MICHIGAN STATE UNIVERSITY

Project Plan

Continuous Improvement of Boeing Assembly Lines

The Capstone Experience

Team Boeing

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From Students…
…to Professionals

Project Overview

- Create a 3D simulation of a Boeing assembly line.
- Compile important data about the construction process.
- Use this data to optimize the design of the assembly line, improving safety and efficiency.

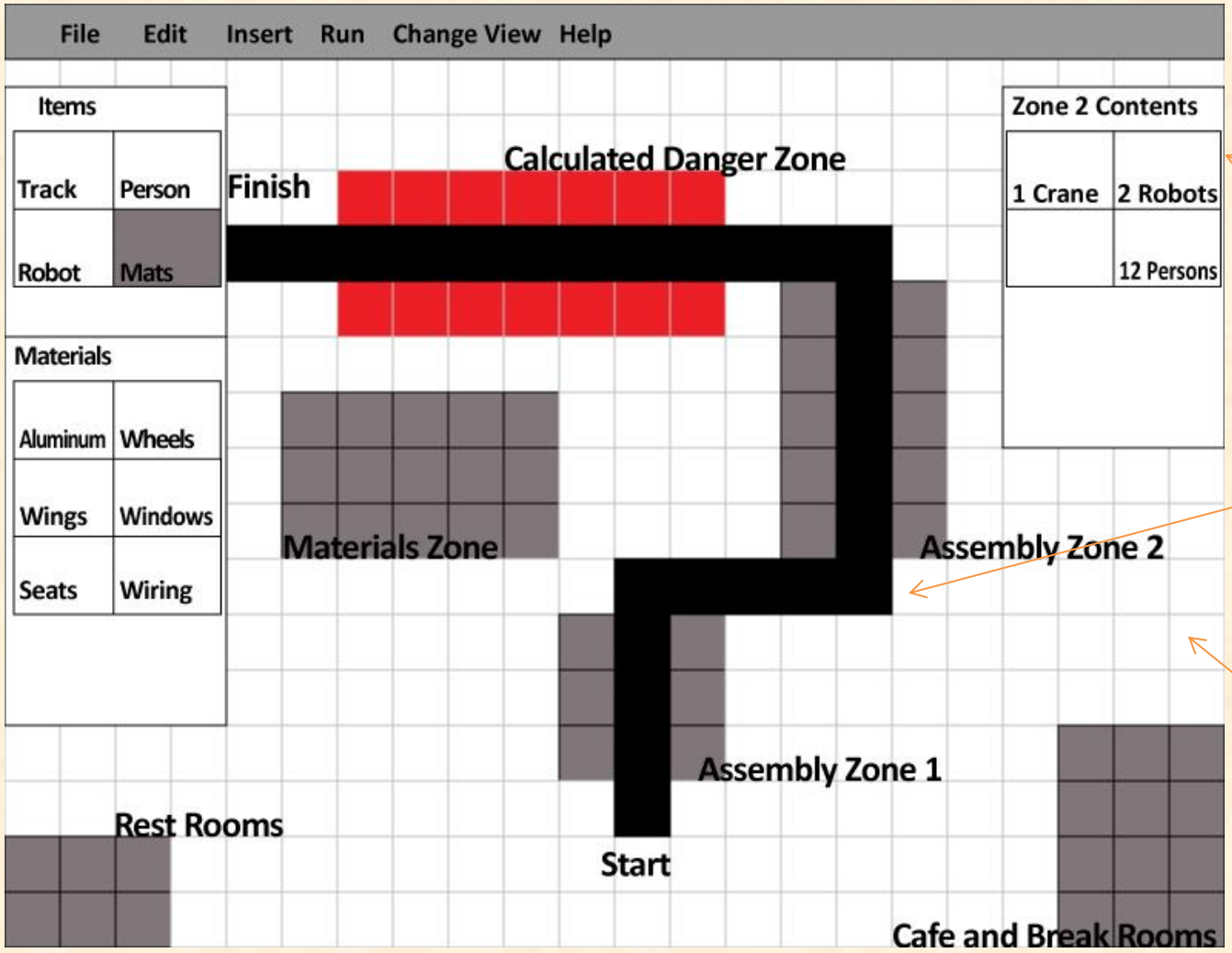
Functional Specifications

- Simulate and monitor a Boeing assembly line
  - Teams of people and robots working together
  - Multiple levels of construction
    - Beneath, above, and inside the aircraft
- Simulate realistic limitations of the workers
  - Limited sight distance
  - Limited hearing distance
  - Fatigue
  - Breaks / idle time
  - Walking distances
  - Etc…
- Must analyze the simulation metrics to identify:
  - Safety concerns
    - Dangerous situations for workers
    - Time spent in dangerous situations
  - Assembly line efficiency
    - Overall Idle time of assembly zones
    - Idle time of individuals and robots

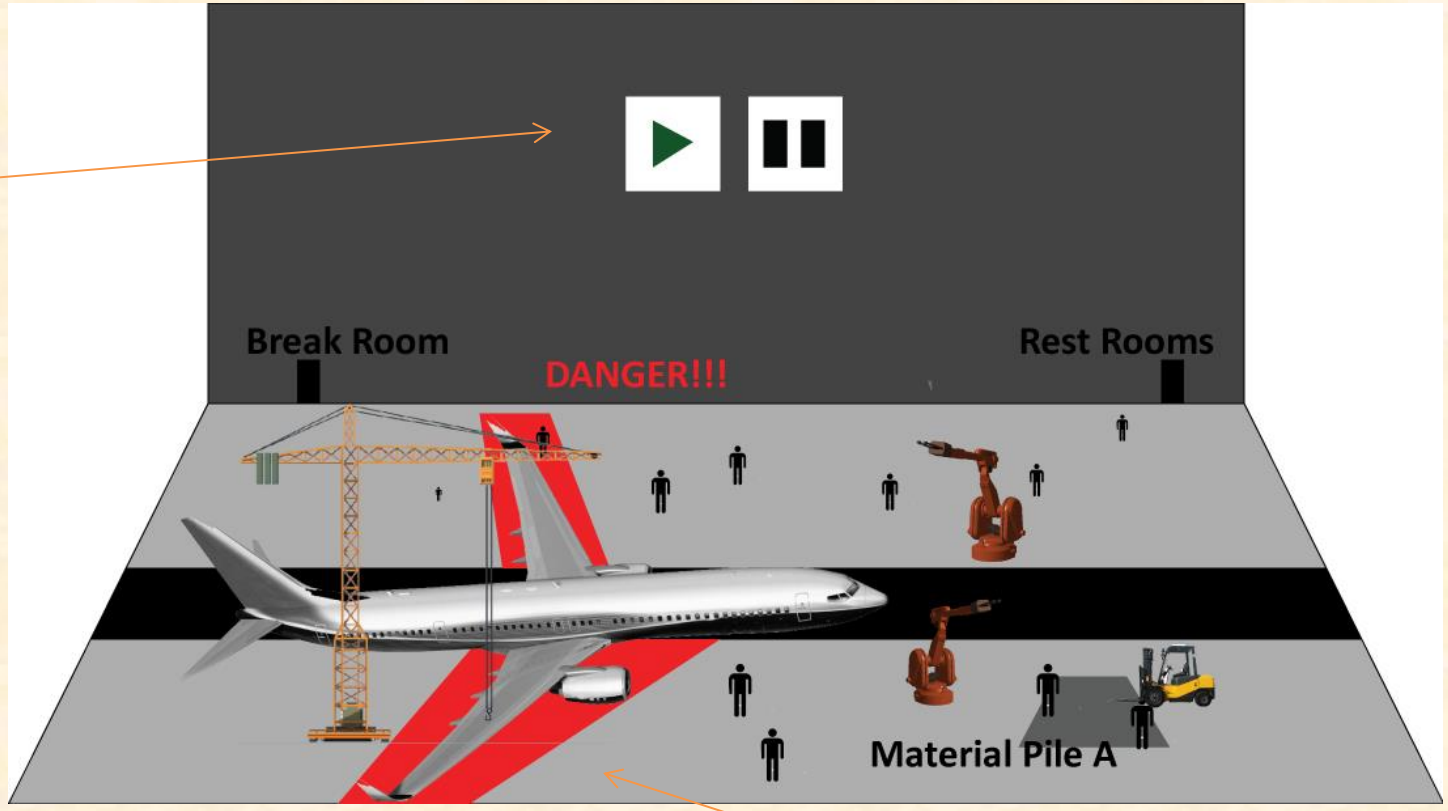
Design Specifications

- 3D Graphical Visualization
  - Top-Down View
    - Must include:
      - ❖ Grid based system for placing the various modules and zones that will make up the assembly line
      - ❖ GUI for selecting and placing the various modules
  - Free-Range Third Person View
    - Must include:
      - ❖ Dynamic information display based on current location along the assembly line.
        - » Current percentage of work completed
        - » Safety concerns
  - Free-Range First Person View
    - Same requirements as the third person view but from a higher perspective
- Quality metrics
  - Must be used to analyze safety and efficiency
  - Must identify specific points of danger in the line

Screen Mockup: Construction View

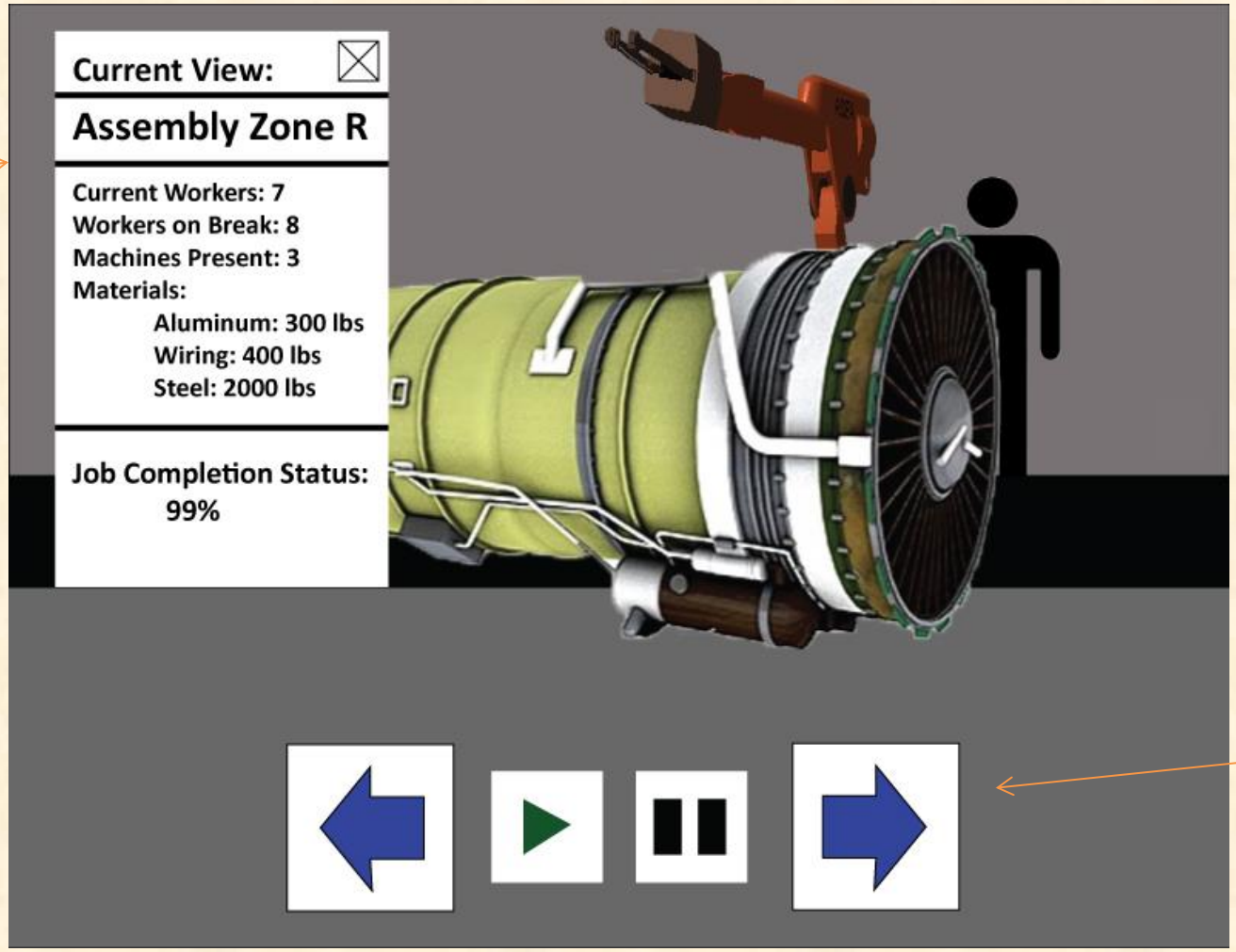


Screen Mockup: Third Person View



Screen Mockup: First Person View

Zone Contents and Job Completion Menu



Simulation Controls

Screen Mockup: Metrics Breakdown

Simulation Metrics

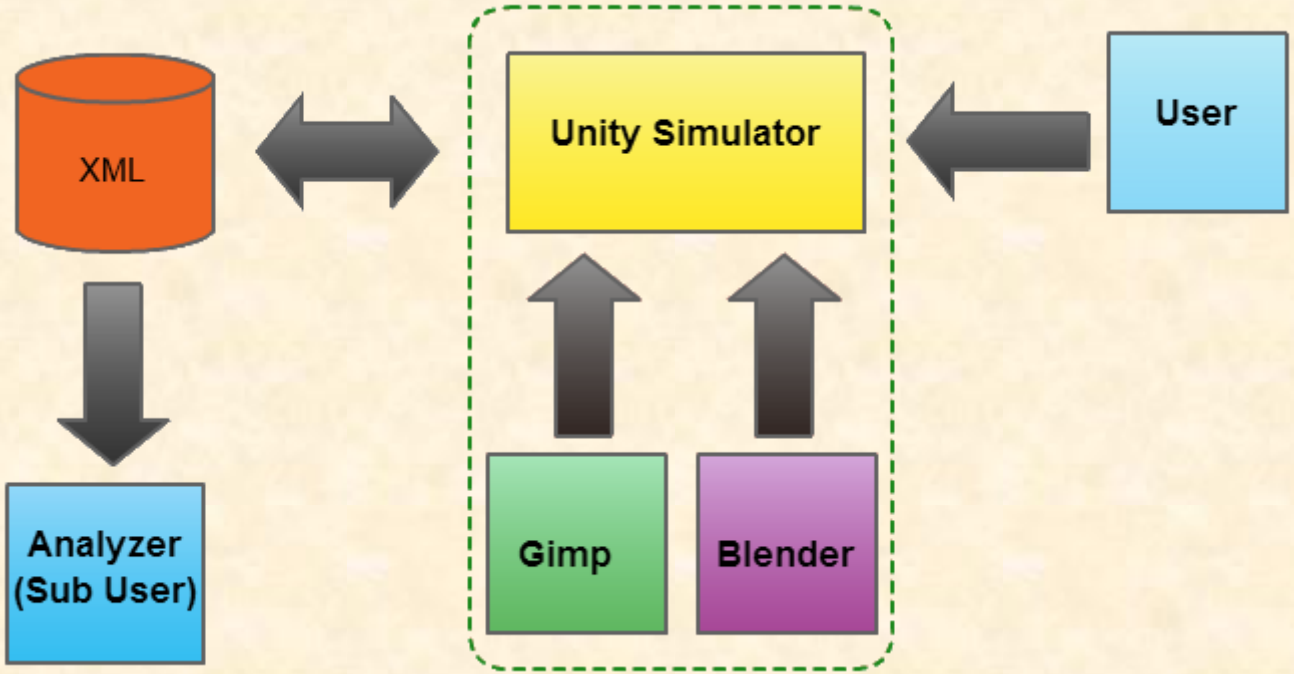
Technical Specifications

- Software Technologies
  - Unity
  - Blender
  - Microsoft Visual Studio 2012
- Development Tools and Methodologies
  - C#
  - XML
  - SQL
  - Test Driven Development
  - Code Reviews
  - Inverse Kinematic Algorithms

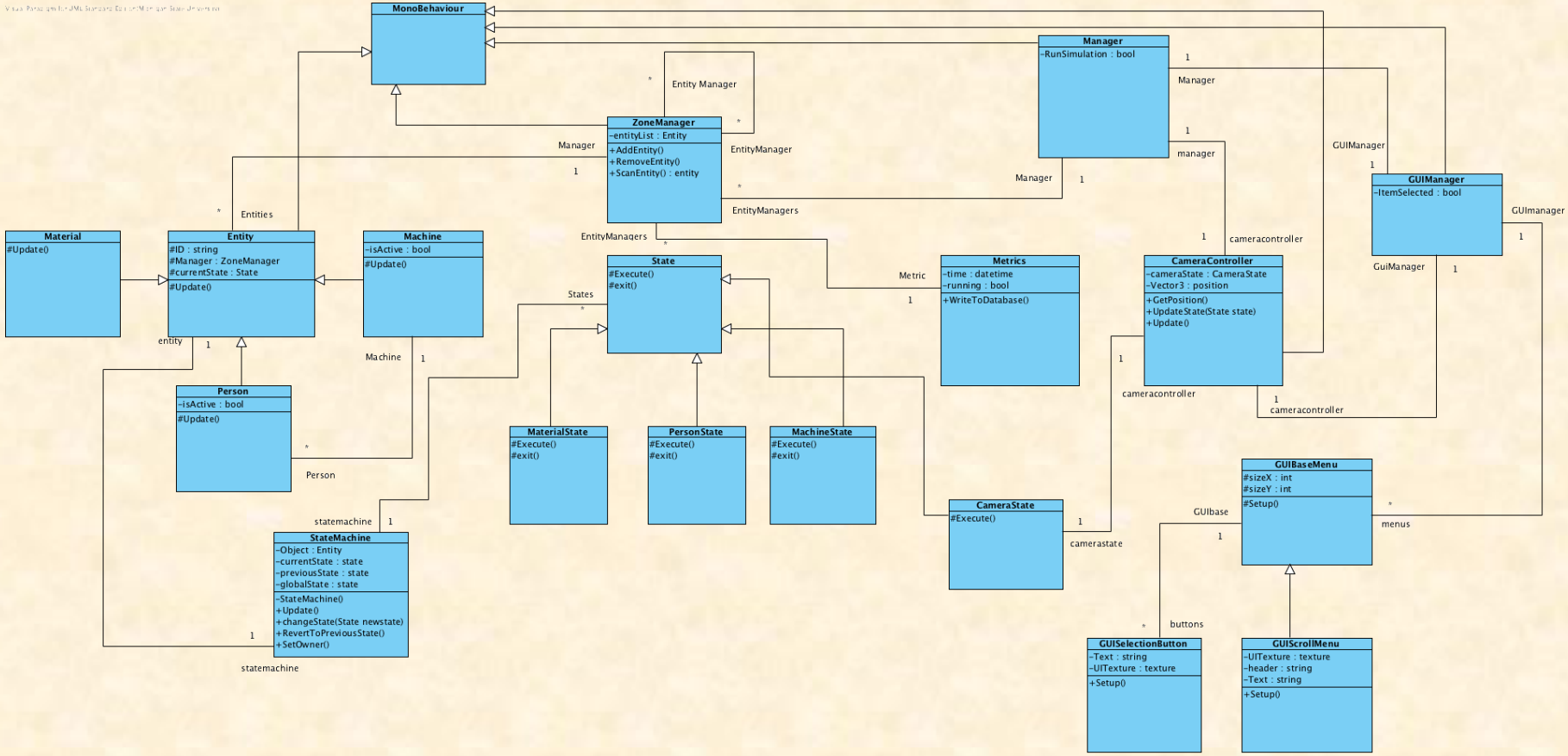
Technical Specifications – continued

- Schedule:
  - 8/27 – 9/15
    - Initial Setup
    - Initial Research
    - Initial Documentation
  - 9/16 – 9/22
    - Prototyping
    - Specifically Research Assembly Lines
    - Implement Initial Project Layout (skeleton)
  - 9/23 – 10/14
    - Development/Testing
    - Alpha
  - 10/15 – 11/11
    - Development/Testing
    - Beta
  - 11/12 – 12/2
    - Development/Testing
    - Release
  - 12/6
    - Design Day

System Architecture



UML Diagram


MonoBehaviour
Manager
-RunSimulation : bool
Entity Manager
ZoneManager
-entityList : Entity
+AddEntity()
+RemoveEntity()
+ScanEntity() : entity
Manager
EntityManager
EntityManagers
GUIManager
-ItemSelected : bool
GuiManager
GUImanager
Material
#Update()
Entity
#ID : string
#Manager : ZoneManager
#currentState : State
#Update()
Entities
Machine
-isActive : bool
#Update()
State
#Execute()
#exit()
States
Metric
Metrics
-time : datetime
-running : bool
+WriteToDatabase()
CameraController
-cameraState : CameraState
-Vector3 : position
+GetPosition()
+UpdateState(State state)
+Update()
cameracontroller
entity
Machine
Person
-isActive : bool
#Update()
MaterialState
#Execute()
#exit()
PersonState
#Execute()
#exit()
MachineState
#Execute()
#exit()
CameraState
#Execute()
camerastate
statemachine
StateMachine
-Object : Entity
-currentState : state
-previousState : state
-globalState : state
-StateMachine()
+Update()
+changeState(State newstate)
+RevertToPreviousState()
+SetOwner()
GUIBaseMenu
#sizeX : int
#sizeY : int
#Setup()
GUIbase
menus
buttons
GUISelectionButton
-Text : string
-UITexture : texture
+Setup()
GUIScrollMenu
-UITexture : texture
-header : string
-Text : string
+Setup()

UML Diagram – continued

- The Zone Manager has many entities within it, each with their own State Machine
- The Manager of the program has many Zone Managers and allows for communication between them
- Entities are divided into three derived classes, person, material, and machine
- The Camera Controller class will be in charge of handling input for movement and will contain an instance of the GUI manager class

System Components

- Hardware Platforms
  - PC
- Software Platforms / Technologies
  - Windows
    - Unity
  - Mac
    - Unity
    - Blender

Testing

- Nunit
  - Testing framework for C#
- Uunit
  - Testing framework for Unity
- Test Driven Development
  - Red – Green – Refactor

Testing: Red – Green – Refactor

- Red
  - Write a test case so that it fails (the functionality is not yet implemented)
- Green
  - Write the code so that the test case passes
- Refactor
  - Clean up redundant and spaghetti string code

Risks

- Purchasing of Unity License
  - We will require access to Unity Pro, which will require the purchase of a license after 30 days.
  - $129 license available through http://www.studica.com/unity
- Familiarity with the concept of Inverse Kinematics
  - Wikipedia: **Inverse kinematics** refers to the use of the kinematics equations of a robot to determine the joint parameters that provide a desired position of the end-effector.
  - Become more familiar with the concept of inverse kinematics.
- Knowing which metrics to measure
  - There are hundreds, possibly even thousands of factors that go into measuring safety and efficiency on an assembly line
  - Speak with Jayson, and decipher which metrics are the most relevant, and which aren't
- GUI for Unity
  - We are trying to use Unity, a game developing tool, to create a useful simulation "game", however limitations with unity's built-in UI functionality will force alternate approaches to be considered.
  - Figure out if it's possible, and if it's not, change our approach