**Predictive Maintenance Systems (Part 2)**

**Team Ostriches**

**Project Initiation Document**

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# 1. Introduction

## Document Purpose

The purpose of this document is to define the Predictive Maintenance Systems (Part 2) Project. This document clarifies the project objectives, background, deliverables, requirements, scope, constraints, risks and organisational structure. This document will also provide a clear understanding of the cost estimate, alongside the project control procedures. The detail in this document will supplement the management team and will be the foundation of success for this project’s software development life cycle.

## 1.2 Project Overview

### 1.2.1 Project Description

This project is an improvement on last semester’s Predictive Maintenance System by Team Clams and Team Elephants. In the previous semester, the two teams simultaneously and successfully created software to read in file data, analyze it, and generate an output to predict when maintenance is needed. The goal of this project utilizes the previous framework of the software, but adds the functionality of a “live” sensor data feed. This concept will use indicator tags that will be classified and matched with a classifier. The algorithm used within the project will then analyze the data over time and learn from the changing data. We can compare the data and the result thrown by each iteration and verify if the algorithm is working correctly to identify the degradation of the parts, The algorithm uses machine learning to determine whether the machine part is in optimal condition, deteriorating, or at a failed state.

### 1.2.2 Project Background

ASRC Federal Mission Solutions is a company that operates mission-critical systems that pulls together its resources and technological advancements to ensure a progressive future of business development. They are looking to expand into more public sectors such as cyber security, big data image/sensor fusion, user experience, and virtual/augmented reality. ASRC can accomplish their achievements with their ambition to create a foundation for a plethora of new business initiatives by implementing Condition Based Maintenance prototype for Hull Mechanical and Electrical systems. Condition Based Maintenance (CBM) appertains to a stragegorical complex maintenance strategy that monitors the conditions and indicates the performance of equipment. CMB has indicators inclusive to the maintenance strategy which determine whether or not the equipment is working to specific standards. The data used in CMB will indicate signs of failure, where the condition will be gathered in intervals with the equipment “internal sensors”. This system helps determine the timeframe in which maintenance of the equipment is recommended or required. CMB is supposed to decrease the repair, maintenance, and overtime costs as well as increase the reliability of the engineered parts. A smart sensor can potentially collect automated data from the physical environment of the machines in order to comprehend the data collected. This collected data is critical for the data analysis procedure. When the program learns how to interpret the machine parts changing their condition, the equipment could foresee future complications and inform the maintenance crew of needed repairs.

The usage of data analysis and smart sensors will allow for a predictive maintenance system to be constructed. Predictive maintenance can also include the improvement of performance, reduction of maintenance, and increased reliability. In the aspect of machines, such as those provided for war and industry, a machine failing would create detrimental problems. A major problem created for a poorly functioning machine would include the long term cost to handle the problem, as well as, the timeframe of repairing the issue and associated costs. The ramifications of these malfunctions depend on the severity of the costs could ascend to millions of dollars lost. The project that is presented will benefit ASRC to continue their research in testing systems for signs of failure with predictive maintenance, without allocating extensive amounts of resources.

# 2. Requirements And Scope

## 2.1 Project Scope Statement

The scope of the project includes defining a feature, splitting data into training/testing data, dividing targets into training/testing, determining what regression object to use, training that model with the training data, and making a prediction using the training set. The system must ingest incoming data, determine states, and predict maintenance on the fly. This technology could be used not only in the federal sector, but centered on residential or commercial products. An end user, such as the maintenance manager, is given a report on the upcoming timeframes for repairs of the equipment. In the future, another potential end user is a future developer who could modify the program to accept CBM data in alternative formats, and modify tolerances based on user selection.

## 2.2 Project Requirements

### 2.2.1 High-level Description

The project indicates a plethora of levels to obtain a completed product that ingests “live” data within the timeframe given for the project. When taking initiative for the first part, the project team accessed data from the Predictive Maintenance Systems project, which was started in the prior semester. During the first level of the project, the emphasis on planning this document was important to continue the rest of the research and development. This level elaborated the research of data analyses, especially when measuring the predictive maintenance on a machine. Next, the algorithms and tools must be created and utilized when designing a prototype for the project. This will be required in order to develop a program that can accurately read a “live” data set in order to determine a machine’s condition. A principal component analysis will be used to classify the data. Afterwards, the data will be compiled into features where the output could be viewed on a graphical user interface. With the “live” data analysis, the system would output maintenance suggestions of the engine systems. Therefore, the completed software will take the data and determine if the engine needs maintenance or not, as well as, improving its decision making algorithm.

### 2.2.2 Deliverables

Every group member is responsible for submitting one deliverable during this project.

The subsequent deliverables will by provided by the given group members as follows:

1. Project Initiation Document - John Stranahan
2. Requirements Document - Craig Wertz
3. Design Document - Nicholas La Sala
4. Validation Plan (including. Traceability Matrix) - Joshua Jackson
5. Test Plan (including Scripts) - Tapan Soni
6. Implementation Plan - Michael Matthews

# 3. Solution Concept

## 3.1 Proposed Solution

### 3.1.1 Description

The solution provided to our team had been based on an example of a predictive maintenance model by the ASRC. The requirements of maintenance are based in three classifications of maintenance as follows: there is no maintenance required, maintenance is required now, and maintenance will be required within a certain time frame. There needs to be further knowledge, researched by the product team, of the engines and the algorithm used on the system. This is recommended in cases where the algorithms output unreliable data analyses in the beginning stages. The product team has used a software to read in file data, analyze this data, and then generate an output to determine predictive maintenance needed on an engine. The code would essentially be used as a standalone code, and could be used outside of the MATLAB program. This cost effective model could potentially be used without a license to use it and on computers without MATLAB installed on them. The product team can use the previous framework of software from the last teams and add the exceptional method of “live” sensor data feed.

### 3.1.2 Dependencies

We will develop a testing suite using python scikit. The required dependencies to build the software versions are: Python >= 2.5, setuptools, NumPy >= 1.2, SciPy >= 0.7 and a working Java compiler. Using Python SciKit is not the only way to deliver a finished product there for clear documentation and comments will be used to ensure that the code could be easily translated to another machine learning implementation such as JavaML or Spark.

### 3.1.3 Constraints

Our solution needs to work within a list of constraints that have been set that include:

* Understanding the software framework from the prior product team in order to create an algorithm that could read the “live” data feed.
* Difficulty of relying on data based off of the original data
* Autonomously figure out the engine’s learning method in the case of the output of data being brought to failure
* Relying on the algorithm to understand “live” data and continuing the predictive maintenance learning
* A software output that is visible in a compatible web browser
* The semester long time timeframe given to the product team
* Efficiency of the engines and algorithms

### 3.1.4 Assumptions

There were a few assumptions that were concluded by the product team within the proposed solution. The starting assumptions that were hypothesized were that the data analyzed that came from the algorithm is accurate and that the product team assumes the data is degrading the system. When looking at the engine itself, the product team assumed what makes a part good or bad data that needs to be analyzed, as well as, the chronological data sets that needs to be determined and how to classify the data. The product team also assumed the amount of time between checks of the algorithm. Due to the fact that there will be a large data set from the software’s algorithm, the product team feels strongly that these assumptions are true. The only verification of these assumptions will come once the data analysis has been performed.

### 3.1.5 Risks

Risks of this project impacted onto the product team can be detrimental to the conclusion of the project scope statement. A risk the product team is taking is the unfamiliarity with machine learning. There is the risk of lack of knowledge from the previous system designed. The lack of knowledge from the prior product team’s project could affect the end data analysis. There also stands the risk of the machine itself learning improperly from a faulty algorithm and those learnings becoming worse as time goes on throughout the project. The unfamiliarity of machine learning may impact the final product and the efficiency of the work.

# 4. Initial Project Plan

## 4.1 High-level Sprint Goals and Specific Dates

The specific dates contained in each sprint and high-level milestones are listed below.

- Sprint 0 (1/29 – 2/12)

* + High-Level Milestone: Determine requirements and creating Product Backlog Items.
  + Specific Sprint 0 Dates:
  + 1/29 – Sprint 0 Planning
  + 2/12 – Sprint 0 Review
  + 2/12 – Sprint 0 Retrospective

- Sprint 1 (2/12 – 2/26)

* + High-Level Milestone: The pseudocode and outline should be finished for the machine learning and training algorithm.
  + Specific Sprint 1 Dates:
  + 2/12 – Sprint 1 Planning
  + 2/26 – Sprint 1 Review
  + 2/26 – Sprint 1 Retro

- Sprint 2 (2/26 – 3/19)

* + High-Level Milestone: Working with the pseudocode of the algorithm, we implement it and produce code.
  + Specific Sprint 2 Dates:
  + 2/26 – Sprint 2 Planning
  + 3/19 – Sprint 2 Review
  + 3/19 – Sprint 2 Retro

- Sprint 3 (3/19 – 4/2)

* + High-Level Milestone: Integrate/ test/ and visualize data.
  + Specific Sprint 3 Dates:
  + 3/19 – Sprint 3 Planning
  + 4/2 – Sprint 3 Review
  + 4/2 – Sprint 3 Retro

- Sprint 4 (4/2 – 4/16)

* + High-Level Milestone: Create a Functional UI/Driver.
  + Specific Sprint 4 Dates:
  + 4/2 – Sprint 4 Planning
  + 4/16 – Sprint 4 Review
  + 4/16 – Sprint 4 Retro

- Sprint 5 (4/16 – 4/30)

* + High-Level Milestone: Ensure program fully debugged/optimized. Design document to be submitted, and reflection of future work made.
  + Specific Sprint 5 Dates:
  + 4/16 – Sprint 5 Planning
  + 4/30 – Sprint 5 Review
  + 4/30 – Sprint 5 Retro

# 5. Project organization

## 5.1 Team Organization

Our team is organized with a student Product Owner who simulates the project’s key stakeholder. The Scrum Master is a facilitator for the Scrum Team. And the development team is responsible for the production of software.

* Product Owner – Craig Wert
* Scrum Master – John Stranahan
* Development Team – Joshua Jackson, Nicholas La Sala, Michael Matthews, Tapan Soni

The sponsor for this project is ASRC Federal Mission Solutions. Three contacts are provided for the sponsor for this project.

* Anuradha Bhat - General Support
* Rukan Shao - Project Lead
* Mike Berenato – Roadmap Oversight

The Scrum Team is designed for a sense of management when deciding on factors that relate to the completion of work. The Scrum Team’s Product Owner has responsibilities that include the backlog of items for the product, remains in contact with the sponsor about certain aspects of the technological side of the product, and suggesting the importance of items to other team members, however they cannot determine what the development team accomplishes. The development team is willing to hear any suggestions given by the product owner during each sprint. This concludes that the development team will perform the development of the program in detail and conclude what is brought upon during the sprints when there needs to be a set amount of work being completed. Finally, the Scrum Master manages the Trello board, as well as, facilitates the development teams activities throughout the timeframe given for the project. The Scrum master will consistently look for ways to advance the project in an efficient and time manageable pathway.

## 5.2 Communication Plan

Along with the required meetups, our development team has decided to code in pairs for certain tasks, as well as set up meetings around their class schedules. Every Friday the team meets before class at 11am to discuss the project and address any questions and concerns. This is on top of the following meetup times to gain an edge and ensure we are being as productive as possible.

The collaboration times are as follows:

1. Three 15-minute daily scrum meetings a week at the following times
   * + Monday 1:30 pm – 1:45 pm
     + Wednesday 1:30 pm – 1:45 pm
     + Friday 1:30 pm – 1:45 pm

2. Sprint Reviews at the end of each Sprint

3. Sprint Retrospectives at the end of each Sprint

4. Sprint Planning at the end of each Sprint and the beginning of the new Spring

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# 6. Project Cost And Benefit

## 6.1 Cost Analysis

There are a plethora of factors that are included in the cost of the project. The ASRC is responsible for the costs in which the sponsors spends throughout this project. This time span of about two hours every two weeks that the sponsor provides has included the engaged amount of time to frequent sprint reviews and stay in correspondence with the Product Owner on the development of the project. Not only where there be a sponsor that contributes to the cost, but also a software developer needs to be present for all the changes to the prototype. The cost for ASRC to obtain a software developer ranges from $73K-102K per year, depending on the range of experience a person has when applying for the position (1). Traveling from ASRC Mt Laurel to Rowan and back it is a total of 56 miles. The current average gas mileage for vehicles in the United States is 25.5 mpg (3). When factoring in the five trips to Rowan University to review the sprints it will take over ten to fifteen gallons of gas. The average gas price in New Jersey as of 2/9/18 is $2.43. In conclusion it will cost ASRC $24.2-$36.45 to reimburse a sponsor for travel expenses.

## 6.2 Benefit Analysis

ASRC is currently researching ways to equip a predictive maintenance system framework within the company. Since there is not a lot of data presented on this concept, it is hard to determine the benefit of the concept until the completion of the project. Even though there is a plethora of unknown factors, the early stages of the project indicate a larger return on investment. This becomes true when the product improves the predictability of engines on ships having malfunctions or failures. The prediction will eliminate man hours needed to revise the situation. One of the future benefits for ASRC is the expansion into their functionality within a predictive maintenance system.

A trial run with Caterpillar Inc. for their method of predictive maintenance system with their tug boats and shipping vessels had shown promising results (2). With the big data investment, the company was able to install shipboard sensors monitors within the equipment; generators, engines, GPS, air conditioning systems, and fuel meters (2). The data was used to obtain the greatest framework for operating systems. The savings acquired by Caterpillar Inc. had been estimated at minimum of $30 an hour, which generated a return on investment of about $650,000 in saving per year after including the fifty ships that operated daily (2). This investment of predictive maintenance systems could benefit a company for the future years to come, especially when there are combined saving of millions of dollars.

## 6.3 Cost Analysis Sources

1. Glassdoor listings of software developer jobs at ASRC

https://www.glassdoor.com/Jobs/ASRC-Federal-Holding-Company-Jobs-E132166.htm

1. The Forbes article online indicating IoT and Big Data at Caterpillar Inc.

<https://www.forbes.com/sites/bernardmarr/2017/02/07/iot-and-big-data-at-caterpillar-how-predictive-maintenance-saves-millions-of-dollars/#318b6e657240>

(3)<http://www.autonews.com/article/20150604/OEM05/150609925/average-u.s.-mpg-edges-up-to-25.5-in-may>

# 7. Implementation And Looking Ahead

## 7.1 Implementation

The project prototype from the product team is designed to implement a correct algorithm when predicting maintenance on systems. In no way is this prototype limited to the future growing on this project. ASRC will be provided with all documentation throughout the timeframe, as well as, for any future developments on the project. The production of the prototype will be readily accessible for implementation. This project is just a beta design for ships within the ASRC and all documentation and data will be provided for future assistance for improvements on the source code.

## 7.2 Future Improvements

Throughout the timeframe of this project, the project team will continuously be considering improvements on the product. A consideration to the data analysis would include actual live data feed sensors in real time rather than simulations. Another future improvement would include the making of further concentrated algorithm penetration that would become more specific. The specificity would include item down the value, motor, machine part, etc. Although there is some known decay apparent within the project, future developments will be able to controls factors such as temperature, pressure, and wear down. These conclusions for future improvements would benefit ASRC when they become advanced in their understanding of the product’s completion.