



# Real-time Weather Rendering System

## Requirement specification

### **BSc Thesis**

The goal of this thesis is to research and implement a real-time, procedural, weather rendering system. The following document reveals the process of creating such a system from both a technical and mathematical perspective, considering different algorithms for techniques like noise generation and raymarching.

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Specialization:	Computer perception and virtual reality
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# 1 General

## 1.1 Purpose

This document serves the purpose of defining and clarifying the goals, which the thesis 'Realtime Weather Rendering System' is supposed to achieve. Furthermore, the requirement specification allows for a more accurate evaluation of the achievement of objectives and of the result itself.

## 1.2 Revision History

Version	Date	Name	Comment
0.1	February 27, 2021	Matthias Thomann	Initial draft
0.2	March 03, 2021	Matthias Thomann	Updated project schedule

## 2 Scope of Work

### 2.1 Initial Situation

TODO: With shaders making up a large part of visual effects in games and in game development generally, they have become more and more important throughout the years. Due to their high flexibility, it is possible to create a wide variation of implementations as well as cheap alternatives to otherwise highly complex and computationally demanding simulations, such as simulating water, fire or clouds.

This project specifically focuses on clouds. But to achieve a realistic look and feel of the clouds, certain methods and knowledge are required. The motivation for this project is to implement such a shader, based on information gathered during the given period.

### 2.2 Goals

TODO: The primary goal of the project is to research and document rendering techniques for real-time procedural cloud shaders. Additionally, one or more prototypes are to be implemented based on the newly discovered knowledge.

#### 2.2.1 Mandatory Goals

TODO: The following tasks must be accomplished during the project:

- Understanding of the basic nature of clouds
- Understanding of what makes good clouds in games
- Research common methods and algorithms involved in rendering procedural clouds, including...
  - volumetric rendering
  - procedural noise generation algorithms
  - the concept of ray marching

#### 2.2.2 Optional Goals

TODO: For further optional research, these tasks can be looked into:

- Light scattering illumination and sub-surface scattering
- Performance optimization
- Simulation of gas

## 2.3 Vision

TODO: This section defines a high-level vision for future work involving the results and prototypes of this project.

As described in section 3, several prototypes about different rendering techniques will be created. By combining these outcomes and with the backing of all research findings, the implementation of a complete cloud system could be achieved. The desired outcome ideally looks similar to the image depicted in Figure 1. A rendered version of such a cloud system can look elusively realistic compared to an actual photograph, like in Figure 2.



**Figure 1:** A rendered image of volumetric clouds [1].



**Figure 2:** A photographic reference of clouds [2].

The first thought about the practical use of a fully-fledged volumetric cloud system might be a video game, since clouds are often a significant part of outdoor scenery in games. However, for this project it is intended that the knowledge and prototypes acquired during the given period will be used to recreate a lifelike weather system instead.

To accurately reflect a weather system, conditions like precipitation, wind and cloudiness should be considered.

## 2.4 Educational Objectives

Educational objectives include shader programming, rendering techniques, common algorithms used in computer graphics, a general understanding about the role of clouds in games and other topics.

## 2.5 Used Software and Tools

All documentation will be written in LaTeX with Visual Studio Code. The shader will be implemented in Unity. The chosen shader language is High Level Shading Language (HLSL). For the presentation, Microsoft PowerPoint will be used.

### 3 Requirements

All requirements are grouped by type. This results in two major groups, which are research and development requirements. Each one of the requirements is derived from a goal listed in subsection 2.2.

#### 3.1 Research requirements

<b>Number</b>	R.1
<b>Name</b>	Understanding of the basic nature of clouds
<b>Description</b>	In order to be able to recreate a realistically looking cloud shape, one has to examine and understand the way a cloud is formed first. This includes the color, density, shape as well other characteristics of clouds.

<b>Number</b>	R.2
<b>Name</b>	Understanding of what makes good clouds in games
<b>Description</b>	Just as for real world clouds, clouds in games must also be examined. This will lead to a clear perception of what is important when rendering clouds in a simulated environment, opposed to the real world example.

<b>Number</b>	R.3
<b>Name</b>	Research common methods and algorithms involved in rendering procedural clouds
<b>Description</b>	<p>It is required to research and keep records of widely-used and popular approaches for rendering clouds. Those methods and algorithms are to be compared and evaluated.</p> <p>They include at least the following topics:</p> <ul style="list-style-type: none"><li>• volumetric rendering</li><li>• procedural noise generation algorithms</li><li>• the concept of ray marching</li></ul>

### 3.2 Development requirements

<b>Number</b>	D.1
<b>Name</b>	Implementing a prototype about volumetric rendering
<b>Description</b>	To fully comprehend volumetric rendering, it is best to implement a prototype, showcasing how this rendering technique works and how it is built.

<b>Number</b>	D.2
<b>Name</b>	Implementing a prototype about noise generation
<b>Description</b>	It is necessary to understand procedural noise generation in order to achieve "natural randomness" as it appears in nature. That is why a prototype must be built from commonly used noise algorithms.

<b>Number</b>	D.3
<b>Name</b>	Implementing a prototype about ray marching
<b>Description</b>	In shader programming, ray marching is a key technique to determine the surface distance of very complex objects, like a cloud. Thus, to see what ray marching is all about, a prototype must be built.

<b>Number</b>	D.4
<b>Name</b>	Evaluation of suitable parameters for a cloud shader
<b>Description</b>	When creating a shader, some parameters should be made public, so the user can influence the outcome of the shader by only tweaking certain variables. The goal is to find out which parameters are the most influential on the output of the shader.

## 4 Testing

### 4.1 Testing of Prototypes

The project will be implemented and tested in Unity. For testing, the following test cases can be used to verify and evaluate the implementation.

Case	Test case	Expected result
1	Working code	The shader code contains a vertex function as well as a fragment function and compiles successfully.
2	Shaded outcome	The rendered image corresponds with the outcome of the related prototype as described in subsection 3.2.
3	Visual comparison	The final rendered output should, to some extent, look similar to a photographic reference image, as seen in Figure 2. For comparison, photographs taken from installed Round-shot systems can be used.
3	Performance	The shader code should run with good performance and should not show visible stutters or frame drops.

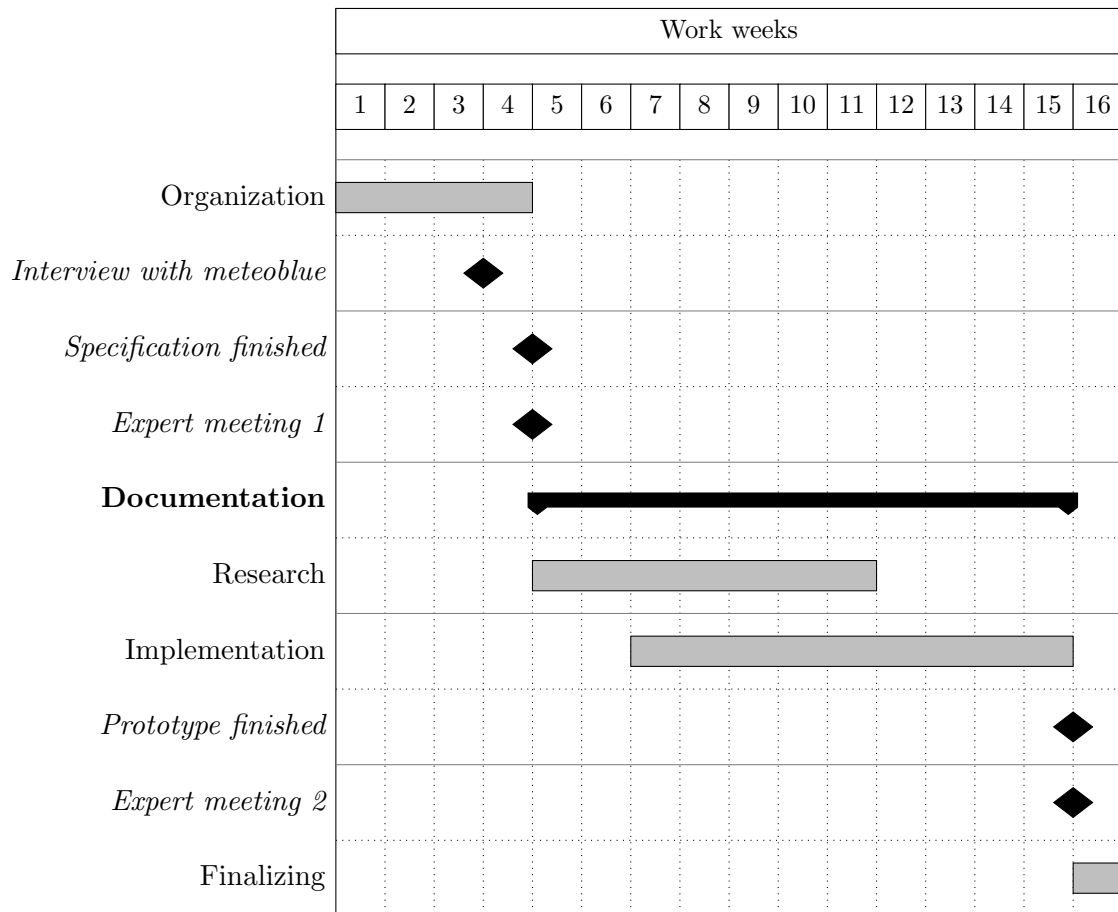


## 5 Project management

### 5.1 Schedule

The time frame of the semester spans over exactly 16 weeks. Being worth 12 ECTS points, this project assumes a maximum work load of 22.5 hours per week, resulting in a total of 360 hours.

Over the course of the term, the project will be split into four primary task groups, namely organization, research, implementation and finalization. Put into relation with the duration of the project, the estimated schedule looks like this:



For each task group, the following distribution of time and effort is estimated:

Task group	Predicted effort
Organization	10%
Research	35%
Implementation	50%
Finalizing	5%

### 5.1.1 Organization

The first task group focuses on creating and finishing the project specification. This includes an technical interview with *meteoblue* as well as the first meeting with the examination expert, Dr. Eric Dubuis. The interview with the firm *meteoblue* will be scheduled during the first couple of weeks, and held at the latest in the third week.

### 5.1.2 Research

- TODO -

### 5.1.3 Implementation

During research and implementation, the documentation will be continuously updated.

## 5.2 Project Organization

There are two kind of meetings during the project. They will be thoroughly documented in the project's journal.

Should a physical meeting be impossible for some reason, an online meeting via Microsoft Teams will be held instead.

### 5.2.1 Weekly meetings

A meeting will be held on a weekly basis to discuss the progress of the thesis, possibly arisen issues as well as planned work for the upcoming week.

Name	Role	Participation
Matthias Thomann	Author	Mandatory
Prof. Urs Künzler	Tutor and reviewer	Mandatory
Dr. Eric Dubuis	Examination expert	Optional

### 5.2.2 Expert meetings

Additionally, both before the research task begins and after the implementation task has ended, a meeting with the external examination expert will be held.

Name	Role	Participation
Matthias Thomann	Author	Mandatory
Dr. Eric Dubuis	Examination expert	Mandatory
Prof. Urs Künzler	Tutor and reviewer	Optional

## 5.3 Project Results

### 5.3.1 Documentation

The following documents must be submitted for grading:

- Requirement specification
- Project documentation including:
  - Conceptual formulation
  - Comparison and details of methods and algorithms
  - Details of implementation
  - Result report

### 5.3.2 Implementation of the System

The Unity project, including all implemented shader code, will be managed and stored in the given Gitlab repository [3]. This will also serve as a form of submission for grading.

### 5.3.3 Presentation

A public presentation will be held on the second last friday of the term, June 9th, 2021.

### 5.3.4 Defense of the Thesis

The bachelor's thesis defense will be held after the term, on a day between June 21st, 2021 and July 14th, 2021. The exact date is yet to be announced.

### 5.3.5 Submission Terms

The following items must be submitted.

Item	Description	Due Date
Requirement specification	This document	March 19th, 2021
Book entry	An advertising one-page description of the thesis	to be announced
Poster	An advertising poster of the thesis (A1 format)	June 7th, 2021
Video clip	An advertising one-minute video clip of the thesis	June 17th, 2021
Thesis	The thesis paper and all of project's source code	June 17th, 2021

## Glossary

**HLSL** High Level Shading Language. 3

**LaTeX** A high-quality document preparation system designed for the production of technical and scientific documentation. 3

**Procedural** Created solely with algorithms and independant of any prerequisites. i

## References

- [1] *Rendered image of volumetric clouds*. [Online]. Available: <https://www.gosunoob.com/guides/change-live-weather-problems-in-flight-simulator-2020/>.
- [2] *Photographic reference of clouds*. [Online]. Available: <https://bantiger.roundshot.com/>.
- [3] *Gitlab: Cloud shader repository*. [Online]. Available: <https://gitlab.ti.bfh.ch/cpvr-students/cloud-shader>.