# Virtual Reality for Prototyping Factory Processes

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Abstract

In many instances, it can be very costly and time consuming to train new workers in factory environments. Training consumes factory resources and valuable time that could otherwise be used to produce new goods. With the advent of virtual reality, it is now possible to create artificial factory environments where new workers can be trained without wasting valuable resources and factory time.

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## 1. Background

### *1.1. The Problem*

Modular home manufacturers build houses inside factories rather than at the site of the property. These factories are set up as assembly lines of multiple stations, each of which is responsible for different parts of the manufacturing process–one might build the floor, another may add plumbing. Companies making these modular homes want to optimize the design of their factories to make these assembly lines as efficient as possible. They are also increasingly looking for ways to automate parts of the manufacturing process.

As it stands today, experimenting with factory design and automation is an expensive and uncertain business endeavor for these modular home companies because there is the added cost of training existing workers to work alongside those changes. Thus, modular home manufacturers need a more cost-efficient method to help workers adapt. To that end, manufacturers are interested in adopting virtual reality to train workers in station activities and tasks so that employees can adapt to factory design and process changes with minimal impact on productivity. Without changing their actual facilities, these companies want to create interactive, virtual environments that mimic the layout of real factories and the processes that occur along an assembly line.

### *1.2. Project Partner*

The partner for this project is Joseph Louis, an assistant professor in the School of Civil and Construction engineering in the College of Engineering at Oregon State University. He is doing research to improve the productivity of modular construction factories through the use of virtual reality.

### *1.3. Stakeholders*

A modular construction factory in North Carolina serves as the test bed to validate the project partner's research. All of the virtual reality models created in this project are based on the actual design and processes of this factory. The company will use the virtual reality program created by this project to aid in the development and optimization of their real factories.

The primary users of this project will be employees of the company. These include designers and engineers tasked with creating and optimizing the company's factories. They will use the virtual reality tool to implement factory changes inside a virtual environment. Employees working on the factory floor will use that environment for training, in order to adapt to those changes.

Other stakeholders for the project are the capstone team members Jason Chen, Zachery Thompson, and Nathaniel Mohr. They will be responsible for developing the virtual reality environment and some of the 3D models that will be used.

## 2. Vision

A simulated factory will allow modular home manufacturers to train employees with minimal disruption to their assembly lines. The virtual environment is designed to mimic their factories' design and processes, so workers can quickly adapt to changes in real-world facilities without reducing productivity.
Training employees in a virtual reality that mirrors the factories they work in will reduce potential expenses from workers making mistakes on the actual factory floor.

Once the problem is solved, the cost of modeling changes to and redesigning modular home factories will be significantly reduced as virtual reality allows experimentation without making costly changes to real-world facilities. Additionally, the speed of experimentation will increase because all assets in the virtual environment can be quickly created on a computer, requiring no physical materials to change the factory. The combined cost and speed benefits mean design teams can quickly iterate on factory changes with little expense.

### *2.1 Central Hypotheses*

*2.1.1 Growth Hypothesis*
With increasing automation taking place, modular home manufacturers will seek additional ways to automate the processes in their factories. These companies will look for solutions that are inexpensive and effective. The virtual reality approach to designing factories and training workers is a solution that will appeal to them because it is largely risk-free, does not require a lot of upfront investment, and allows them to very accurately mimic their real-world factories.

*2.1.2 Value Hypothesis*
By encapsulating the factory in virtual reality, companies can take advantage of a virtual training tool to save money and time. If there are changes to factory processes, or if a company hires a new employee, then the employee(s) can be trained on the virtual assembly line. This virtual factory tool eliminates the need for a veteran employee to dedicate their time to training new workers, reducing the company's labor costs. The tool would also allow the factory to function as normal while employees train in the simulated environment.

### *2.2 High-Level Requirements*

*2.2.1 Functional Requirements*
Some of the functional requirements for the project are listed below.

1. Users should be able to move around the factory.
2. Users should be able to interact with tools and materials.
3. Users should be able to follow on screen instructions to complete a task.
4. Stretch Goal: AI should be able to assist the user in completing tasks.

*2.2.2 Non-Functional Requirements*
Some of the non-functional requirements for the project are listed below.

1. The virtual reality environment needs to be built using the Unity game engine.
2. The virtual reality program needs to be developed using a headset-agnostic tool, such as SteamVR.
3. The virtual reality program must be compatible with HTC Vive Pro headset and controllers.

## 3. Prioritized Project Constraints

### *3.1 Time*
The entire project needs to be completed before the expo at the end of the year. The group has allotted two times during the week for stand up meetings as well as a longer time frame to get together once a week and work on the project together. We will work in sprints to ensure we are making consistent progress on the project. Time is the main constraint on the project.

### *3.2 Resources*
As this project deals with creating an interactive environment in virtual reality, we will need a virtual reality headset in order to see that our environment is working properly. Our project partner has a headset that will be available for one of us to have during the duration of the project for the purpose of testing the environment. Most of the 3D modeling has also been provided to us.

### *3.3 Scope*
Our scope will mostly be restricted by the time allowed for the project. Other restrictions to our scope come from the models that we have available to us. The models we are using come from a specific factory, so we would only be able to implement parts of the factory that we already have the models for.

**4. Scope**

### *4.1 Process Flows*

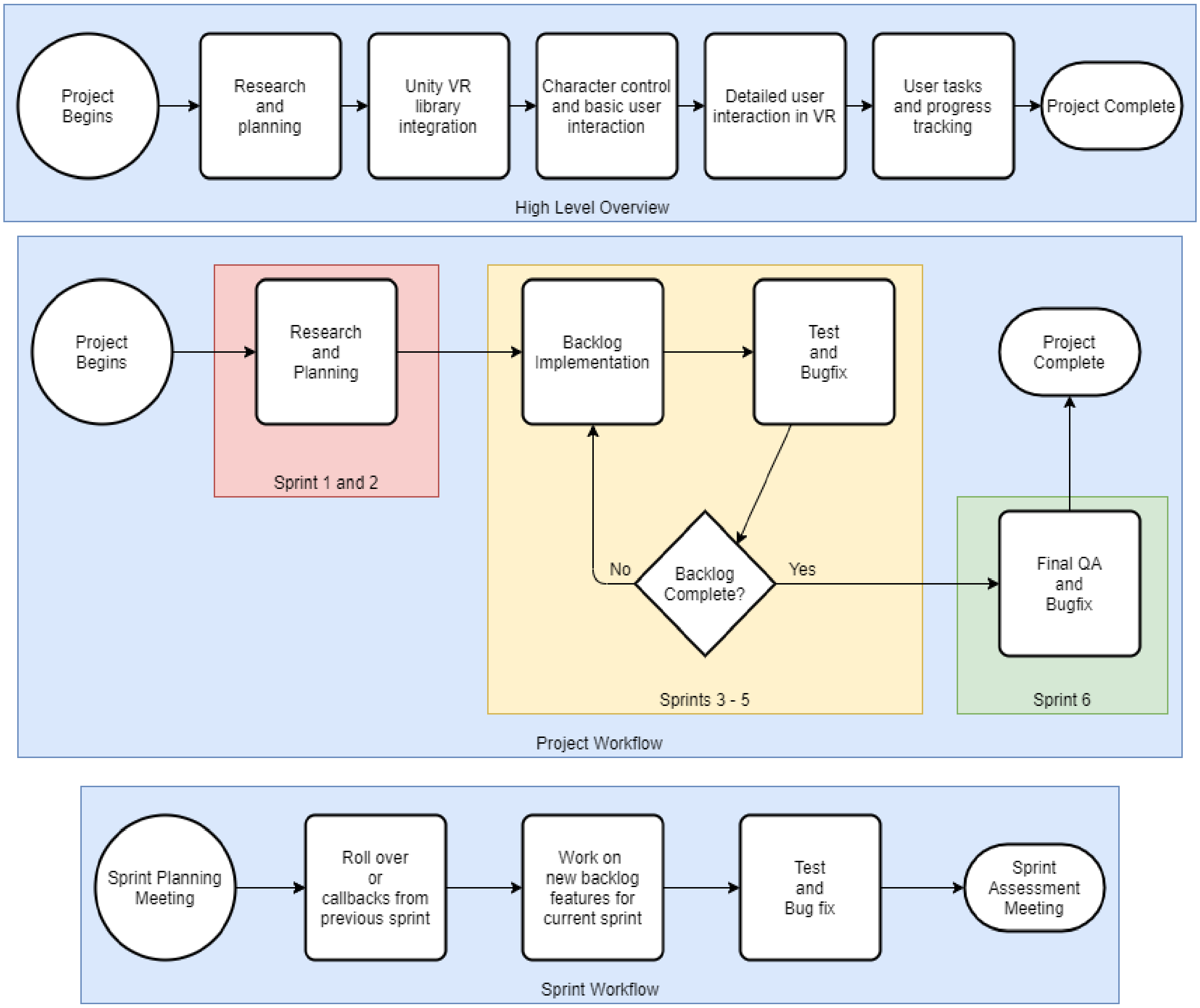


Figure 1. Overall project workflow and high level sprint overview.

### *4.2 User Stories*

1. As a user, I need to be able to move around in VR so that I can move between tasks.
2. As a user, I need to be able to interact with virtual objects so that I can work on an assigned task.
3. As a user, I need to be able to pick up/put down different tools so that I can perform different aspects of assigned tasks.
4. As a user, I need to be able to track my progress on tasks so I can learn the task.

**5. Iteration Plan and Estimate**

All work for this project will happen in 6 distinct sprints. Each sprint will last 3 weeks and cover specific aspects of the project. Each sprint will begin with a planning meeting to assess any outstanding work not completed in the previous sprint and to determine which items in the backlog are critical to the sprint. At the end of each sprint will be a retrospective meeting that highlights what work was done and what work still needs to be done. The retrospective meetings will help prepare for the next sprint and allow us to determine if we need to change or adapt the current iteration plan.

Sprint 1 (Oct 26 - Nov 13): Sprint 1 covers familiarization with the project and pre-planning. This sprint will consist primarily of communication between us and the project partner to determine high level goals and expectations. This sprint will also give us time to familiarize ourselves with the tools necessary to complete the project.

Sprint 2 (Nov 16 - Dec 6): Sprint 2 will cover the initial research and planning for the project. Research will be done on what VR library to use and how to integrate it into Unity for use in this project. Other research will be done to determine what other libraries or external tools may be necessary. In this sprint the initial backlog will be groomed and prepared for development in the following sprints.

Winter Break (Dec 7 - Jan 3): As of this time we will not be working over winter break, and this time period is reserved for personal life.

Sprint 3 (Jan 4 - Jan 24): Sprint 3 will cover development of the building blocks and low level foundations of the project. This sprint will cover VR integration with existing project files and low level character control and interaction in a VR environment. This sprint will cover any backlog items that are essential to later development to provide the building blocks for the rest of the project.

Sprint 4 (Jan 25 - Feb 14): Sprint 4 will begin to use the building blocks created in Sprint 3 to build intermediate functionality described in the back log. This sprint will enable the user to begin interacting with the simulation in VR and with the environment as well. At the beginning of this sprint any items left over from Sprint 3 will be assessed. Critical items will be carried over into this sprint, and we will decide if any non-critical items should be dropped from the backlog.

Sprint 5 (Feb 15 - Mar 7): Sprint 5 will cover structured interaction between the user and the simulation. This sprint will tackle direction intervention by the user and allow the user to progress the simulation by their interactions. This will be the last development sprint and all critical backlog items should be completed by the end of the sprint.

Sprint 6 (Mar 8 - Mar 28): Sprint 6 will be the final sprint and consist primarily of testing and quality assurance. During this sprint any existing bugs and defects will be corrected and the project will be thoroughly tested for the presence of any unknown bugs or defects. At this stage all major systems should be in place, and no major changes should occur.

## 6. Report of Alpha Functionality

### *6.1 Jason Chen*

*6.1.1 Bio*
Jason is a computer science student in the systems option. His primary interests are in DevOps, Linux systems administration, and infrastructure engineering. He currently works as an engineer for a consulting firm, helping clients design and build out their cloud infrastructure.

*6.1.2 Work Description*
Jason worked on the initial integration of VR into the virtual factory Unity project provided by the team's project partner. He added SteamVR to the project and made the virtual factory environment viewable on an HTC Vive Pro headset. He also did the initial work to map actions inside the virtual environment to the headset's controllers using SteamVR. In addition, he has worked on adding support for more object interactions, specifically for picking up and moving materials (like floor boards) around a workstation using a controller.

### *6.2 Nathaniel Mohr*

*6.2.1 Bio*
Nathaniel is a Computer Science student with a focus in graphics and simulations and a minor in Mathematics. He is interested in data science and will be starting an internship with Washington County/Clean Water Services beginning in June 2021.

*6.2.2 Work Description*
Nathaniel was responsible for obtaining the virtual reality headset for which the project is being tested on. He incorporated an updated Unity project with enhanced models and scripts into the project repository. Nathaniel has been responsible for the creation, formatting and development of documentation for the project. He has kept a steady backlog of meetings and project requirements in order to keep track of project scope and development.

### *6.3 Zachery Thompson*

*6.3.1 Bio*
Zach is a Computer Science student studying simulation and game programming. He has a passion for working on games and hopes to find a job as a game engine engineer.

*6.3.2 Work Description*
Zach was responsible for getting minor VR interactions working on top of the Steam VR integration. He created the interactable nail gun that was shown in the demo video which will become a building block for the rest of the VR project. He also implemented basic VR movement so that the user can move around the factory.