirements document lists and describes all needed and desired functions in the system. The requirements were compiled through interviews with the clients Steve Biegalski, and Jane Bohlin of Veridian-PSR, radionuclide station operator in Charlottesville Bo Hostika, and the head US Air Force Technical Applications Center’s radionuclide group John Lucas. In addition to these interviews requirements of other maintenance systems were examined to determine if the radionuclide maintenance monitoring system could benefit from additional functions. Commercial Computerized Maintenance Management Systems (CMMS) were researched and users of these systems were interviewed to add requirements to the main document.
C. Use-Case Scenarios

The team employed Use Case Modeling to develop a series of scenarios to supplement the requirements gathered through interviews. Station operators were interviewed and asked to supply scenarios including Bob Shipman and Bo Hostika. The scenarios map out possible maintenance problems and how the system would react to each type of error. There are several different ways in which maintenance work can be requested of the system, each with its own path to follow. Different personnel and systems are alerted depending on the type of problem and work requested. The team reviewed the scenarios to look for any requirements that may have been overlooked in the gathering phase.

D. CMMS Selection

The CMMS selection processes began by researching maintenance industry resources for potential products. Terry Wireman’s book *Computerized Maintenance Management Systems*, and the maintenance resources web site provided contact information on hundred of CMMS vendors. Fifteen CMMS products were selected based on the recommendations of industry experts, the amount of information available and preliminary research. These fifteen vendors were contacted and asked to send information about their products. E-mail was sent to each company with a preliminary list of requirements the system should have. Companies replied to this e-mail and sent information via e-mail, regular mail, sales brochures, software demonstrations, and telephone calls. This information was gathered and reviewed. A final list of criteria necessary in the CMMS was determined and each company was assigned a rating.
The performance areas included:

- Price
- System Requirements
- Inventory
- Support
- Ease of Use
- Work Orders
- Predictive Maintenance
- Scheduling
- History/Reports
- Web Capability

For more information about the requirements for each of these performance areas see Appendix C. The top five products, (Eagle ProTeus, Maintstar, Mapcon, Maximo, and Ultramain) were described and ranked in a document presented to the client in order for them to have a complete view of the products selected. Each system’s ability to meet the criteria set out in the selection criteria was discussed. Appendix C contains the full evaluation of the top five CMMS selections.

E. Conceptual Design of Implementation System

The team created an information system design to illustrate the requirements and scenarios specified by the stakeholders. The team created this system using Rational Rose software to ensure smooth integration to using the CMMS. Rational Rose is a software program used to lay out the framework of a computer system in order to ease transition from planning to implementation. Rational Rose is a software design tool, which aids in system development by documenting the system’s architecture. The design maps out the uses of the CMMS and how it will interact with the radionuclide monitoring system. The design puts the conceptual plans for
the system on paper and walks through each scenario. The clients and other potential users of the
system tested the design to ensure its accuracy. This design will aid Veridian-PSR and any
groups that will continue to work with the radionuclide monitoring system by integrating all the
background information, requirements, and scenarios the group collected into one easy to view
design layout.

F. Presentation/Documentation

The team documented the selection and creation of the information system design to provide
information to all stakeholders. Information about the CMMS product chosen and its
functionality will benefit all users, from field operating technicians to supervisors. The client
received the Rational Rose generated use-case scenarios and design layout so they can use the
software to ease transition to the maintenance monitoring. The team presented the process and
outcome of this project to a variety of stakeholders who will benefit from the documentation of
the system methodologies used over the course of the project. The process and results from this
thesis project was presented at the annual Capstone Conference in the form of a proceedings
paper and an oral presentation.
IV. RESULTS

A. CMMS Selection

Based on the research completed by the Capstone team, the CMMS products that will serve the needs of the Radionuclide Monitoring System are Ultramain and Maintstar. This was determined through these product’s superior performance in areas that were critical to the radionuclide monitoring system. The team gave each system a rating for each area in regards to its performance in that area also the team assigned each criteria a weight relative to its importance in selecting a system. The rating scale is a 5 point scale (5 = excellent, 4 = good, 3 = fair, 2 = poor, 1 = non-existent). The following chart describes the each system’s performance in each area. The overall rating is the sum of products of the importance factor and the rating. A higher rating indicates the system may be more suited to the project, based on the decision criteria.

Table 1. The ratings of the top five CMMS chosen.

<table>
<thead>
<tr>
<th>Weight</th>
<th>Eagle</th>
<th>Maintstar</th>
<th>Maximo</th>
<th>Mapcon</th>
<th>Ultramain</th>
</tr>
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<tr>
<td>Price</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>System Req</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Inventory</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Support</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Work Orders</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Predictive Maint</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Scheduling</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>History/Reports</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Web Capability</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>RATING</strong></td>
<td><strong>128</strong></td>
<td><strong>168</strong></td>
<td><strong>165</strong></td>
<td><strong>139</strong></td>
<td><strong>168</strong></td>
</tr>
</tbody>
</table>

Maintstar’s strong points include its web capability and its ability to evaluate trends for predictive maintenance purposes. The system’s web based module provides the capabilities of creating work requests and work orders through the Internet. Its predictive maintenance
functions allow automatically generated corrective maintenance work order to be created when a station’s state of health fails into an unsatisfactory range. Ultramain was selected because its performance in the areas of reporting and work orders. Being able to create detailed maintenance reports is crucial for a system that must keep records of all maintenance activities, and all parts in inventory. Work Order creation is another key piece to this maintenance system and Ultramain allows for easy and accurate work orders. Both systems scored highly in the ease of use performance area because of their well-organized user interfaces. Figures 2-4 show samples of the user interfaces Maintstar and Ultramain provide.

Figure 2. The user interface for Maintstar which illustrates its ease of use (Maintstar)
Maintstar and Ultramain appear to be the best suited CMMS for the Radionuclide Maintenance Monitoring System but only through further analysis can one product be chosen, purchased and implemented. Contacting these companies to discuss sales and actual implementation may yield more information and aid in selecting one of two. The complete evaluation of each system can be found in Appendix C. A meeting held February 13, 2001 allowed the team to discuss these findings in the CMMS selection process and demonstrate the available products for the client, Veridian PSR.
B. Conceptual Design

The team finished the conceptual design layout of the system. This design created in Rational Rose shows the possible paths the CMMS would take to correct a variety of maintenance problems. This system was designed as a method to transfer the information gathered in the process of this thesis project to future groups who will continue to do work on this system. The design was presented to the client Veridian-PSR along with a test plan to ensure its accuracy. The test plan was a series of mock screen shots which simulated the actions of the CMMS system. Veridian tested the design and found no critical mistakes in the design layout. Figure 5 on the following page shows a sample of one of these user tests. The complete conceptual design can be found in Appendix D.

This conceptual design will be used to aid the implementation of the CMMS. This design will serve those in charge of implementing and customizing the system by clearly illustrating the normative scenario for the radionuclide monitoring system. The design combines all available resources and sources of information into one easy to use system that users can easily access. By providing this tool future groups can complete the implementation of the radionuclide maintenance monitoring system with less background information.
Figure 5. A screen shot of the functionality testing

![Screen shot of Systems User Directory]

- Dean, James
- Fox, Michael J.
- Grant, Cary
- Kant, Emmanuel
- **Keaton, Alex P.**
- Tracy, Dick
- Walton, John
V. CONCLUSION

A. Summary

The objective of this senior thesis project was to create a design of an information system for the purpose of maintenance monitoring in radionuclide stations. The team researched and selected two Computerized Maintenance Management System (CMMS) commercial software products that fulfilled the needs of the client and the radionuclide monitoring system. The needs for the system were researched and combined to form a requirements document which outlined all needed functions of the system. We recommend the client use the products Maintstar and Ultramain, which we found both meet and surpass these requirements. Although the team did not implement this maintenance system we created, a conceptual design of how the system will function when implemented was developed. This design, created using Rational Rose, employs Use-Case Modeling and aids future work to the system by setting up the background of object oriented design for the system. The conceptual design will guide implementation the software and provide the appropriate documentation that will also allow further work to be done.

B. Interpretation

The maintenance monitoring system utilizes modern technology to create a convenient, reliable, and complete maintenance tracking and decision-making system. Parties who need the information to maintain certification and to ensure accurate verification of the Comprehensive Nuclear Test Ban Treaty will have access to the system and will be able to view each individual station. The design of the system is one way to improve the verification of the Comprehensive Nuclear Test Ban Treaty by making the monitoring process reliable and ensuring its long-term performance.
C. Recommendations

The next stage of this project would be the actual implementation of the CMMS selected. Negotiations should begin with the Maintstar and Ultramain vendors to determine which will be ultimately chosen. Using the design drawn up in both Microsoft Word and Rational Rose, the software engineers would take up this project to customize the software to fulfill all needs of the Radionuclide Monitoring System. This methodology of evaluating systems and then mapping out the design architecture may be applied to other projects of similar scope that include multiple teams working on different parts of the project. This CMMS product chosen combined with the conceptual designs should allow for easy implementation. Using this system to limit the maintenance problems, the Radionuclide Monitoring System will be able to bolster the verification process described by the Comprehensive Nuclear Test Ban Treaty.
VI. WORKS CITED


A. BIOGRAPHICAL SKETCH OF THE AUTHOR

Maureen Reilly is currently a fourth-year undergraduate at the University of Virginia, Charlottesville VA USA. She is pursuing a Bachelor of Science in field of Systems Engineering with a minor in Environmental Engineering. Ms. Reilly worked for two years at the United States Geological Survey (USGS) as a physical science aid (GS-4). At the USGS she worked on an array of research projects focusing on the use of nitrogen isotopes to study contaminant transport. Ms. Reilly earned the STAR award from the USGS in August of 1999 for her work in the field of environmental research. During the summer of 2000, Ms. Reilly interned at the information technology firm of American Management Systems (AMS). At AMS she applied her education in systems engineering to design information systems for the Environmental Protection Agency’s (EPA) Office of Water. Ms. Reilly is currently in the process of applying to graduate institutions to continue her work in the field of Environmental Engineering. She plans to earn a Master of Science degree. She will specialize in contaminant transport in water, and is considering pursuing a Ph.D.
APPENDIX B

REQUIREMENTS DOCUMENT
REQUIREMENTS FOR THE RADIONUCLIDE MAINTENANCE MONITORING SYSTEM

State of Health
Gen18 The system shall provide a display that allows daily inspection and visual confirmation that all items have been performed as scheduled. The system shall enable users to understand the current state of the network, the stations, and of the equipment at the stations.

Scheduling Maintenance
Gen20 The system shall schedule preventive maintenance and planned maintenance activities.
Gen30 The system shall initiate work orders through a work order request form.
Gen17 The system shall analyze state of health data for the purposes of predictive maintenance.
Gen21 The system shall schedule inspections of overall station health.
Gen33 The system will provide a display for users to see data related to preventative and predictive models.

Notification Functions
Gen03 The system shall automatically provide notification for preventative maintenance calls.
Gen05 The system shall automatically provide notification for predictive maintenance calls.
Gen15 Reword The system shall automatically notify technicians when repairs are required. The notification will include a description of the equipment needed to complete the repair.
**Reporting**

Gen19   The system shall provide a daily Operation & Maintenance Report (OMR) of all activities performed by personnel for each station.

Gen35   The system shall generate reports for anything stored in the CMMS database.

**Database Related**

*Equipment/Parts*

Sto15   The system shall store all parts currently in use in the individual stations

Sto16   The system shall store a complete list of unused parts stored at the station.

Sto01   The system shall store equipment serial numbers.

Sto02   The system shall store equipment model numbers.

Sto04   The system shall store equipment start and end dates.

Sto07   The system shall store equipment maintenance history.

Gen01   The system shall track the maintenance of station equipment.

Sto09   The system shall store dates of equipment failures.

Sto10   The system shall store descriptions of equipment failures.

Gen29   The system shall provide hierarchical relationships between equipment and parts.

*Station*

Sto08   The system shall store station maintenance history.

Sto12   The system shall store comments from each maintenance visit.

Sto13   The system shall store information concerning how failures were fixed.

Sto20   The system shall store the locations of each field station.

*Points of Contact*

Sto17   The system shall store contact information for all parts and equipment suppliers.

Sto18   The system shall store contact information for all station operators.

Sto19   The system shall store contact information for all technicians.

*Miscellaneous*
Sto03  The system shall store software version numbers.
Sto11  The system shall store known corrective measures.
Sto14  The system shall store detailed maintenance procedures.
Gen09  The system shall have the ability to walk maintenance personnel through maintenance routines.
Gen28  The system shall allow real-time access to operating and repair manuals

**General**

Gen06  The system shall have a user-friendly graphical interface.
Gen23  The system shall allow for different views for different users.
Gen26  The system shall interface with the Depot, parts inventory.
Gen31  The system shall interact with a billing or procurement system.
Gen32  The system shall interact with a human resources module.
Gen36  The system shall support multiple, simultaneous users via remote or local access.
Gen27  The system shall be stored and used on a computer.
Gen07  The system shall have a web-based interface for remote staff.
Gen37  The system shall support access via modem and intranet/internet.
Gen10  The system shall provide varying levels of access for all users, based on need.
Gen08  The system shall require 128-bit encryption for all web-based interface connections.
Gen11  The system shall physically reside in the central location.
Gen13  The system shall be capable of integrating with the seismologic, hydroacoustic, and infrasound maintenance monitoring systems.
Gen24  The system shall be flexible in the way notifications are made.
Gen38  The system should be capable of accessing station state-of-health parameters from a relational database.
APPENDIX C

CMMS Evaluation
C. SELECTION CRITERIA

The process of selecting a Computerized Maintenance Management System involves developing criteria and analyzing each potential system as to their ability to meet the criteria. Fifteen CMMSs have been selected from the large number of software products in the industry using information from various web sites and Terry Wireman’s book on CMMS. The original group of fifteen was then narrowed down to five base on preliminary evaluation and the amount of information available for each product. Each system was then given a rating for each section in regards to its performance in that area. The rating scale is a 5 point scale (5 = excellent, 4 = good, 3 = fair, 2 = poor, 1= non-existent). The major areas in which the products will be compared are:

- **Price** – The product may be either licensed for a yearly fee per user or purchased out right for a flat fee. The cost of each system will most likely vary on the amount of customization needed, as well as the additional modules that will be added on. The system’s price range must be within the resources of Veridian. The rankings for this section depend on the approximate price given by the vendor compared to other CMMS prices.

- **System Requirements** – The software must be able to run on a Windows NT platform. Any other computer needs (e.g. Oracle license, computer speed, etc.) must be taken into consideration. The rankings for this section depends on the variety of platforms which the product can be used.

- **Inventory** – The system’s inventory needs include the ability to track and store inventory information for the individual stations as well as the central depot area. The information may vary in accessibility and amount of detailed information across products. Procurement capabilities would also increase the level of the system in the inventory section. The rankings for this section depend on the capacity to store and track spare parts, equipment, and other materials. In addition functions like notifying the user of the need to reorder and on-line procurement options will raise the score.

- **Support** – The CMMS vendors offer various support mechanisms including on and off site training, telephone help lines, web/e-mail support, upgrades of software for free or at a discounted price, and aid in the implementation process. The rankings for this section depend on the availability of the vendor for training, technical assistance, implementation, possible upgrades, and additional help. The methods that a user can contact the vendor will also be taken into consideration.

- **Ease of Use** – The software system must be user friendly. Various international users should be able to easily navigate and understand the software. The rankings for this section depend on the use of icons, menus, and general usability of the interface.
- Work Orders – The level of information to be entered into each work order vary across products. Other features like the flexibility of work orders, the ability to customize, sending a work order via e-mail. The ability to receive work orders from an automatic alert is another item that is necessary in the system we select. In addition some products may allow for work orders to be officially “closed” but upper level management. The rankings for this section depend on the flexibility of work order design, the functions that can be performed, and the methods of initiating them (automatic, manual, and batch).

- Predictive Maintenance – The system may be able to analyze trends in the state of health data and determine if the stations need maintenance work. The system may be able to automatically generate work orders, schedule the work, and deploy the proper personnel. The rankings for this section depend on the ability of the system to store and evaluate information regarding the predicted performance of the equipment. Higher ratings will be given to the products that integrate their predictive maintenance module with other areas of the system such as work orders and scheduling.

- Scheduling – The system must be able to store preventive maintenance procedures in a schedule and be able to transmit this schedule to the necessary maintenance personnel. Each system varies in the extent, which is scheduled, and how much information is automatically scheduled. Real-time updates regarding the status of the machines would also add to the value of the system. The rankings for this section depend on the ability to schedule and notify maintenance personnel. Also the ability to add requested tasks to the schedule, as well as creating alternative schedules to determine how many resources will be used in a given situation will also be taken into consideration.

- History/Reports – The software systems must be able to store and retrieve information about the history of the equipment, stations, work orders, maintenance work completed, and ongoing. The extent of the history store and the ease of retrieval will be a determining factor in selecting a CMMS. The ability to print and store reports from the stored information is also a beneficial part of a software system and the capabilities will be reflected in this rating. The rankings for this section depend on the ability to store information about past, present, and future maintenance. Also the ease of creating specialized reports on the multiple areas of the system will be taken into consideration.

- Web Capability – The system must be easily used via the Internet and allow for access at both a local and international level. The ease of web access to various parts of the systems is important. The rankings for this section depends on the ability to have full functional capabilities at all user locations and the method the system accomplishes this connection.
EAGLE ProTeus

Contact Information

Product Name: Proteus
Company Name: Eagle Technologies
Address: 10500 N. Port Washington Rd.
          Mequon, WI 53092
Phone: 262.241.3845
       18003883268 ext 600
E-mail: sales@eaglecmms.com
Website: www.eaglecmms.com

Eagle Technology, Inc., helps companies who are looking to increase their plant or facility’s efficiency through computerized maintenance management solutions. ProTeus is the latest addition to Eagle Technology’s award-winning line of powerful Computerized Maintenance Management Systems (CMMS). The new program offers optimized database access and other advanced features that translate to improved productivity, reduced downtimes and a more attractive bottom line. Eagle has more than 3,000 customer organizations in over 30 countries, including many in the Fortune 500.

- Price - Currently the product’s information for this area has not been determined.
- System Requirements – Windows NT operating system and reasonably modern computers are required for this product.
- Inventory – Eagle has the capability to track reorder point, economic order quantity, maximum quantity, last cost & date last purchased, unit cost, and total cost. Also it has the ability to assign multiple vendors per part, store last PO number, and attach MS Binder & Drawing files.
- Support – Purchase includes one day of on-site assistance at no charge.
- Ease of Use – Eagle was designed for ease of use. Screen shots are available on the following page.
- Work Orders – ProTeus’ Standard Service Request module extends basic functionality to any workstation. This module allows users to submit work requests from any workstation connected to the company’s network. The request is sent to the Administrator, who will accept or reject the request. If accepted, a ProTeus work order number is automatically assigned, and can be sent to multiple printers. The Service Request module is commonly installed on computers in warehouses, hospitals, off-site buildings, or other remote locations. Works Orders include tracking of the originator, closed date, completed date, and runtime information. Eagle’s work orders also track downtime and have the ability to manually activate, as well as batch close.
• Predictive Maintenance – Currently the product’s information for this area has not been determined.

• Scheduling – Scheduling capabilities have the ability to print work orders from calendar. ProTeus’ pre-defined preventive maintenance tasks list for common HVAC equipment is used to build preventive maintenance work orders within ProTeus. These task lists can be edited and customized to meet the specific needs of the equipment to which they will be assigned.

• History/Reports – Standard reports & graphs as well as unlimited user defined selection filters, reports & graphs are available.

• Web Capability – Eagle’s products have Internet/Intranet access via web browser as well as a Client/server, object oriented development.
User Interface

The Main Menu provides two methods of selecting menu items.

The Equipment Master file contains many fields to record information on your equipment.
B. MAINTSTAR

Contact Information

Product Name: Maintstar

Company Name: Bender Engineering
Address: 3535 Farquhar Ave Suite 2
Los Alamitos, CA 90720
Phone: 800.255.5675
E-mail: info@maintstar.com
Website: [www.maintstar.com](http://www.maintstar.com)

Founded in 1984 as an engineering consulting firm, Bender Engineering, Inc. has evolved into a global provider of Asset and Maintenance Management Software. Their major program, MaintStar, provides the many features and capabilities for maintenance tracking because it is "modular" in design.

- Price -Pricing does start at $995 for fewer than 200 pcs. of equipment, single user and goes up from there. Companies are required to buy MaintStar I and then there is two ways of going, either buy additional module packages to add to the basic package or buy individual modules to go with the basic package.

- System Requirements – Maintstar uses SQL and Oracle as well as Sybase, which have separate price lists. It runs on NT, 95, 98, and 2000. MaintStar operates on three different database engines that are described further in the web capabilities section.

- Inventory – MaintStar follows each part from the time it is purchased to the actual work order when it is installed. MaintStar directly links inventory, work orders and purchase orders together and automatically reserves parts assigned to future work orders when reporting usable inventory. Once the item is used on a work order, the inventory level is automatically adjusted to reflect its usage. MaintStar guards against "stock outages" by automatically checking the availability of each part every time a work order is issued. Inventory information is always displayed on the work order screen. If the inventory level is less than the defined minimum, a message is displayed indicating the potential shortage.

- Support –MaintStar offers a quarterly update schedule and installing a MaintStar Management System is relatively simple. Easy to follow, step-by-step instructions quickly put the system on-line, ready to accept data, and easy to maintain. Training specialists are available to come to your site and to train the future users of the system. A special toll free "Assistance Hotline" number connects directly with Bender Engineering where a group of technicians are available to answer your questions.

- Ease of Use – Based on the demo that was sent to the capstone team from Maintstar, the program is easy to use. Picture icons are easily recognizable and easy to click. A variety of separate program modules enable you to accommodate any maintenance operation regardless of company size or application. However, like most systems the further a user...
grows in each area the harder it becomes to return to the main screen. Overall the system has good usability.

- **Work Orders** – MaintStar automatically generates a schedule of preventive maintenance work orders as well as corrective (emergency) work orders as needed. It allows you to issue work orders in different ways: by date, craft location, equipment, priority or a customer defined category. Work orders can be reviewed by individual work order number or all work orders within a specified numerical date range. They can also be reviewed by individual equipment, location, priority, or by a customer-defined category. Each work order may include an unlimited listing of all parts and materials, as well as multiple craftsmen needed to perform the maintenance tasks specified.

- **Predictive Maintenance** – Combining Predictive and Preventive Maintenance techniques to monitor the operation of machinery and then performing preventive maintenance on the machine before it fails is the ultimate goal of this product. This information is compared against a standard for a specific machine and reports any deviations outside established limits. The system will then automatically generate a corrective maintenance work order. In addition to vibration analysis, a combination of different types of sensors can also be applied, such as pressure, temperature, torque, radio frequency, etc. MaintStar claims that if properly implemented, predictive maintenance can reduce downtime by 2 or 3 times. MaintStar will interface with a variety of commercially available control systems to provide on-line equipment monitoring. The on-line data, such as equipment working hours, cycles, frequency, and other signals, including alarms, will be received from programmable controllers or other control devices and systems. This data will automatically update the PM schedule. When "out-of-range" or "alarm" data is received, MaintStar will automatically issue corrective maintenance work orders. These work orders can be generated on paper or electronically with an automatic e-mail notification to the responsible service and management personnel.

- **Scheduling** – MaintStar quickly and efficiently prepares a PM Master Schedule, which allows you to visualize future work activities at a glance. Matching the available workforce with the workload is immediately apparent as well as what spare parts and materials are going to be required. This allows the user to schedule PM maintenance tasks based on calendar days, meter units (hours, miles, gallons, etc.), or whichever comes first.

- **History/Reports** – Capable of storing an unlimited number of work orders, assets, parts, vendors or pieces of equipment. New fields can be created such as alphanumeric, numeric decimal, date, hours, etc. MaintStar's powerful Query Report Writer will automatically recognize any new fields and will let you utilize them when you need to create custom reports for your particular application. MaintStar also has the capability of sorting on any combination of new fields.

- **Web Capability** – MaintStar provides a multi-user enterprise-wide system which links any number of locations directly with your control center. Daily work orders, reports, or special information may be printed at any satellite workstation as required. All web capabilities and e-mail functions can be accessed. This module provides the capabilities of creating work requests and work orders through the Internet or a company Intranet. When using the web browser, the work request is created in the MaintStar system. The requester can view only their own work requests, including status, priority, work order assigned, execution date, and comments. The work request status can be reviewed by date range, location, asset number, customer or department, and then be automatically turned
into work orders. Actual work orders can be directly generated through this interface as well. The three server options are:

- **Sybase SQL Anywhere** is the standard database engine. This is perfect for small to medium sized operations. It is responsive and very easy to maintain. The single database file makes the system easy to backup and remain portable.

- **Microsoft SQL Server** is for medium and larger organizations that will be generating a higher volume of information. The increased power of this system will be appreciated. It can handle more concurrent users and process more data at a higher speed.

- **Oracle** is recommended for larger installations. This robust version can maintain increased data integrity and system speed even under the heaviest of workload conditions.
User Interface
C. MAPCON

Contact Information

Product Name: Mapcon
Company Name: Mapcon Inc.
E-mail: Joeyt@mapcon.com
Website: www.mapcon.com

MAPCON 2000 is a fully integrated, PC-based Computerized Maintenance Management System (CMMS) for Windows. MAPCON is installed worldwide in manufacturing plants, hospitals, power plants, etc.

- Price - The MAPCON System prices are as follows:

  MAPCON SOFTWARE
  Ver. 3.4 for MS Windows = $ 4,050.00 (Single Server)
  NETWORK SOFTWARE
  Revelation Lanpack Multiple-User License = $ 1,300.00 to $ 9,000.00
  Revelation NT Service License = $ 1,495.00
  YEARLY SUPPORT CONTRACT
  = $ 1,300.00 for Base System

  ON-SITE IMPLEMENTATION
  = $ 3,000.00 for Base System

  ON-SITE TRAINING
  On-site End User Training = $ 3,000.00 for 2 days

  SYSTEM MANAGER COURSE
  (4 1/2-days at our Des Moines, IA location) = $ 1,750.00 per person

- System Requirements – Mapcon has both an MS-DOS and Windows version, accessing a common database, allowing the intermixing of old and new workstations.

- Inventory – Mapcon offers a fully featured, real-time inventory system that includes stock, non-stock, memo, and consignment inventory types. The module integrates with Work Orders and Scheduling. Inventory usage data is kept on-line as is the information on Vendors, manufacturers, and alternate parts. A “Where Used” listing specifies the pieces of equipment for which each part is used.

- Support – Training of the future users must be trained in MAPCON 2000. Experienced Mapcon personnel install the system at your site and provide additional hands-on training. Consulting services and custom programming are also available.

- Ease of Use – According to the company Mapcon has “consistent user interface across all menus, screens and sub-systems reduces training and startup time.” The quality of the few screen shots supplied by Mapcon is unclear if this program would be easy to use. There is limited number of available icons on the main menu.

- Work Orders – The Work Order screens can be customized or modified for data entry. The Work Order System provides for Standard Repair Orders, Blanket Orders, Contract Service
Orders, PM Work Orders, Route Work Orders, After the Fact Work Orders, Service Work Orders, Patrol Orders and Work Requests. The complete, formal workflow enabled Work Order System includes planning and scheduling. Multiple levels for approval and Work Order priority are easily established.

- Predictive Maintenance – Work Orders can track Equipment Downtime, user defined Causes of troubles/Failures, and Actions to help determine why a piece of Equipment breaks down, how often and the cause. Corrections for causes are kept and can be reported. Reports are available on several areas of predictive maintenance (see reports). Trend analysis reports are created using data from the Work Order History files.

- History/Reports – Many standard reports are available within the system. Both users and designers of the system can create custom reports. Two ad-hoc report generators are provided, as is a graphics ad-hoc report generator. Excel Spreadsheets can be created directly from a MAPCON Report Generated Report. Complete equipment records include the hierarchical equipment relationships, original cost, warranty information as well as in-service date. Total year-to-date, lifetime, period and hierarchical maintenance costs can be displayed at any time. Separate costs are shown for labor, stock, purchases, contract services, etc. Procedures included on Work Orders may be job steps, safety procedures, tasks, problem descriptions, etc. MS Word and Excel files can be added or attached to the text boxes. Predictive maintenance reports include action codes, failure codes, top failures (Most Frequent and Highest Value failures). Historical comparisons are reported by costs and failures for equipment. Graphic reports by area/zone are available for M-T-D Equipment Downtime (in Hours) and Equipment Failure Analysis.

- Scheduling – The Scheduling System utilizes user defined Crews, Crafts, Shifts and employees. Scheduling supports multiple Tasks on a Work Order, multiple schedulers scheduling simultaneously (using multiple Zones), automatic Preventive Maintenance scheduling, and Project Work Orders being scheduled automatically. PM Work Orders can be generated a specified number of days in advance of their due date, and can be used as fill work. On-line Gantt charts help visualize the scheduled workload.

- Web Capability – The iMAPCON Intranet/Internet Module uses any web browser without having to log into MAPCON. Using the web server supported by your organization, any authorized user can log onto your designated web page and use iMAPCON to start a work request, check the status on previous requests, or browse for inventory part information. Other capabilities may be added, based on each customer’s needs. This Module employs several methods of security both in MAPCON 2000 and in the WebPages used for iMAPCON.
User Interface
D. MAXIMO

Contact Information

Company Name: MRO Software
Product Name: Maximo
Address: 100 Crosby Dr.
Bedford, MA 01730
Phone: 18003265765
Website: [www.maximo.com](http://www.maximo.com)

Maximo is an CMMS product designed by MRO software. They offer several packages including an Extended Enterprise version, which contains modules for asset management as well as procurement capabilities. The Facilities software is the base CMMS, most of the equipment maintenance tasks and functions. Maximo’s clients are found in a wide variety of industries and has over 75,000 licensed users.

- Price – Currently the product’s information for this area has not been determined.
- System Requirements – Maximo supports all of the industry standards, including ActiveX and SQL, required to interface with today’s office systems. So you can trust your Excel ® budget report to automatically query MAXIMO.
- Inventory – Maximo has modules dedicated to inventory and procurement. The system also allows a large capacity to store information about vendors, parts, and manuals. This system allows maintenance personnel instant access to technical documents and spare parts information.
- Support – MAXIMO is a product that is easy to update. Its allows for the addition or subtraction of users without changing systems. MRO Software Professional Services seek to meet consulting and training needs anywhere in the world.
- Ease of Use – Maximo prides them selves in this category. Screen shots are available on the following page. Their sales brochure claims: “ It’s clean — easy on the eyes, not overly detailed, but with all of the information and fields you need right in front of you — and it feels good to use.”
- Work Orders – MAXIMO can plan, schedule and dispatch PMs, work orders and job and safety plans.
- Predictive Maintenance – Currently the product’s information for this area has not been determined.
- Scheduling – Currently the product’s information for this area has not been determined.
- History/Reports – Currently the product’s information for this area has not been determined.
- Web Capability MAXIMO’s designers were the first company to develop a Windows-based maintenance system, the first to add access to SQL and the first to introduce a client/server architecture.

**User Interface**
E. ULTRAMAIN

Contact Information

Product Name: Ultramain

Company Name: Software Solutions Unlimited Inc
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Albuquerque NM 87109
Phone: 505.828.9000
E-mail: Info@ultramain.com
Website: www.ultramain.com

Software Solutions Unlimited Inc. (SSU) produces Ultramain, as well as Xponent® software products. SSU is a privately held corporation, founded in 1980 with sales, programming, training and technical support personnel.

- Price - Ultramain implementations can be subdivided into two main cost categories: 1) Software license fees, and 2) implementation services (and related expenses such as travel and per diems). Current Ultramain implementations range from $500,000 to $5,000,000. The ratio of implementation services to software license fees range from 1:1 to 3:1.
- System Requirements – Ultramain is also designed for operational versatility. Ultramain uses Client/Server architecture on all popular networks and standard hardware platforms. Its User Interface is engineered to operate under both Windows 95 or Windows NT clients. Its server functions seamlessly with Progress®, Oracle®, RDBMS, and ODBC compliant databases operating on IBM®, SUN®, Digital® (DEC), Hewlett- Packard® and Intel® based server platforms.
- Inventory – Ultramain has an inventory tracking functionality, however there is no evidence to the effectiveness of the inventory module.
- Support – Currently this product’s information for this area has not been determined.
- Ease of Use – Ultramain is a native 32 bit GUI application. The product was designed to be user friendly and screen shots are available on the following page.
- Work Orders – Ultramain supports customizable data entry on work orders. Additionally such customized data can trigger On Event or On Condition planned maintenance work orders. Ultramain’s work order functionality also supports priority tracking of approvals, signoffs and much more.
- Predictive Maintenance – Ultramain contains a number of trend analysis reports that are linked to Excel. Ultramain Downtime Analysis (UDA) helps evaluate the performance of maintenance personnel with regard to asset availability. UDA helps establish the operating schedules and monitor downtime. The system also allows reports on trends and patterns of failure.
- Scheduling – Ultramain offers short term or long term scheduling functionality. Ultramain Capacity Planning allows users to even establish "what if" scenarios and have Ultramain tell them what additional resources would be needed under each plan.

- History/Reports – Ultramain offers over 800 standard reports covering histories, to failure analysis to cost analysis. Each report offers applicable sort and selection options for users to choose from so they can report on just the data they desire and in a sort order they desire that makes sense for a respective report. These pre-set options make it very easy for users to pull the data they want from the system, provided a "standard report" exists. To add new standard reports customers can license the Xponent report writer, which is the tool we use to write all Ultramain reports.

- Web Capability – Currently Ultramain is a native client-server based application. It can and does operate over the web today using Citrix, however. Also, Ultramain is undergoing changes that will make it a native n-tier stateless web based application in an upcoming release, which will be available next year.
APPENDIX D

CONCEPTUAL DESIGN
(Prepared by Alex Linthicum, capstone team member)