# Milestone 1 - Identify a Problem to Solve

Milestone 1 is where you begin working on your course project, a proposal for your own autonomous AI. Your goal is to: propose a use case, describe the value of the problem, and analyze the current system and its limitations.

You may use one of the case studies presented in the course as examples, but we strongly encourage you to be innovative and curious enough to create your own.

## 1 | Use Case Title: Chemical Reactor Tube Cleaning Assistant

## 2 | Use Case Overview *(<=100 words) Provide a brief description of the use case and the system that your autonomous AI will improve.*

A chemical company has a series of chemical reactors that need cleaned at a frequency. This cleaning involves a detailed but somewhat inflexible procedure. This reactor is brought to specific temperature ranges and chemicals are used to remove the foulant. It is a harsh process, both time and amount of chemical used effects the usable life of the coil. The amount and behavior of the foulant varies from cleaning to cleaning. Cleaning produces heat and reduces the amount to heat required to maintain box temperature. Experienced operators can improve the process, but it is not always easy to identify opportunities. AI would let an operator know when to move forward or stop the process in a more reliable way.

## 3 | Use Case Value *(<=100 words) Explain the value of improving the performance of this system.*

Reducing time and chemicals used could increase reactor tube life and increase total production.

## 4 | Current Methods *Select and explain the current methods used to control or optimize the system*

|  |  |  |
| --- | --- | --- |
|  | **Method** Check all that apply | **Description** |
|  | Human Operator / Engineer | Operator monitors the process for indications the procedure is being followed correctly. At the end of the procedure testing is done to show the procedure is complete. |
|  | Expert System | The expert system is the procedure which specifies the amount and time chemicals should be applied. This is where AI would help add flexibility. |
|  | Control Theory (PID, MPC) | Various temperatures and flows are controlled with control systems. |
|  | Optimization Techniques |  |
|  | Other |  |

## 5 | Limitations of current methods *Select and explain the limitations of current methods*

|  | **Limitation**  Check all that apply | **Description** |
| --- | --- | --- |
|  | Ability to control well across scenarios / conditions |  |
|  | Multiple or changing optimization goals |  |
|  | Human Operator /  Engineer Limitations  May include  · Difficulty managing many variables and dimensions  · Difficulty adapting to changing conditions  · Large performance discrepancy between novice and expert operators  · Inconsistency across expert operators | There are multiple variables that are indications that a tube is completed with cleaning, but they are difficult to discern because they may represent the interactions between multiple tubes.  There is inconsistency in that relatively clean tubes may take as long to clean with the procedure as dirtier coils. Experts have some leeway to improve but it is difficult because the procedure constrains it. |
|  | Uncertainty in the measurement of the inputs or the process make it difficult to control or optimize. | There are multiple coils. At the end of the cleaning cycle a manual measurement verifies the group of tubes are clean. |
|  | Time to develop control or optimization system is prohibitive |  |

**Milestone 1 – Ends Here**

The remainder of this worksheet (Part 2) can be completed after you have finished the “Learning the Solution” module (which includes course items 3.1 to 3.4).

# Milestone 2 - Identify Autonomous AI Components to Use

For this week’s milestone, we will continue working on the proposal for an autonomous AI that you began last week. This week, you will propose an autonomous AI solution, determine which of the components you’ve learned about the system will include, and explain the autonomous AI superpowers that your autonomous AI brain will exhibit.

*You may want to update Sections 1 & 2 with any new insights you’ve gained.*

## 6 | Autonomous AI Overview *(<=100 words) Provide a brief description of how your proposed autonomous AI would improve the process.*

In a chemical process, a reactor’s tubes must be cleaned at a frequency. Tubes may not have the same amount of fouling. This complicated cleaning process involves several steps where the cleaning chemicals are increased at a set time frequency. The chemical cleaning process damages the equipment over time. Operators can modify this depending on process readings combined with skill and experience. Operators also use process measurements to ensure that cleaning is complete.

Autonomous AI could help minimize the time and amount of cleaning chemicals required either through making suggestions to operators or online control.

## 7 | Optimization Goal *List and describe the key performance indicators that will define control/optimization of the system (Example: maximize (throughput)*

The key performance indicators are to minimize time and chemicals used (subject to constraints).

## 8 | Autonomous AI Components *Select and explain the automation methods your AI will use.*

|  | **Method**  Check all that apply | **Description** |
| --- | --- | --- |
|  | Math (control systems) | The background control systems will still likely remain in place for some parts of the system. |
|  | Menus (optimization) |  |
|  | Manuals  (expert rules and systems) | Process limits and constraints may be required for safety. |
|  | Machine learning | How the cleaning chemicals react with the foulant change from run to run. It will be important to incorporate this into the model – and learn from movements. |
|  | Deep reinforcement learning | There is a large amount of data for previous cleaning operations. This data along with general engineering mathematics can build a simulation model (with machine learning). This simulation along with the expert constraints from the procedure can be used to build a DRL model which optimizes on the cost function of proper cleaning + Time + Cleaning chemicals used. |

## 9 | Autonomous AI Superpowers *Select the superpowers that your autonomous AI brain will exhibit and explain how they will lead to an improvement in the process.*

|  | **Superpower**  Check all that apply | **Description** |
| --- | --- | --- |
|  | Makes human-like decisions | Decides when a tube is clean and when to stop applying chemicals. It analyzes the reactor variables to separate out which tubes are still adding heat indicating and the rate of heat addition. It adjusts cleaning parameters accordingly. |
|  | Perceives, then acts | Stops or modifies process to optimize the process. |
|  | Learns and adapts | Understands how the foulant is reacting, the current status and change with this information. |
|  | Spots patterns |  |
|  | Infers from experience | Statistical model of previous cleanings to understand what is likely response. It uses moves to understand the status of the system (current state) and uses the RL controller to make recommendations for actions based on this current state. |
|  | Improvises and strategizes |  |