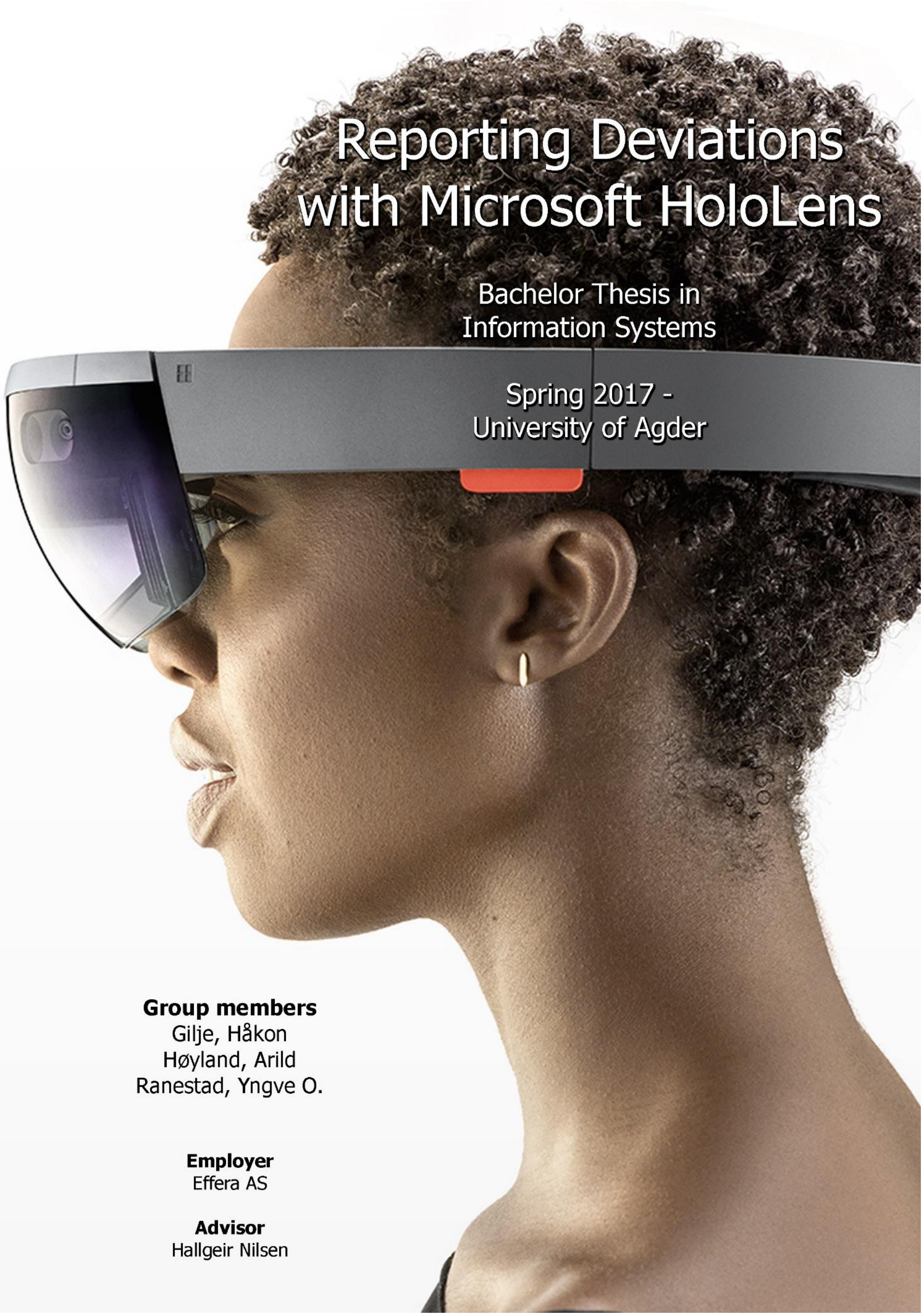

Reporting Deviations with Microsoft HoloLens

Bachelor Thesis in Information Systems

Spring 2017 -
University of Agder

Group members
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Employer
Effera AS

Advisor
Hallgeir Nilsen

Preface

Purpose, Background and Context for the Project

Being able to utilise the potential of augmented/mixed reality is something which can be very beneficial and efficient in many settings. This can be particularly helpful and useful in situations where hands-free operation is difficult or impossible to achieve with current technology or tools. Our product will be built with such an environment in mind. Allowing hands-free operations or achievement of tasks can be a great improvement on current operating procedures.

Co-operators

Employer - Effera

Effera is a medium-sized IT company located in Kristiansand, Norway. They develop and maintain personnel management software, especially targeted towards the construction and industrial sectors, as well as web pages and other digital solutions.

Advisor - Hallgeir Nilsen, University of Agder

Our advisor during this project has been Hallgeir Nilsen. He is a teacher in the Department of Information Systems at the University of Agder, and is the teacher responsible for the course *IS-304 Bachelor report in information systems*.

Special thanks to:

Our advisor, Hallgeir Nilsen
Our employer, Effera
Fellow bachelor project group and test users, *The Dreamers*:

- Kevin Benjamin Zeppo Adriaansen
- Linda Tran
- Andreas Nordtorp Kjærner-Semb
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- Ole Aarsnes

Institute of Information Systems at UiA and *Kompetansetorget*

Summary

The purpose and goals of this project has been to explore the possibility for adapting an existing system to the Microsoft HoloLens (a cutting-edge device in the emerging field of augmented reality), use and expand on our knowledge and experience from our bachelor programme in IT and information systems, and gain experience with working in a professional setting.

Our chosen methodology for this project has been Kanban, both because our employer suggested it and because it fit well with our project. We have established quality procedures where each piece of work has been reviewed by another group member, both enhancing quality and increasing group involvement and ownership in all parts of the project. We have chosen to use Unity and Visual Studio for development of our application, and have spent time establishing standards and conventions for our development. Because of the exploratory nature of the project our project did not have a dedicated analysis phase at its beginning. Rather, we undertook analysis at important times throughout the project.

Our project has run since January 2017 and the nature of our work has changed throughout this time. Early on we spent a lot of time exploring and becoming familiar with factors important for HoloLens development, and deliberately focused on building competence and not rushing any decisions. After a while this accumulated knowledge and experience allowed us to develop more efficiently, something which was very useful when we moved on to developing a proper user interface and user experience for the application, and getting it close to the target state (a minimum viable product which can be demonstrated to clients). After getting to this point our main focus has been on establishing a solid ending of our project and handing our application over to our employer in a satisfactory and orderly manner.

The exploratory nature of the project has required us to be thorough in our planning and management of the project. A result of this is that we've had very few and limited resources available for planning and implementation of our application. We have faced many significant challenges in this project, and handling them has been a very valuable learning opportunity. We have also been able to become familiar and experienced with HoloLens and AR, using and testing it over time and being able to discuss benefits and drawbacks. This expertise will most likely become more valuable in the future. We are very satisfied with the project and what we've learned and achieved throughout its course.

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1. Introduction

In this chapter we provide an introduction to the project, what product we will be developing, background information about our project group and our employer, outlining our major goals of the project and clarifying concepts used in the report.

1.1 The Product

The product is a HoloLens application for reporting deviations/defects during inspections in the construction and industrial sector. The product will involve several of our client's key technologies and products, and explore the possibilities and the options for implementing these with a new technology.The main functionality of the product is to report deviations. This will include the possibility for hands-free uploading of deviations to a database for review. Additional functionality of the product could include an interactive overview of inspection tasks. Key characteristics of the product is that it's easy to use, reliable, and hands-free.

1.2 The Project Group

Our group is composed of Yngve O. Ranestad, Håkon Gilje and Arild Høyland. We've completed several courses as a group and have used a lot of this time to explore collaborative methodology and tools which, over time, has helped us become an efficient group. The content of the courses we've completed together have mainly covered programming, planning, designing, and implementation. The different group members have also taken different electives during their study programmes. This, in addition to the interests of each group member means that we have a wide and varied array of knowledge, interest and insight - a lot of which we assume will be useful during this project.

1.3 Employer

Effera AS is a private company located in Kristiansand, Norway. A rather young company, Effera is constantly changing and developing, something we've experienced while working with them. Effera is a medium sized IT company (by Norwegian standards) with 20-and-something employees at the time of writing this report. This means that Effera has a varied, far-reaching staff with many different skillsets and knowledges, but due to its size does not have resources available for a full-time, dedicated R&D department. Knowing the importance of innovation and exploration of new technologies, Effera has established a close relationship with the University of Agder, wishing to develop and utilise the benefits of a strong academic staff and student body, creating a mutually beneficial relationship. This is how our group met Effera.

1.4 Reasons for Choosing the Project

In October the University arranged a meetup at the coworking space *CoWorx* for the students about to embark on their bachelor projects and companies that had potential assignments for these students. At this meetup Bjellås from Effera was present, and Effera got highlighted as the most sought after company because they wanted something different from a *standard web solution* (a web page/application with a user interface and some form of database), but rather a completely new hardware that few, if any, of the students had tried before. Our group knew Bjellås from earlier as he's been present at meetups held by the student organisation Open Source UiA. Because we trusted Effera and they had an interesting assignment they were the clear choice of employer for us.

1.5 Goals of the Project

This project has several important goals. One of these is to utilise and expand on the knowledge, skills and competence we've built over the last 2 ½ years of participation in the IT and information systems bachelor programme at the University of Agder. We are a diverse group where each group member brings different strengths and perspectives to the project team, and this means that there's a great potential for learning from each other.

Another goal of this project is to develop a product within the emerging field of augmented reality. Our mission has been to explore possibilities for implementing an existing application on, and adapting it to, the Microsoft HoloLens. This is a task with no straightforward answer or implementation UIdelines. As both AR and the HoloLens itself are fresh and untested, we expect to use a significant amount of time on research, acquiring knowledge and building proficiency. The challenges are plenty, but the potential even greater. Completing this project and graduating with this kind and amount of experience is a very valuable asset when we face life after university.

A third goal of the project is to gain experience working in a professional environment and with actual, necessary and sought-after tasks. Gaining this kind of experience and exposure to a professional setting, and being allowed into an exciting, challenging and innovative IT company is very valuable and a great asset to include in our education.

1.6 Concepts and Information

1.6.1 Abbreviations

Abbreviation	**Full**
FPS	Frames per second
IDE	Integrated development environment
MOSCOW	Analysis technique for systems development Categorises functionality as either must-, should-, could- or won't have
MVP	Minimum viable product
PBI	Product backlog item
UiA	Universitetet i Agder (University of Agder)
UI/UX	User interface/user experience

VR/AR/MR	Virtual/augmented/mixed reality
VS	Visual Studio Development environment
VSTS	Visual Studio Team Services Project management platform, incl. Kanban-board

Table 1 Abbreviations used in this report

1.6.2 Concepts

- **Microsoft HoloLens**
  AR/MR smart glasses developed by Microsoft, and made available to developers in the US and Canada in March 2016, and later in selected countries in October 2016. The glasses run Windows 10, are completely self-sufficient, mobile and wireless, and can be operated by the user's hands and fingers (gestures) and through voice commands.
- **Gestures**
  Navigation option for Microsoft HoloLens using fingers and hands. Three distinct gestures existed at the time we did this project (tap, tap and hold, and *bloom*).
- **Unity**
  A game engine and development environment used for developing games and other applications using 2D/3D models, room models etc.
- **Effera Insight**
  Effera's backend infrastructure with server stack.
- **AR/MR**
  A note regarding the use of these concepts. AR is the most widely used term for the field of technology which HoloLens belongs to, but Microsoft prefers the term MR. We have chosen to use AR in this report as it is the best known term.
- **Project and product/application**
  When we refer to *the project* or otherwise use the term *project* in this report we refer to its entirety, meaning all forms of project management, administrative tasks, communication/correspondence with co-operators and all work related to the product/application. The terms *product* or *application* refer to the HoloLens application we developed in Unity and which we will hand over to Effera at the end of this project.
- **The project group**
  This refers to the three *core members* of our group, and does not include either our advisor or any personnel from Effera.
- **Constraints**
  The word *constraints* in regard to either the project or the product encompasses the major constraints of this project - namely due to our group only having three members, not having previous experience with HoloLens or Unity and the rather short duration of the project (January to the middle of May).

1.6.3 Key Personnel at Effera

People mentioned in this report (besides the project group and advisor):

- Sondre Bjellås - senior solution architect, our main contact at Effera for all development questions throughout the majority of the project.
- Frank Wehus - CEO, a frequent contact person for business aspects, logistics and project management.
- Ole Marius Mathiassen - UI/UX-developer, helped with drafting and developing our UI.
- Frode Jensen - product manager, our main contact regarding the Unity license.
- Arnt Berge - senior systems developer, team lead for Effera Insight, our main contact for development questions in the later stages of our project.
- Øyvind Mjølund - CTO, a contact person for administration and logistics

2. Central Choices and Decisions

In this chapter we explain the central choices and decisions in this project. These include our chosen methodology, routines for quality control and management, project steering and management, chosen platforms and technologies, established standards and conventions as well as other important decisions we've made. Evaluations of and reflections on these choices and decisions can be found in chapter 4.1

2.1 Methodology

In this project our project management methodology has been Kanban. An important reason for this is that our employer is using this methodology, and therefore strongly recommended we use it as well. We were not familiar with Kanban in advance, as projects done in earlier semesters/classes had mostly been managed with Scrum or a Scrum-based approach.

"Kanban at its core is summarized by the premise: 'Stop Starting, Start Finishing'. The entire team's focus is on 'getting to done' for the tasks in progress." (VersionOne, 2012, 30.03.). This quote highlights one of the ways in which Kanban is different than Scrum. Although Scrum also has "*working software over comprehensive documentation*" (ScrumAlliance, 2017, 09.05.) as a central concept, Kanban places a greater emphasis on flexibility. Examples of this are prioritising continuous delivery over timeboxing, more flexible sprints/iterations (allowing changes mid-cycle) and greater flexibility when priorities can vary greatly (VersionOne, 2012, 30.03.).

These were important reasons for why we considered Kanban to be an appropriate methodology for this project. The nature of our project (and product) was exploratory, and we therefore saw it as very likely that changes would need to be made during iterations. There was also a large degree of uncertainty regarding prioritisation, estimations and difficulties in developing the application. These were all arguments in favor of using Kanban.

Another result of this is that we estimated required time for each work task only to a limited degree, mostly for larger work tasks. As we worked and got a better understanding of the matter at hand we were also able to estimate roughly *time to complete* for a given work task. We did not have a formal procedure for this process, but such estimations were often expressed in our regular and rather comprehensive *daily scrum* meetings.

As Kanban does not require or utilise timeboxing or a set iteration length/sprint cycle as Scrum does, we have chosen not to use this approach in this project. Instead our iterations ran between central milestones in the project, most of these being meetings where past, current and future development and project management were discussed. An overview of our iterations is given in chapter 3.

An important part of Kanban is also that it doesn't contain any predefined roles (VersionOne, 2012, 30.03.; Radigan, 2017). We saw this as a strength because we knew each other well in advance of this project and have significant experience working together on similar projects. We also wished for all group members to be equally involved in the management of the project.

2.2 Quality Control and Management

Early in the project we decided to implement a quality procedure in which every work task being finished should be reviewed by at least one other team member. This procedure has been used for each and every task, no matter its size or kind. This means that for every piece of functionality developed, each email, meeting summary or report chapter written, and any other task done or decision made with consequences for the product or the project, has been reviewed and approved by at least one other team member.

By subjecting every task to another perspective than the author we will ensure high quality as most tasks may be subject to refinement after feedback. When sharing feedback on tasks we increase transparency of the product within the project group, something which allows for a better understanding of all levels of our product.

This approach shares many similarities with software quality assurance. The focus is on preventing defects and ensuring high quality in all processes and products, focusing on the process and involving the entire organisation (in our case, the entire project group)(Software Testing Fundamentals, 2017, 05.04).

As we would not need to do full stack development in this project, and our product would also require rather small amounts of code (because so much of the development work is done within Unity), we made a decision early on in the project to not spend time on developing automated test procedures, choosing instead to do manual testing (integration testing, system testing and smoke testing) (Software Testing Fundamentals, 2017, 05.04; Smoke testing (software), 2017) both within Unity and when the application was deployed to the HoloLens.

2.3 Project Steering and Management

Our group decided to use a democratic and flat organisation form. There’s been no formal leaders or managers of either the product or the project. This was a deliberate choice based on our previous experience working with each other in similar settings. As we knew each other well by the time we started this project, we were also familiar with each of our strengths, weaknesses, and interests. This allowed us to quite accurately predict which topics and areas each group member would take responsibility for and how they would contribute to these and other areas of the project.

From the beginning of the project we decided to use some aspects from the Scrum methodology that we were familiar with and had positive experience with. These were mainly the daily scrum, *sprint planning* and *sprint review* meetings, used for daily review and coordination, and reviews and plannings of iterations respectively.

2.4 Platforms and Technologies

When it came to choosing platforms and technologies for our project we got useful input from Effera. Wishing to learn from their knowledge and experience, as well as making co-operation as smooth and efficient as possible we chose to use VSTS for development management (and to a certain extent project management). Slack was also used (as well as email) as a way of getting in touch with personnel at Effera. For the remainders of the platforms and technologies we used we were not given any constraints by Effera, and we therefore selected these based on research and previous knowledge/experience.

VSTS
VSTS is a collaboration environment that comes with a Kanban board and sprint tool for Scrum. VSTS uses Git or Team Foundation version control to make the version control and code available inside the tool. We used this tool for managing our work, creating a complete backlog of our tasks. Work tasks were divided into different parts - *epics, features and product backlog items*. *Epic* work items were used for categorisation of features. A *feature* was often a concrete piece of functionality, such as capturing photos or establishing a connection to Effera Insight. A *product backlog item* was the smallest piece used for planning, reviewing and prioritising our work tasks. Most of these were also assigned to one group member, and all were reviewed by one or all group members upon completion. For clarity PBIs were sometimes broken further down into *tasks*, mostly done for the convenience of the responsible group member.

Unity and Visual Studio 2015
Unity is a game engine that is heavily featured by Microsoft in development of HoloLens applications. It is interoperable with Visual Studio 2015 which is Microsoft's IDE. Following Microsoft's tutorials, blogs etc. on HoloLens development made using this combination of tools ideal as the relative abundance of resources outshines competitors.

Google Drive
Google Drive is Google's platform for storing and collaborating on editing documents, drawings etc. This is a collective favorite tool of its kind for our group and we've come to use Google Drive after having tried Microsoft's equivalent tool (OneDrive/SharePoint), and since this has no integration towards the rest of the development environments we wouldn't have gained further advantages from using OneDrive.

Facebook
Facebook is used as a messaging platform for the group to communicate with each other to arrange meetings, quickly share resources (such as links), and discuss project related topics.

Slack
Slack is a developer facing chat service. This has been used mainly to communicate with Effera personnel in regards to questions/support regarding the development and especially the connection to Effera Insight.

2.5 Standards and Conventions

To keep up with modern business standards for developing using C# we've followed the naming guidelines Microsoft has established, which for example states that we should use camelCase (lowercase first letter and each following word starts with uppercase) for parameter names and PascalCase (each word including the first should start with uppercase) for variables, class names etc. (Microsoft, 2009).

Our use of Unity and decisions regarding standards and practices within Unity has changed throughout the project. From the beginning we adopted a pragmatic approach, where we focused on acquiring competence and familiarity before making any decisions regarding Unity practices. As we've become more familiar with Unity we have chosen to utilise its potential as much as possible. Discussing this potential between each other we agreed at each stage on a singular way, thereby facilitating and increasing code centralisation. Examples of this are handling as many actions as possible within Unity and where possible setting up references and variables within Unity.

2.6 Other Central Decisions in the Project

We chose not to begin this project with a significant analysis phase. Instead we focused on becoming experienced and knowledgeable with our development environment, target platform and client's requirements. However, during our project we did develop user stories, as well as using MOSCOW, something which helped us maintain an overview of our goals for the product and our progress towards these goals. These were continuously reviewed, discussed and updated, especially after stakeholder meetings and other important communications with our employer.

2.6.1 User Stories

"User stories are a type of boundary object. They facilitate sensemaking and communication, that is, they help software teams organize their understanding of the system and its context." (Ralph, 2015).

This is descriptive of how we've used user stories in this project. Because of the exploratory nature of our project (and product) we did not write all user stories from the beginning. Rather, our user stories were written during development as features was added to the application. This was useful for reviewing the added feature, gaining an overview of the product (and its current state) as well as allowing us to discuss and evaluate the goals and rewards of said feature. Our application has 19 user stories which have been prioritised using MOSCOW criteria.

User story table:
All user stories within each MOSCOW part is sorted after most important to least important (eg S1 is more important than S5).
M = Must have, S = Should have, C = Could have, W = Won't have.
User story ID = MOSCOW rating + priority index

User Story ID	As a	I want to...	So that...	Impemented
M1	User	log in securely	I can use the app using my own identity.	**Yes**
M2	User	navigate seamlessly in the app using gestures only	I can navigate even if it's too noisy to use voice commands	**Yes**
M3	User	take a photo of a deviation	I can illustrate/demonstrate the deviation	**Yes**
M4	User	upload the deviation to Effera Insight	I can submit a deviation report from the HoloLens	**No**
S1	User	delete all information about the current deviation and return to the start menu	I can dispose of a deviation with minimal effort if necessary	**Yes**
S2	User	record a message explaining a deviation	It's easier to understand for those looking through the deviation report.	**Yes**
S3	User	set a priority level for the deviation	I can suggest a priority level and help with prioritisation	**Yes**
S4	User	set the zone a deviation has occurred in	I can indicate where the deviation is found	**No**
S5	User	set a discipline type for the deviation	I can indicate what competence/skill is needed to fix the deviation	**Yes**
S6	User	take multiple photos for a single deviation report	I can better illustrate/demonstrate the deviation (eg multiple angles)	**Yes**
S7	User	delete photos	I don't have to submit unsatisfactory/unnecessary data	**Yes**
S8	User	delete recordings	I don't have to submit	**Yes**

			unsatisfactory/unnecessary data	
S9	User	enter an inspection mode	I can wear the HoloLens with only relevant info in my field of view	**Yes**
S10	User	logout of the app	the next user can log in or I can refresh my user info/session	**No**
C1	User	have an indication of which zone I'm in	I know which deviations to look for	**No**
C2	User	navigate seamlessly in the app using voice commands only	I can navigate while my hands are occupied	**Partially**
C3	User	scan a QR code using a tap gesture	it *locks* the items ID and fills in information about it for me	**No**
C4	User	customise photo capturing	the application can fit my needs and no time is wasted	**No**
C5	User	annotate on a photo	I can indicate what's important/relevant	**No**

Table 2 User story table

2.6.2 Function List

Due to our decision to limit the amount of analysis done early in the project we did not write a function list. The reasons for this choice were much the same as for not writing user stories from the beginning - we didn't know enough about the product and development environment in order to do this with any confidence. We made a conscious decision to revisit both user stories and function list throughout the project and evaluate if they would provide some value later on. Unlike user stories, we did not see a need for a function list later in the project.

3. Project's Lifecycle

We have chosen to organise this chapter around a timeline. This will roughly correlate to the iterations we've had in our project, although these haven't always been formally planned in advance or explicitly decided/formalised. Each iteration has started and ended on a project/product milestone.

Prior to the *official start* of this project we'd done some preparatory tasks - in December we held one initial meeting with Effera, and submitted a brief project description to our advisor at UiA. For the project group ourselves, we had also discussed our wishes, expectations and requirements to ourselves, the project and other group members in detail several times. We wanted to make sure that there was a common understanding between all group members and that any uncertainties or possible misunderstandings were cleared up as soon as possible, so that this would not hinder or affect the progress and outcome of our project. This thorough preparation is also reflected in our comprehensive group contract (see appendix 4).

3.1 Iteration 1 (10th of January - 24th of January)

Our first day at work at Effera was the 11th of January. Prior to this we'd attended a startup lecture held at UiA on the 10th. In this first iteration of our project we focused on setting up and becoming familiar with the Microsoft HoloLens, researching the potential tools and becoming familiar with our chosen tools (Unity and Visual Studio). In this work we utilised the resources provided by Microsoft in their *Holographic Academy*. This gave us a basic starting point for becoming familiar with the HoloLens and developing for it in Unity, although as a lot of Microsoft's examples were geared towards game development we spent some time figuring out which parts were useful and which were unnecessary for our application.

In this iteration we made some early guesses and attempts at functionality we assumed our application would require. Most time-consuming of these were functionality for capturing photographs and providing the user with a keyboard that could be used with gestures. We realised that the photo-capture functionality we had found would be very important moving forward, whereas we were less certain about the usefulness (and especially user-friendliness) of the keyboard, and decided not to pursue this further at this point.

Towards the end of this iteration we felt ready to start designing, planning and do early, explorative development on/towards our application. We set up a meeting with Bjellås and Jensen in order to learn more about their wishes and visions for the application. This was helpful as it gave us a more detailed overview, and it also gave us a concrete list of features that we would try to implement in the application (or explore the possibilities for implementing). These features were also roughly prioritised, which helped us when deciding what to focus on in the next iteration.

Reflection
Our decision to do a practical approach helped us to get the basic understanding of HoloLens development before committing to a larger plan. Using Microsoft's *Holographic Academy* worked well by giving us an understanding of how concepts unique to the

technology work. Their technical solutions showed to be overly comprehensive but well documented.

3.2 Iteration 2 (24th of January - 15th of February)

After the meeting the 24th of January, we started planning and preparing initial development. We briefly did some sketching and discussing of the design and layout of the UI. At this point we did not do this in detail or make any long-term decisions in regards to the UI, because we considered it to be more important to implement basic functionality. We therefore made an early prototype/*skeleton* of the application's user interface.

This work took some trying and failing as we tried to adjust and tailor our knowledge and experience from the *Holographic Academy* to the requirements of our product. We also borrowed and based some of our basic functionality on pieces of the Academy lessons. Examples of these are the cursor functionality (a point which works as the equivalent of a mouse pointer) and a way to give the user feedback on whether or not the user's hands are within the HoloLens' field of view (the cursor changes from a point to a circle when this is the case). In this work we also made sure that what we added and implemented in our product fit appropriately (meaning we did our best to remove unnecessary functionality), made sure we complied with licenses (Microsoft's lessons from their *Holographic Academy* are released under the MIT license) and double-checked that we understood the structure and inner workings of the functionality.

In this iteration we explored the possibilities for connecting to Effera's SignalR hub. The wanted result was to receive real-time location data from SignalR. This would allow us to automatically populate the location data in deviations (see user story C1). Because of Unity's restricted .NET versioning we weren't able to successfully connect to SignalR as this requires a newer .NET version. Using custom code to manufacture a websocket connection, which in itself wasn't easy to set up because of the lack of asynchronous functionality in the .NET version, we still weren't able to connect to the hub. We discussed these issues with Bjellås at multiple occasions and ended up deprioritising SignalR as its value decreased, especially when compared to the expected time we'd need to invest.

Towards the end of this iteration we prepared for our first meeting with the stakeholders in our project. This was the first time we presented our project to Wehus, and the prospect of getting feedback from more employees at Effera, hopefully with some different perspectives, was something we looked forward to. This meeting also represented an opportunity to follow up on the information and input we had gotten in our previous meeting (24th of January). This meeting was also the first time our advisor got a look at our product, and a more detailed overview of our work up until that point. A detailed summary of this meeting can be found in appendix 3.1.

Reflection

We believe our decision to not focus on the UI and UX at this point in time was sensible, as it would've taken a lot of time to both gain valuable basic skills and at the same time plan, design and develop a *proper* or *final* UI. In order to comply with this decision we also made sure that we did not spend any significant time discussing UI/UX (nothing more than necessary for the implementation of basic functionality). It could be argued that by waiting to implement the *basic functionality* until a later time when we'd become more experienced with Unity development we could've created some of this functionality ourselves, thereby tailoring it to better suit our application and spending less time trying to *decrypt* and customise what we used from Microsoft. However, as mentioned it would also have been difficult to start fully-fledged UI/UX development at this time, and one way or another we had to gain Unity experience.

It's difficult to say whether or not spending as much time as we did on the SignalR/Websockets research and attempted implementation was a good choice or not. It was clear early on that it would not be easy, but we also experienced continued progress by utilising workarounds and our employer encouraged us to continue as the feature would add significant value to the product. It is our opinion that we handled this challenge quite well. It's always difficult to reach a decision in such circumstances, because another hour may yield significant results (possibly even reaching the objective). With this in mind we spent as much time as we believed was reasonable, and then asked for a decision on future development during the first stakeholders meeting.

3.3 Iteration 3 (15th of February - 8th of March)

The first stakeholders meeting gave us valuable feedback and input from both our employer and our advisor. We got positive feedback on our work so far, with particular praise for an independent and efficient effort. We also got a confirmation that what we'd seen as basic functionality was indeed this, and also some wishes/requirements for further functionality. Wehus also told us about questions and interest he'd gotten from customers about the possibilities of VR/AR and QR-scanning, and suggested we hold a meeting regarding further, long-term planning of our project and also giving the business approach and commercial aspects of the product consideration. In the meeting we also got confirmation that we could halt exploration of the Websocket networking approach, and focus on implementing/using REST API for now, as this would be required anyway.

As our planned meeting with Wehus was delayed quite a bit, the progress in this iteration did not go as planned. We finished up some *leftovers* from before the stakeholders meeting, such as reworking the starting point of the application and adding some elements to the temporary UI. 24th of February we held our first demonstration to employees at Effera. Most of the feedback from this demonstration was in regards to the design, layout and flow of the UI. This was not something we had planned to address in this iteration, but we briefly discussed the feedback and used it in the next iteration when we did rework the UI. The results and outcomes from this first demonstration is further expanded on below.

After this, we started researching and implementing the extra functionality that had been requested in the stakeholders meeting. This included changing focus in the networking aspect from Websockets to REST API, support for capturing multiple photographs (and viewing them in the application), creating audio/voice recordings and the functionality for scanning QR codes.

At the time of our meeting with Wehus (8th of March), support for multiple photographs and recordings had been added to our application. We had also started on implementing a connection using the REST API, although a significant amount of this work remained. We had also found examples of how to implement QR scanning, and knew this was possible to implement in our product. In this meeting we discussed and agreed on new tasks/priorities for the coming weeks, and gave estimates for when these could be completed. The tasks we decided to focus on were: 1) a new design and total rework of the UI, 2) a thorough review and check of standards, conventions and practices in all aspects of the application and 3) implementing a connection to Effera Insight using REST API. Other possible tasks were implementing QR scanning and continuing attempts at Websockets integration, but these tasks were not given priority at this point.

In this iteration we held our first of two demonstrations. These demonstrations included short presentations of the product in its current state and some information around our recent work. Whereas Effera uses weekly demonstrations to cap off a week, our demonstrations have been less frequent because of the smaller scale and the fact that product development is often done on parts of the product that are not presentable. The demonstrations take place in the common area at Effera and most of the development staff attend these.

The first demonstration was 24th of February. This was an impromptu demonstration and we therefore hadn’t prepared a programme. During this demonstration the product was in an early state and what we had to show were mainly ideas for interaction, as the focus was still on getting elements like the cursor and other basic functionality to work properly. Mathiassen tested the HoloLens during the demonstration and from this we learned that we had plenty to improve on the UI and that introduction to general HoloLens use was probably necessary in future demonstrations and user tests. The feedback we got from this was scattered, ranging from things like custom gestures to being able to pin UI elements. Most of the feedback were out of scope for our project, although functionality such as pinning UI elements were more relevant and could be researched and implemented if found to be of a sufficient priority.

Reflection

It is our opinion that we handled the work well in this iteration. When our scheduled meeting was delayed we reorganised our work and started development on features we knew we’d need. This worked well and proved our ability to be flexible and optimise our time. We saw the results of this by the time we held the meeting - many of the goals of this iteration were finished, and we were able to plan and estimate the work in the next iteration well.

It is possible that we could’ve enhanced the output of the demonstration if we had planned it in advance. We did not know exactly when we were going to hold a demonstration, but it had been mentioned in the first stakeholders meeting, so we could’ve made some general preparations. We could also have been more clear in the demonstration itself that the current UI and UX was not at all representative of the final product. It’s possible this could’ve raised the relevancy of the feedback we received, but we have to acknowledge that our product was in a state that was rather ill-suited for demonstration. We did however gain valuable knowledge and experience from this event, and made several alterations in later demonstrations which greatly enhanced their relevancy and overview of our project.

3.4 Iteration 4 (8th of March - 24th of March)

During these two weeks our application saw a total rework of its UI and significant parts of the flow/use of the application were also changed. This was done after a meeting with Mathiassen, a discussion which provided us with new perspectives and much needed UI/UX expertise. In this meeting we discussed our current UI layout, and also a new suggestion we had sketched in advance. After this meeting we started to change and adapt our UI based on the decisions we'd made. A few days later Mathiassen provided us with a complete electronic prototype, and in order to comply with this we further reworked the UI. As this meant the flow and layout of our application would be changed, we also had to do significant restructuring and refactoring of our application. Most of this work happened during one week, and the Friday of that week was our *deadline* (our second demonstration). This work, and to a certain extent this iteration, therefore became somewhat rushed. We did our best to avoid making rushed decisions or lowering the quality of our product during this time, but some (temporary) loss of quality was inevitable.

In this iteration we also continued development on the back-end connection using REST API. Our estimate in the meeting the 8th of March had been that this could be complete by the 24th, but we did not quite reach this goal. This was because of delays from waiting on resources from Effera, and some of it was due to the focus on the work-intensive rework of the UI.

Another task estimated to be completed by the 24th was the review and check of standards, conventions and practices. This work had to be done in two parts, only the first of which was completed in this iteration. This was done prior to the rework of the UI, and mainly focused on establishing conventions and practices, and ensuring compliance with these, in our code. The second part of this task was to look at the structure of our Unity project and standards and conventions in Unity structures and hierarchies, as well as use of different elements, naming conventions etc. This work could not be done prior to the rework of the UI, and since the UI rework started later than expected, the review/check was therefore delayed and pushed into the next iteration.

Towards the end of the iteration we had still not received an appropriate Unity license. This license is something we had requested since before our start at Effera, and many times since the project started. As we had still not gotten (or even been given any information) about when/if we could expect an appropriate Unity license, we reluctantly reached a decision to halt development in Unity after the demonstration on the 24th if we had not received an appropriate license by then. We informed Effera of this in an email sent the 17th of March. Further information about how we handled this challenge can be found in chapter 3.5 and 4.2.1.

The second demonstration was on the 24th of March. This was a planned demonstration. Using the HoloLens' *Windows Device Portal* we were able to show a live stream of what the HoloLens user saw and did. To utilise this we had Ranestad equip the HoloLens and show the product, its interactions and an example use case. The example use case was to log in and deliver a deviation with a recording attached. Using the *Windows Device Portal* added great value to the demonstration, however we did have some freezing issues which disrupted the flow. The feedback from this demonstration was positive in nature, but there were no concrete suggestions or constructive criticism. This meant that the demonstration gave us little to further expand upon. To counteract this we contacted Mathiassen and asked for a meeting to discuss our implementation of his design and what we may improve further. This meeting with Mathiassen was much more fruitful and gave us some good ideas on how to further improve the UI. Mathiassen meant that in this state the user interface and user experience constituted a minimum viable product.

Reflection

This iteration became a very intense and work-heavy one. Part of the reason is because we required resources from Effera in order to start reworking the UI and UX, something which didn't happen until 3 days before our *deadline* (the second demonstration). It's possible we could've prevented this by getting in touch with Mathiassen earlier, but we did not face any major difficulties with handling the increased and somewhat time-sensitive workload. We had previously seen that we were flexible and adaptable in our work, and this was an important reason for why we chose such an early demonstration date and confidently challenged ourselves.

Although we were not able to meet all of our objectives by the deadline, we believe our effort paid off very well. The second demonstration was a big improvement on the first, and we got positive feedback. We had taken care not to rush implementation any more than sensible - meaning that we could quickly cleanup and refactor any shortcuts or temporary solutions we'd chosen. This was a deliberate decision, and throughout the iteration we continuously evaluated what to do if we'd encountered major obstacles (eg having to choose between dropping functionality or delaying the demonstration). Due to our previously acquired experience and well structured and divided work tasks this did not become necessary.

3.5 Iteration 5 (24th of March - 5th of April)

In the first part of this iteration we finished the tasks which had been pushed from the previous iteration. We reviewed and changed the code structure used to handle Unity objects and scripts. This task was done to create a set of standards and conventions for further development. This change gave us greater predictability in our work and will strengthen the value of our product. In addition we successfully established a connection to Effera Insight, uploading a partial deviation (without file attachments).

In this part of the iteration we also planned the next stakeholders meeting which was set to the 5th of April. Our ability to develop the application was also greatly reduced as we did not get more than one Unity license, which only allowed product development on one computer. We therefore shifted our focus, focusing on report writing to a greater degree than earlier. This was a part of the project which had not been prioritised highly up until this point, but as we had now reached a MVP-state for (most parts of) our application, and with the reduction in development capacity due to the license issue, we found this a suitable time to focus on the report and make real progress.

This iteration finished with the stakeholders meeting held on the 5th of April. In this meeting we presented an overview of the work done since the last such meeting (including a demonstration of the application), gave information about our future plans for the project (moving from development to evaluation), and also bringing up challenges we'd faced since the last meeting. The last point took up a sizeable amount of time during the meeting, but we got positive feedback from our employer for bringing it up in an appropriate manner. A meeting was planned for the 19th of April for further discussion of this as well as planning the remainder of our project. A summary of this meeting can be found as appendix 3.4. The final stakeholders meeting of our project was set to the 18th of May. This is after the delivery of this report, and as such this meeting won't be mentioned in this report.

Reflection
Our major objectives for this iteration were sorting out the Unity license issue and preparing the second stakeholders meeting. In order to do this well we spent a significant amount of time discussing this issue and how to address it in the meeting. We believe our decision to limit Unity development (based on only having one license) was correct, but came too late in the project. Having finished our major rework of the UI and UX in the previous iteration, it was easier to reach such a decision in this iteration. However, this was not necessarily the best course of action. We recognise that we should've done this much earlier in the project, ideally after having decided to use Unity for development (eg requesting a license in the meeting on the 24th of January and not starting development until the license was provided).

3.6 Iteration 6 (5th of April - 16th of May)

This iteration started after the stakeholders meeting the 5th of April, but due to a focus on other work and Easter holiday there was little progress in the project until the meeting with key personnel from Effera at the 19th of April. During this meeting we were able to give feedback to Effera on how the project had been handled from their side. Effera took this feedback to heart, and gave us insight into how they would consider approaching co-operation with students in the future. We also presented a rough estimate of remaining work on the application both in order to reach a MVP-state, but also possible fine tuning and optimisation we'd planned or considered. Lastly, we were given a new main contact for questions about connecting our application to Effera Insight, and the issue of the Unity license was also discussed.

A few days after this meeting we got a confirmation from Effera that we would not be receiving more than one Unity license. Our estimate of remaining work showed that we could reach a MVP-state working with only one Unity license. In this email, Effera also wrote that they did not see what we'd developed prior to gaining a license as conflicting with the Unity license terms, as our project was a research and exploratory project and not directly focused towards sales (see appendix 5.1). Despite this, we decided to continue using only one license in order to make sure we complied with the license terms for the remainder of our project.

After this meeting the main activities of the iteration has been to further finetune our application and this report. The application has been successfully connected to Effera Insight and we are now able to upload a deviation with data such as disciplines and priorities. We are also able to generate discipline choices for the user based on available options in Effera Insight. However, due to a lack of resource from Effera we have not been able to verify whether or not file attachments are successfully submitted with a deviation. Besides this, finishing the report was the main activity of this iteration and took up most of our time. Wishing to get some feedback on this, we made contact with our advisor and got helpful answers and recommendations.

Other central activities in this iteration has been planning and discussing the handover of our product to Effera, including a seminar where we demonstrated our work and provided an insight into our acquired knowledge and experience. We've also briefly planned the demonstration of our product at the *Bachelor EXPO*, the 23rd of May, at UiA. Finally, we have briefly planned the final stakeholders meeting (scheduled for 18th of May) and the overall conclusion of our project.

Reflection

Because a major part of this iteration has concerned the conclusion of our project and finishing this report, our main takeaway from this iteration concerns mostly the seminar we held for Effera. Before this seminar we requested some information from Effera about the content type, audience etc. We did not get any relevant response which made it somewhat difficult to prepare our seminar. We decided to give an overview and insight into both the project and how we developed the product. Based on the feedback we got the seminar went well and was relevant to the audience.

If we'd gotten a concrete response of what the goal or purpose of our seminar was, we would have tailored our seminar to this purpose. An example could've been a workshop, or a discussion about the strengths and weaknesses of the HoloLens and AR based on our experiences.

4. Results and Experiences

In this chapter we will reflect on the goals and results we've achieved in this project as well as our experiences and acquired knowledge. We will reflect on our central choices, how we've handled challenges and tested our product and the HoloLens, as well as reviewing our co-operation and looking towards the future of our product and AR as a platform.

4.1 Project Management

This subchapter mirrors chapter 2, and we will reflect on the central choices and decisions we've made throughout our project.

4.1.1 Methodology

As Kanban does not require or utilise timeboxing or a set iteration length/sprint cycle as Scrum does, we have chosen not to use this approach in this project. Our project has run continuously with no *hard-set* prior plan of what should be done at a specified time. This has allowed us to be more flexible in our work - shaping our current and future tasks after newly gained competence/experience or new input from our employer. It is important to point out that we have, to a large degree, always finished one task before moving on to another, in order to not lose control in the project, and also abide by one of the central goals of Kanban, which is to have no excess work in progress (Radigan, 2017). A detailed overview of our project's iterations can be found in chapter 3.

Our decision to use estimates to a small degree has worked quite well, but it's possible the handling of some of the challenges we've faced in this project could have benefitted from a greater use of estimates. In several of our large work tasks we experienced delays as we had to wait for resources from Effera. We changed our work routines in order to better handle this challenge, but it's possible that by having more detailed estimates (if possible at an earlier stage in the project) we would've been able to get the necessary resources from Effera when we needed it instead of having to wait. The handling of this challenge is described in chapter 4.2.3.

4.1.2 Quality Control and Management

Our established quality procedure where everything is reviewed by at least one other group member has been useful not only because it increases quality, but also because this allows each member of the team insight into what the others have been doing. We have not demanded that a review should be supported by detailed, extensive knowledge of the related work task, but the reviewing team member should be given enough knowledge and briefing by the developer in order to understand and evaluate the submitted work task.

After these forms of testing, where each piece of functionality was tested by itself, with its *partners* and in its greater scope (within the application as a whole) we discussed and evaluated the recently added functionality. This was done in order to control and evaluate to which degree the developed functionality fulfilled the requirements and fit the needs/wishes of our employer and the target group (Software Testing Fundamentals, 2017, 05.04). This form of acceptance testing is something we used widely and ties quite closely into our *review-everything* strategy. In these tests we used both white- and black-box testing, hearing the opinions of other group members and gaining their perspectives. This review also often exposed edge-cases, which further increased our ability to enhance the quality of our product.

When it comes to programming and code, reviewing the code in order to ensure well-documented scripts with an appropriate level of cohesion and coupling has been important. We've also focused on making sure that the code and scripts are understandable to someone who has little to no experience with developing in the Unity environment. Balancing between over-documenting and exhaustive, detailed comments has been a challenge and something we've focused on when writing and reviewing code. In the documentation we've also taken into account the fact that we'll be handing the application over to developers with less knowledge of the quirks of development within Unity.

By reviewing all text that has been written, such as (but not limited to) emails, meeting agendas and summaries, and chapters for this report we've increased the quality of the process by making sure that we are all *on the same page*, meaning we have a common, shared understanding of what should be written, and what the goals of these activities are. If such an understanding has not been reached or agreed upon, we've been able to take measures in order to rectify this.

4.1.3. Project Steering and Management

In managing the development of our application our use of VSTS has been very helpful. We have also made sure to schedule meetings with external co-operators (employer or advisor) well in advance, and utilised these as milestones in the project, allowing us to plan most of our work around these milestones.

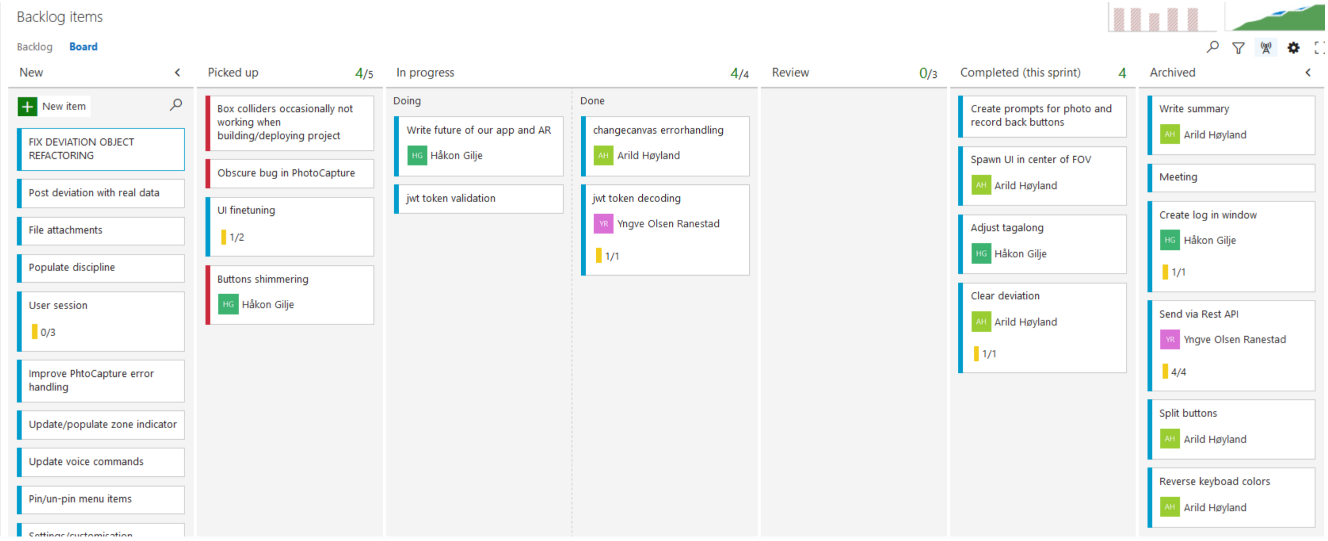
Iterations have been planned and reviewed using meetings similar to the sprint planning and sprint review meetings we are familiar with from Scrum. These have been of varying lengths depending on the kind amount of work being discussed, but have generally been between half an hour and one hour long each.

We've also used something like a daily scrum meeting. This has been used in order to maintain an overview of what each team member has done since the last such meeting (the previous one-two days), and what each member plans on working on forward (the next one-three days). These meetings have usually lasted around 15 minutes, but as for the sprint planning and review meetings the lengths have varied based on the amount and kind of work being discussed. Some have been as short as two-three minutes, others closer to 30 minutes. We've focused on making sure that the average has been somewhere around what Scrum suggests as max length (15 minutes) in order to avoid wasting time, but also making sure we spend enough time to discuss topics thoroughly (or plan appropriate meetings for such matters). Throughout the project we've gotten better at completing the daily scrum part of such a meeting before moving on to other topics, for example administrative decisions or email correspondence.

4.1.4 Platforms and Technologies

Visual Studio Team Services

A centerpiece of our project approach, methodology and management has been our use of VSTS. This has served as our *Kanban board* and been used both for planning, daily operations and review. On this board we have organised and broken down functionality and tasks, gaining an overview of large tasks and which components they include. This has also been useful when given each task and sub-task a priority and continuously updating and adjusting these priorities after getting feedback from Effera, as well as maintaining control over which tasks are assigned to which group member, as well as their current state. When these tasks have been completed, other group members have been able to see this on the Kanban board and review them. This has been a key component of our quality management and has given us continuous quality assurance.



Backlog items

Backlog Board

New
- New item
- FIX DEVIATION OBJECT REFACTORING
- Post deviation with real data
- File attachments
- Populate discipline
- User session 0/3
- Improve PhtoCapture error handling
- Update/populate zone indicator
- Update voice commands
- Pin/un-pin menu items
- Settings/customization

Picked up 4/5
- Box colliders occasionally not working when building/deploying project
- Obscure bug in PhotoCapture
- UI finetuning 1/2
- Buttons shimmering — HG Håkon Gilje

In progress 4/4

Doing
- Write future of our app and AR — HG Håkon Gilje
- jwt token validation

Done
- changecanvas errorhandling — AH Arild Høyland
- jwt token decoding — YR Yngve Olsen Ranestad 1/1

Review 0/3

Completed (this sprint) 4
- Create prompts for photo and record back buttons
- Spawn UI in center of FOV — AH Arild Høyland
- Adjust tagalong — HG Håkon Gilje
- Clear deviation — AH Arild Høyland 1/1

Archived
- Write summary — AH Arild Høyland
- Meeting
- Create log in window — HG Håkon Gilje 1/1
- Send via Rest API — YR Yngve Olsen Ranestad 4/4
- Split buttons — AH Arild Høyland
- Reverse keyboad colors — AH Arild Høyland

Figure 1 Kanban board in VSTS

Unity and Visual Studio 2015

Unity has many strengths which have been useful in this project. There is a wide array of resources available for development, debugging and reviewing many aspects of a developed application (such as the performance cost, which is something we've kept in mind due to the HoloLens' weak hardware). The most important of these strengths has been the maturity of Unity and the width and depth of support and resources available in the Unity community. This has been important when we consider how few resources for AR development there are. That being said, Unity does have some disadvantages which we discuss in chapter 4.2.2.

Utilising the strengths of the Unity-Visual Studio integration (described in chapter 4.1.5) allowed us to spend more time developing and fine tuning new functionality. We have also used Visual Studio for deploying our application to the HoloLens and for debugging purposes.

Based on our experiences and findings it's our opinion that Unity and Visual Studio were an appropriate choice considering the goal and scope of our project.

4.1.5 Standards and Conventions

When working with Unity we have tried to be consistent, creating standards and conventions which all group members have followed when developing in Unity and Visual Studio. These standards and conventions have been updated and modified as we have progressed in the project. Our growing competence and experience has allowed us to make more educated guesses and estimations about which approach is the most suitable. We have paid great attention to the need for balancing application performance with ease-of-development, and tried to make the most of Unity's capabilities. In this way we have been consistent in handling as many functions and links as possible within Unity. This has both helped us reduce the amount of written code and fully utilise Unity, but has also required experimentation to find the best practices and suitable situations for such use.

We realise that this approach may make the introduction and learning curve somewhat steeper for anyone without experience with Unity (or other game engines), but we have chosen to put functionality and performance slightly above ease-of-development in this regard. We have done our best to explain these development procedures in detail to Effera. We held a seminar for personnel at Effera where we summarised our project and gave an insight into how development using Unity and VS is done.

Unity has several ways of referring to other scripts in the same application and we have tried several during the project. In the end we've used static instances to implement the singleton pattern as it allows for flexibility and loose coupling so that developers can easily move components and change them around without *breaking* the application. Using static instances of most scripts does not prevent us from using non-static instances of other scripts where needed. Scripts that are used for navigating the application and handling actions by the user are for the most part static, as per now only one of each of these scripts are needed. Model classes that prepare and transmit data to the backend are dynamic as the application will require several instances of these.

4.1.6 Other Central Decisions in the Project

User stories

We stand by the decision we made at the beginning of the project to develop and add user stories throughout the project when necessary and appropriate. We wrote the majority of our user stories at a point when we had a large amount of the basic functionality in place and were considering what to develop first of more advanced functionality. In order to do this work well it was necessary to establish and maintain an overview of required functionality and discussing and evaluating how these should be prioritised. Writing user stories helped us a great deal in this work.

Because we ranked all of our user stories with a MOSCOW score we also got a clear list of prioritised features. This was useful both in planning future work, evaluating completed work and maintaining control in the project, as well as forming a picture of what state our product was in (how close we were to a finished product).

If we'd chosen differently, for example developing user stories at the start of the project, this would've had ramifications for other parts of the project, especially the important research and experimentation work we did at this time. This is not to say that this option would inherently have been any worse than the one we chose, but it would've meant that development of the application would be slightly delayed. Even if we had developed the user stories early we would have had to revisit them several times, as they would likely need to be changed and updated as we accumulated knowledge and experience with developing for the HoloLens. Based on our decision to write these at a later stage, we were able to limit the possible complications arising from the known systems development paradox "*we make the most important decisions when we know the least*".

Function list

Although we never wrote a list of functions in the style of a function list/functional requirement, such overviews of functionality were provided by Effera and written by ourselves throughout the project. This was necessary in order to maintain control in the project, evaluate previously completed work, current work and plan future development.

This has been a running process throughout the entire lifetime of the project. The priority of different pieces of functionality (or whole user stories) has been altered after input from Effera or at our own initiative. These have usually been optional functionality and features that have been outside the scope of our MVP. This means that most of the basic functionality our application needs in order to function (eg capturing photos and making recordings) has been consistently prioritised highly without much change throughout the project.

Work that has been subject to frequent evaluation and changing prioritisation has been adjustments, error proofing and small, optional functionalities. Throughout our continuous process we have often discussed the need for such functionalities and adjusted their priority accordingly. This has also included some functionalities suggested/requested by Effera, such as being able to scan a QR code and annotating on captured photos. We have responded positively to these suggestions and recognise that they would add significant value to the application. We did some research on QR scanning and found libraries and implementations of this. However, due to the constraints of our project we did not spend a significant amount of time finishing the implementation of it into our application. We also chose not to research/develop photo annotations, as Effera underlined that this was of low priority.

4.2 Handling Challenges

Handling challenges has been one of the most valuable and educating parts of this project, and in this subchapter we review and evaluate our handling of the largest and most important challenges we've faced.

4.2.1 Unity License

Acquiring an appropriate Unity license has been a major challenge in the project. This license is required for using Unity in a professional setting. We mentioned Unity license as a possible requirement the first time we were at Effera the 11th of January. In a meeting the 24th of January we confirmed that we'd use Unity as the development environment and Effera confirmed that they could provide us with licenses. After this meeting we did not get an answer regarding the licenses. The license issue was also brought up by us on the following dates:

- the 15th of February - mentioned in the stakeholders meeting (Bjellås and Wehus present).
- the 24th of February - on Slack (to Bjellås).
- the 8th of March - in an email to Bjellås, Mjølund and Wehus.
- the 17th of March - in an email to Wehus, Bjellås, Mjølund and Jensen. We stated here that we'd stop development after the demonstration on the 24th if we had not gotten the license by then. We did not receive an appropriate license within this time limit, and for the remainder of this day (the 24th of March) we suspended all Unity development.

The following monday (the 28th of March) we got one license and was told the other two were requested and awaiting financial approval. The 4th of April we notified Jensen that we'd put the license on the agenda for the 5th of April stakeholders meeting. During this meeting we decided on a common review of the license issue in the meeting on the 19th of April. On this date we presented the list of remaining work on our product, underlining that we could finish the product with the one license we'd gotten and highlighting our wish for a speedy and clear decision about the license issue. The decision to continue with only one license was made final a few days later. This challenge is also mentioned in chapter 3.5 and 3.6, and Effera's final decision regarding the license issue in appendix 5.1.

The handling of this challenge was demanding and required us to be flexible and restructure our planned and current work around new and somewhat unexpected constraints. We spent some time coming up with a way to work effectively with one Unity license, and did a thorough review and prioritisation session of our remaining functionalities, features and optimisations, as our reduced Unity capacity and productivity meant that prioritisation was more important than earlier. We also saw and experienced the benefits of being flexible, making the management of unforeseen challenges and constraints possible and rather straightforward.

4.2.2 Using Unity

Acquiring knowledge and competence with development in Unity
Another central challenge in our project has been our use of Unity. None of us had previous experience with using a game engine and we therefore needed to spend considerable time acquiring and developing knowledge and competence. When starting with something new and unfamiliar it takes some time to get used to its demands and quirks, and the first iterations of our project were no exception to this.

In order to handle this challenge well, we spent a significant amount of time early in the project trying and failing and becoming familiar with several approaches and solutions to a given task or problem. During this early phase of our project we did not set any limits on how much time we spent on researching and experimenting in Unity. This was deliberately done in order to gain a thorough and wide understanding of the matter at hand.

During iteration three (towards the end of February) we started to see major rewards of this approach. At this point the time we spent on research and experimenting went significantly down. We were instead able to spend time on evaluating different approaches and solutions to a task, based on knowledge or experience we'd acquired earlier in our project.

Constraints and issues with Unity development

The main constraints and issues with Unity development has its root in the fact that Unity has their own fork of Mono. Mono is a development platform containing a C# compiler, .NET framework, Mono runtime and Mono class library. Unity's Mono fork has not kept up with all the changes happening to the C# compiler and the .NET framework, which in turn means that there is a limited availability of functionalities and packages related to the development environment. The versions currently supported by Unity's Mono is C# 4.0 with the newest being 7.1 and .NET version 2.0 with the newest being 4.7. It's worth mentioning that the .NET version 2.0 is a Unity subset which does include some libraries such as linq which is from a later version of .NET. The issue of the versions were clear to us from the start, although the individual problems emerged continuously throughout the project and we'll elaborate some of them underneath.

SignalR:

Effera wished to implement a websocket connection to Effera Insight using SignalR to display live data to the client. SignalR is a library which implements hubs for websocket connections that have fallbacks in cases where websockets aren't supported. However, the library to implement SignalR weren't supported by the Unity .NET subset and after a lot of trial and error and discussions with Bjellås, we decided that implementing SignalR was out of scope for the project. A possible solution to this could be to try building our own Unity compatible SignalR implementation, however this would take too much time and be too complicated.

REST API:

Connecting to Effera Insight's REST API was supported by libraries and was therefore seemingly problem free. When using data from the response we noticed discrepancies. Since async functionality is lacking in C# 4 (introduced in C# 5.0) we didn't have the possibility to await responses and therefore got errors when trying to assign the response before it had been completed. To solve this we looked at a Unity solution for this which revolved around yielding the result, however this wasn't consistent and we ended up using a while loop on the response status in order to not allow assignment before it was done. This has the side effect of possibly locking the process for the duration (of the loop), however this has been unproblematic.

JSON Serialising:

We noticed sending objects via the REST API resulted in error codes at times. To inspect this issue we sent the requests to requestb.in. Requestbin is a REST API echo solution that returns what is sent and provides a dashboard for the received requests. This showed that the data was not being serialised to JSON properly. We couldn't use popular libraries such as Newtonsoft for this because of the .NET limitations, however we did find a somewhat similar solution for Unity called JSONObject. JSONObject was unfortunately licensed under the LGPL license which could put unnecessary requirements on the project. We sent an email to the creator (Defective Team) about this and they waived all the requirements connected to the library (see appendix 5.2). In most cases JSONObject solved a lot of the

JSON serialisation issues, however where it didn't we did manual serialisation to a JSON string.

JWT validation:
To handle authentication against Effera Insight we used JWT (JSON Web Token). An issue which arose with this was validation of the token to ensure it's valid. Again the source of the problem was the outdated version of .NET. Because of time constraints we decided that this was out of scope. However if we had the time to solve this we'd want to do validation only on the server side. Validating on server side would be necessary in any case, but was troublesome for us without control over the server side (Effera Insight).

4.2.3 Communication with Effera

At certain points during the project we have had challenges with getting timely and decisive answers from Effera. This was a problem especially during the first half of the project, and at one point the progress of both development and planning of product and project was very difficult to proceed with. At this point we held a discussion where we tried to find and evaluate possible actions we could take to improve the situation. We sent an email to our advisor describing the situation and asking for advice on how to approach a few key issues we had. This was useful in that it forced us to review each issue in detail and express them in an orderly, coherent manner. The day after we'd sent this email we got an answer to several of our pending questions, something which went a long way to *remove the blockade* for the moment. However, this experience had given us some doubts, and we wished to improve future communication to avoid similar situations.

During the following week we brought this situation up in a meeting with Wehus. His response was that we had to be tough and persistent, but most importantly to clearly lay out consequences to our progress if we did not get resources in a timely manner (ideally specified by us). After this we improved our correspondence with Effera by being more explicit and clear. We have been able to do this with a varying degree of success. Working on resolving the Unity license issue (see chapter 4.2.1) we did set deadlines and clearly laid out potential consequences to the project's progress. However, we could've done better by being more consistent, eg including such estimates and details when we asked questions about matters relating to backend integration.

4.2.4 Scarcity of Resources for AR Development

Scarcity of choices in IDE and development approach
The cutting-edge and untried nature of both the Microsoft HoloLens as a device and AR as a platform means that the amount of resources available to us is very limited. Early on in the project we decided to use Unity as this is one of few IDE's that has any significant amount of resources available. This set some constraints on our options when developing and working on our application. It also meant that we were *locked* to one approach to AR development - that of using a game engine, and developing a very simple application (compared to a game) which did not use or need a large amount of the functionality in the game engine. It is possible other approaches, frameworks and IDE's could've been just as good or better, but any consideration of this or comparisons have been outside the scope of this project.

Scarcity of theory, standards and best practices
Another challenge in working with such a new platform and technology has been the scarcity (or non-existence) of reviewed conventions or best practices. We have experienced this especially well when working on development of the UI and the UX. We possessed knowledge of theory and best practices (as well as significant experience from usage in our daily lives) for web, mobile and desktop applications prior to this project, but deciding to which degree this could be applied to our application was difficult. This issue was also confirmed by Mathiassen when he spent a day designing the UI for our application. He reported back to us that he had tried, unsuccessfully, to find any standards, conventions or best practices for designing UI on AR platforms.

4.2.5 Product Delivery

Delivering the product (and our acquired knowledge/expertise) to Effera to a satisfying degree is something we’ve spent a lot of time planning and preparing. This is reflected in this report as this matter has been covered thoroughly, especially regarding quality control and management (chapters 2.2 & 4.1.2) and standards and conventions (chapters 2.5 & 4.1.5). Towards the end of our project we established a dialogue with Effera on this subject, and held a seminar where we presented our work, acquired knowledge, and experiences to Effera, thus allowing employees at Effera to ask questions, gain insight into our project and future possibilities regarding our product and AR as a platform.

4.3 Testing

Towards the end of our project’s lifecycle we sat down and did a thorough evaluation of limitations and drawbacks of both our developed application and the HoloLens as a platform for use in industrial and construction sectors. This was done in order to give our employer feedback on what needs to be kept in mind when/if moving ahead with development for the HoloLens (or other AR devices), as well as which features of the HoloLens we think are drawbacks and hinders in its current state.

4.3.1 Testing of HoloLens and Application with Inexperienced Users

Towards the end of our project we wanted to do more thorough testing of our developed application than we’d done so far. A centerpiece of this was a testing session where we co-operated with another bachelor project group (*The Dreamers*). This gave us valuable insight into how users unfamiliar with the HoloLens would fare when being given more-or-less free reign inside our application. In this session we focused both on how users experienced and used our application, but also which aspects of the HoloLens they struggled with, disliked or otherwise commented on. After each participant had run through all parts of our application, they filled out a short survey ranking the overall impression of the HoloLens and application, and were asked for any particular observations.

Before the testing session we wrote down expected feedback and observations. We did this in order to see if what we considered weak points or drawbacks (both of our application and the HoloLens) would be noticed by someone completely new to the application and platform. For the most part our predictions were correct, but not totally. Participants in the test particularly commented on difficulties with finding and keeping the HoloLens’ field of view stable. Participants also struggled somewhat with using gestures in the beginning, but besides one exception, all participants quickly got the hang of gestures. This proved a surprise to us, as we'd expected more trouble at this point.

Participants were also generally uncertain about navigating within our application, expressing particular problems with finding photos or recordings after they'd been made. It is difficult to say if this is due to our participants lack of knowledge of the current systems and designs of our employer, or if it is due to misleading names and/or icons on buttons in our application. Naming of buttons/options as well as their illustrations (icons) should be checked with Effera's current practices, in order to ensure that they are the same/as similar as possible. After this, new testing should be done with users already familiar with Effera's systems to see if their knowledge and experience of using and navigating in Effera's systems/applications transfers to the HoloLens application.

All in all, the participants in this testing session handled the use of both the HoloLens itself and our application easier than what we'd expected. This is reflected in the answers in our survey, where only one participant responded that it was somewhat difficult to navigate. On the survey we asked the participants to rate their overall impression of the user experience. The feedback from this was definitely positive. However, we have to underline that the low number of participants, as well as the participant's shared traits (all being IT students), in this testing session means the results should only be viewed as an indication and in no way be applied or generalised to other user groups.

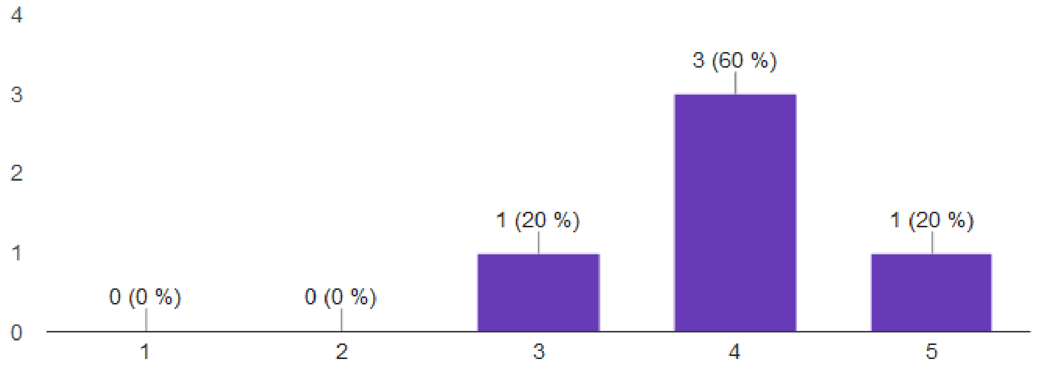


Figure 2 General impression of user experience (1 = very poor, 5 = very good)

4.3.2 Criteria and Requirements for Successful Adaptation

We have compiled a list of all factors we could think of which could affect the operation of the HoloLens and our (and other) application(s) in our target work environment (construction and industrial sectors). The list is meant to be a summing up of every possible factor a company considering adopting the HoloLens should consider. To the best of our abilities we've found and considered every factor, but we make no assumptions that this list is exhaustive or applicable to every company or need. Our main objective with this is to highlight that there are many criteria in a wide array of categories.

- **Gestures:**
    - Gloves
        - What if the user is wearing very thick gloves, potentially blurring distinction between fingers, or making the bloom gesture difficult to see?
    - Light
        - Will the HoloLens notice gestures from users in environments with poor lighting?
    - Gesture feedback
        - Are the feedbacks our application (and the default HoloLens feedback) provides the user on whether or not the HoloLens is recognising the user's hands (the *ready* state for a gesture) accurate?
        - Are they obvious or could they be changed or otherwise improved upon?
    - Potential for abuse or instability
        - Could passersby trigger a gesture, either on accident or purpose?
        - Could the HoloLens potentially mistake something in its field of view as a gesture?

- **Recordings:**
    - Background noise during recordings
        - Will this be picked up by the HoloLens' microphone when recording a voice?
        - What if the user wishes to record a sound, to what degree (if any) will the HoloLens be able to differentiate between one sound and background noise?
    - Background noise during playback
        - Will the user be able to listen to a recording in a noisy environment?

- **Voice control and commands:**
    - Noisy environments
        - Will voice control work in environments with significant background noise?
    - Accents and pronunciations
        - To what degree (if any) will the user's accent or pronunciation affect voice control? This is particularly applicable to users with a different mother tongue than English.
    - Speed, rhythm of speech
        - At what point does *clear* become *too clear*, for example if it creates unnatural pronunciation or long breaks between words?
        - How fast can the user speak while still being able to use voice controls?
    - Using Microsoft Cortana
        - Could Cortana be used inside an application?
        - If so, could this be utilised by the developer?
        - To what degree (if any) could an application use Cortana and other default HoloLens services/applications while running another application?

        - How easy is it to accidentally trigger Cortana (both inside and outside the application)?
    - Potential for abuse or instability
        - Could passersby trigger a voice command, either on accident or purpose?
        - Can background noise be picked up and trigger a voice command?

- **Menus/holograms:**
    - Visibility/performance in bright environments
        - Sunlight (direct and non-direct)
        - Daylight
        - Brightly lit interiors
    - Visibility/performance during changing light conditions
        - Shadows
        - Partial cloud coverage
    - Visibility/performance in dark environments
        - Dark interiors
        - Evening/nighttime
        - Darkness

- **Camera:**
    - Changing light conditions
        - How does the HoloLens' camera handle such conditions? Shadows, moving between indoors/outdoors etc.
    - Low light conditions
        - The HoloLens does not have a proper blitz, how does it handle low light/darkness when capturing photographs?
            - Where is the cut-off between *just bright enough* and *too dark*?
            - Especially applicable in the extreme north/south during winter months
    - Motion
        - To what degree can the HoloLens move (if user turns his head or moves) while still capturing (acceptably) clear photographs?

- **Weather and similar factors:**
    - Water
        - The HoloLens isn't waterproof, is this required?
        - To what degree (if any) is the HoloLens water resistant?
        - What kind of humidity levels does the HoloLens support?
            - This is important both for the functioning and well-being of the HoloLens' hardware, but also the comfort of the user.
                - The HoloLens can get hot and may be uncomfortable to wear because of the temperature (especially if worn inside a helmet/similar headgear).
    - Dust
        - To what degree (if any) is the HoloLens resistant to dust?
        - How long will a HoloLens function in a very dry/dusty environment?

            - This is important both for the functioning and well-being of the HoloLens' hardware, but also the comfort of the user.
                - Will wearing the HoloLens for a long duration in a dry environment dry out or irritate the user's skin?

- **Durability:**
    - Tolerance
        - How much *punishment* can the HoloLens handle?
            - Shocks, falls, movements, vibrations and similar
    - To what degree (if any) does the HoloLens require maintenance?
        - What kind of maintenance is needed?
            - Daily/regular and/or simple maintenance?
            - Periodical and/or thorough maintenance?
        - Can this be performed on-site, or is shipping or other transport necessary?
        - Who handles maintenance?

- **Comfort for user:**
    - Max duration before user experiences fatigue
        - For head, neck, and back?
        - For eyes and sight?
    - Encumbrance
        - Does the user feel that the HoloLens is a hindrance while wearing it?
    - Equipping/unequipping the HoloLens
        - How easy is it for the user to equip and unequip the HoloLens?

4.3.3 Testing Results and Experiences

We have done some early and preliminary testing of some of the aspects and criteria mentioned above. There were some tests we could not do, either because of time constraints or other constraints, such as testing the durability of the HoloLens by exposing it to harsh environments, testing its reliability over time etc. Because of the HoloLens' limited use in professional situations, we have decided not to undertake a survey or other form of data gathering. This could be used, especially in the future when more data is available, in order to explore and gain knowledge of areas such as durability, maintenance, support infrastructure etc.

The usability and ease-of-use for first time users is something we've kept in mind throughout this project, especially as we have given people outside the project group the possibility to try the HoloLens. We also got useful information about this from our testing session with *The Dreamers*. We did not intend to test all criteria mentioned, and we therefore approached this testing in a rather pragmatic way, testing those criteria and issues which were easy to test in an office environment.

Gestures:

- **Gloves:**
  We tested if a user can use the HoloLens while wearing quite thick gloves. We used a pair of winter gloves, dark grey in color. In size/thickness, these equal quite thick

work gloves. We mention these aspects because we assume that both the size/thickness of the gloves (to what degree it blurs the distinction between fingers) and the fabric color can affect to what degree the HoloLens registers gestures.
Result:
The tap gesture worked well (only marginally less accurate than without gloves) both within our application and in other HoloLens applications. The bloom gesture did not work at all.

- **Gesture feedback:**
  We tested the gesture feedback (changing the cursor to a circle when HoloLens recognises a hand in a ready-for-gesture state) in both the HoloLens' default view and within our application. We also discussed briefly if this support mechanism is clear enough to future users.
  Result:
  Both of these worked very well, with good accuracy and a smooth operation. In our application we've mimicked the functionality which Microsoft uses for its default cursor. We (as well as Microsoft) strongly recommend that all applications developed for the HoloLens incorporate a functionality such as this (Microsoft, 2017, 15.05.), as it is very helpful to users. We also recommend to make new users aware of this mechanism from the beginning, as it may help them significantly in becoming familiar with gestures.

- **Potential for abuse or instability**
  We did some small tests in order to figure out if the HoloLens would recognise gestures made by people other than the wearer, either in order to sabotage operation, disturb the HoloLens wearer or on accident. We also checked if the user could accidentally trigger gestures herself, for example by gesticulating while speaking.
  Result:
  We were not able to make the HoloLens recognise any gestures while standing or moving through its field of view or otherwise standing in front of the HoloLens. We also found that it is rather difficult for the wearer of the HoloLens to accidentally trigger gestures, but it is possible. Logically, the closer a hand movement resembles a gesture (such as pointing and circling in a small circle) the easier the HoloLens will pick it up as a gesture. However, we wish to underline that in these scenarios there are a multitude of edge cases and unique situations, so no conclusive assumptions should be made from our brief testing.

Voice control and commands:

- **Speed and rhythm of speech**
  We wished to test if the wearer needs to speak extra clearly or otherwise differently from normal speech while using the HoloLens' voice control.
  Result:
  The HoloLens requires a user to talk rather slowly, and especially pronouncing each syllable in a command clearly. It is more tolerant of a slow talking speed than a quick one, most likely due to the fact that it needs to separate and recognise each syllable. This means that command words does not necessarily need to be said in full, as long as all syllables are included. This is something which should be kept in mind when

researching and developing voice control and commands for HoloLens applications.

- **Using Microsoft Cortana**
  We wanted to find out if Cortana is available inside third-party applications such as ours.
  Result:
  Cortana is available and does respond to commands from within a third-party application. However, at the present time, in order to launch any other applications Cortana needs to close ours. It is possible that our application could be implemented or run in a different way on the HoloLens thereby allowing it to run simultaneously as other applications and expanding the usability of Cortana, but we have not researched this as it's been outside the scope of this project.

- **Potential for abuse or instability**
  We wanted to test whether or not people other than the wearer could trigger commands, either purposely or on accident. We also wished to see if keywords would be picked up from conversations around the HoloLens wearer.
  Result:
  We were able to *hijack* the voice commands only to a small degree. This requires the person uttering the command to be close to the HoloLens wearer (within 2 metres) and speak slowly, clearly and rather loudly. We were not able to trigger voice commands on accident, for example by uttering the keywords as we passed by close to the HoloLens wearer. This was also reflected by the fact that we were not able to trigger voice commands from background noise such as conversations around the HoloLens wearer. This is most likely because the speed and rhythm of such conversations, as well as the clarity of each syllable, is not clear enough for the HoloLens to pick up. As for our testing of gestures, we wish to underline that in these scenarios there are a multitude of edge cases and unique situations, so no conclusive assumptions should be made from our brief testing.

Comfort for user

- **Encumbrance**
  We asked ourselves to what degree the user feels that the HoloLens is a hindrance, uncomfortable or otherwise distracting while wearing it.
  Result:
  Throughout this project we've used the HoloLens for many hours and can therefore say with some authority that the glasses feel quite heavy, especially because most of the weight is placed around the forehead of the user. This can lead the user to experience some strain and fatigue of the neck while wearing the HoloLens, especially when bending forward. Another issue is that the HoloLens can become quite warm after prolonged use, or while doing demanding tasks (an example of this in our project has been using our application whilst streaming the camera feed and holograms to a computer). Both of these aspects have been pointed out by people outside the project group when testing the HoloLens.

- **Equipping/unequipping the HoloLens**
  Throughout our project we've equipped and unequipped the HoloLens countless times, and have become familiar with this procedure. However, how difficult is this for

inexperienced users, and what if a user has to do this many times throughout a working day? These questions were the basis of our reflection and discussion of this topic.

Result:

Equipping and adjusting the HoloLens to a comfortable wearing position is quite tricky for inexperienced users. It takes some time to find a comfortable position, and difference in personal preference among users can make it more difficult to make any standard recommendations. As users gain experience with wearing the HoloLens this gets easier and quicker, but we still see it as a drawback of the HoloLens. In its current form the HoloLens is not in a place where it could be used comfortably throughout a working day while equipping and unequipping it often. Improvements in this area should be made in future versions.

4.4 Co-operation with Employer

Our overall co-operation with Effera has gone well. There's been a few challenges, the Unity license issue being the most significant of these. We also experienced that decisions made in meetings weren't followed up on from Effera's side without any further inquiries from us. Another example of this is that we were told that Effera would acquire a powerful desktop computer. This could've allowed us to develop more efficiently (one reason being we could've used a HoloLens emulator). After deciding on a hardware requirement, we never heard anything more about this computer. This in itself has not affected our project in a negative way, but it adds to a pattern which emerged during the project where we found it difficult to get clear feedback and responses from Effera (especially without repeated inquiries).

Towards the end of the project these issues were brought up and discussed with Effera. They praised us for bringing it up in an appropriate manner and discussed some ideas and asked for our inputs on how this could be improved upon in future projects of this kind.

Now when our project has reached its end, we wish to underline our gratitude to Effera. They have provided a good office space, an interesting project, hands-on experience with an exciting groundbreaking technology (Microsoft HoloLens) in the emerging field of AR, time with developers, demonstrations at Effera, and even lunch. We have enjoyed our time working with Effera, and have gained a lot of valuable knowledge and experience.

4.5 Co-operation with Advisor

Co-operation with our advisor Nilsen has been about as we expected. Nilsen has answered questions well in a timely manner and given relevant feedback in meetings. We chose Nilsen because, based on our previous experience with him, he allows us to operate to our best potential. We also appreciate Nilsen's pragmatic and sensible approach. Towards the end of the project we also got very valuable feedback from Nilsen regarding this report.

4.6 Microsoft HoloLens - Further Plans for Development

Effera is looking at Microsoft HoloLens as an interesting and innovative technology which within a few years may enter different markets and once there might grow rapidly depending on how well the market(s) respond to it. When/if that happens it would be a great advantage for companies to have a product/MVP of an application they can use as an example when meeting customers. Not only showing what they have done, but also assuring the customer that they have already developed applications for AR and therefore “know what they are doing”. This can give said company an edge when customers compare them to competitors which may not have researched AR related development yet.

As for AR and the HoloLens, being *new technology* isn’t reason enough to start using it in the workplace. It would have to create value for the user by making their work more efficient, precise or perhaps work under conditions where other options would be problematic to use. For our application to be used and prefered over mobile/manual writing of deviations the main criteria that would have to be improved in our opinion (supported by test subjects, see chapter 4.3.1) would be the device itself. Either in a newer version of Microsoft HoloLens, or other AR smart glasses.

We’ve ranked a few of these improvements below:
Must have (needed to use effectively and comfortably throughout a working day):

- Increased comfort when wearing/using the smart glasses
- Greater field of view
- Increased battery lifetime.

Should have (for even better user experience):

- Increased processing power, allowing better quality holograms and greater FPS
- Increased voice control/command functionality and possibilities

HoloLens 3.0 is under development although minimum information has been revealed about it yet. It could bring improvements which enables the HoloLens to become a preferred platform over current mainstream platforms (smartphones and tablet devices).
“The successor to HoloLens will reportedly arrive in 2019, three years after the headset started shipping to developers. It’s not clear what Microsoft has planned for HoloLens, but it’s reasonable to assume the company will shrink the headset’s size and improve things like battery life, processing power, and maybe even the field of view.” (Warren, 2017).

Microsoft probably have multiple reasons regarding their decision to skip HoloLens 2.0. One forum user observes the following “(...) *Do you rush out products that are expensive, quickly obsolete and don't grab many buyers in the name of "getting to market first"? Or do you iterate it internally and among select developers until your actual concept is practical and at prices that will gain a high volume of sales? The technology in this area is advancing faster than they can integrate it into a coherent product and get it to manufacturing.”* (swb, 2017). Waiting a few years might be the best business strategy. With that said, by waiting too long an AR competitor might swoop in and take the market by surprise.

4.7 State of AR - alternatives to Microsoft HoloLens

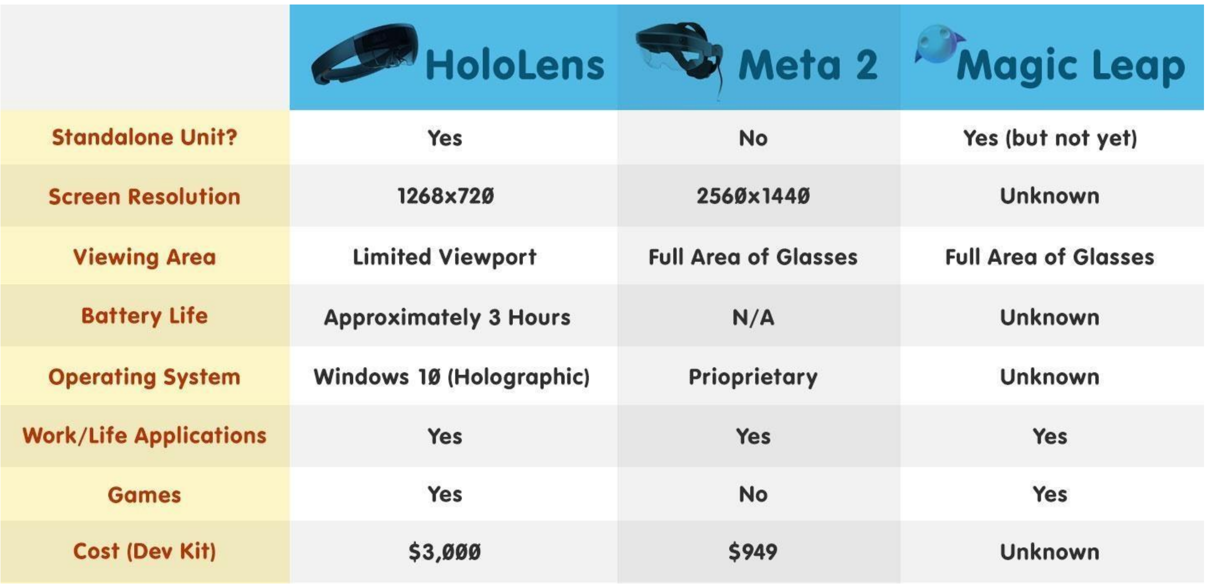
There are multiple AR smart glasses in the works. Some can already be acquired like the HoloLens, while others aren't available. After a bit of research it seems like the different competitors are keeping their cards close to their chests. They are probably all aware that whomever *wows* the AR market first may get a big advantage and foothold as it grows.

As we've said there are different types of AR headsets in the works. We will make a short comparison of three of them: Microsoft HoloLens, Meta 2 and Magic Leap. There are other in the works, like DAQRI, but due to limited information we will only compare the 3 mentioned above.

HoloLens is wireless which grants a lot of opportunities, but also certain constraints. Particularly the battery lifetime and processing power is somewhat reduced. It features an in house made Holographic Processing Unit (HPU). This HPU processes terabytes of data in real time, in order to handle, among other things, spatial mapping (Dachis, 2016). HoloLens are the only smart glasses where we've found examples of practical use in our research. ThyssenKrupp claims their workflow is 4x faster using the HoloLens (O'Brien, 2017). Another positive thing about the HoloLens is that it recently passed a protective eyewear test for use in the workplace (Mangiaracina, 2017).

Meta 2 is going a different route and since it is tethered to a computer it offers more processing power and a better resolution, but obviously with the catch that you are limited by a (currently) nine-foot long cable. Meta 2 is focusing on practical applications and has no focus towards games, since tripping on the cable wouldn't be much of an experience. Meta 2 wants to move away from the traditional computing environment. They have turned to neuroscience, with the goal that their operating system creates an environment which the user *just understands* - even without having to learn it first. To interact with a hologram in Meta 2 you can treat it like a physical object. They have a realistic view of their goals and don't believe the hardware they need will be available for another five years time (Dachis, 2016).

Magic Leap is a holographic headset which creates augmented reality experiences suited for both games and practical applications. You can place information around the room similar to what can be done with the HoloLens. HoloLens utilises a set of gestures while Magic Leap has a different approach where it seems to understand your hand movements more intelligently. A common problem for all smart glasses is that they struggle with lights, windows and mirrors. HoloLens tries to solve this with their selected gestures. It will be interesting to see whether or not Magic Leap will overcome these issues and understand natural hand movements in different environments. Should that be the case Magic Leap would have quite the advantage as it would have the positives of HoloLens (being wireless and supporting spatial mapping), while also having a more natural way of interaction like Meta 2 aims for (Dachis, 2016).



	HoloLens	Meta 2	Magic Leap
Standalone Unit?	Yes	No	Yes (but not yet)
Screen Resolution	1268x720	2560x1440	Unknown
Viewing Area	Limited Viewport	Full Area of Glasses	Full Area of Glasses
Battery Life	Approximately 3 Hours	N/A	Unknown
Operating System	Windows 10 (Holographic)	Prioprietary	Unknown
Work/Life Applications	Yes	Yes	Yes
Games	Yes	No	Yes
Cost (Dev Kit)	$3,000	$949	Unknown

Figure 3 A visual presentation of some of the differences between the 3 smart glasses, 2016.

A market in which AR might prove valuable could be 3D modelling within architecture and construction (eg how something would look like after (re)construction), as well as any type of work where your hands are occupied (carrying something, dirty hands (eg oil or grease) etc.). Smart glasses can be used in situations where it would be sensible to replace the use of a handheld device. Live streaming a video feed from the smart glasses can also add value to situations where the user needs input from an expert - both can look at the same thing and work out a solution.

4.8 External Interest in our Project

While working with this project we have gotten definitive proof that it concerns a new and interesting technology. Prior to starting our project we had briefly discussed the possibilities for creating some attention and some *light marketing* of our project and application. A few months into our project, we mentioned our project to representatives from the IS department at UiA, and they hired *Kompetansetorget* to write an article[1] about us and our project. This was very useful both as marketing for our chosen study programme (bachelor in IT and information systems) and for promoting co-operation between the university and local businesses, but also for marketing our own knowledge and experience.

A short while after this article was published we got an inquiry from a student group writing a paper about using VR for learning purposes. They'd read the article, found it interesting and wanted to have a conversation with us about what we'd learned and found during our project. Both of these events underline the new and exciting nature of our project as well as the technologies and the field it's taken place in. This has been a significant motivator in our work and has pushed us to make the very most of it and do our absolute best.

[1] http://kompetansetorget.uia.no/siste-nytt/ser-inn-i-fremtiden-med-effera-i-bachelorprosjekt

5. Conclusion

Prior to this project we wanted to use and expand on the knowledge and competence we've gained over the last 2 ½ years of our education. We also wanted to push ourselves and were very interested in a challenging project from a demanding and professional employer.

Working with this project has given us a wide array of knowledge and experience. We've learned a great deal about the technologies and relevant fields (Microsoft HoloLens and AR), as well as how development for this platform can be done. This knowledge is very valuable as it is brand new and its relevancy and importance will only grow in the future.

Our project has also given us significant experience of working in a rather large system development project and for an employer. We have had to use and expand on a lot of our knowledge of methodologies, project management and quality management. We have also learned a lot from having to discuss, prioritise and delegate tasks, managing our time (both the group's and for an individual group member).

In terms of the product we want to conclude by stating that HoloLens is the *proof of concept* for AR, and shows us that AR has a place in the future. We still consider HoloLens to be slightly ahead of its time, however a lot of the issues lies in the hardware and software maturity and not in the concept itself. The current state of our application proves that it's possible to adapt current systems to the HoloLens, but further improvements to the HoloLens is needed in order to gain an advantage over current platforms.

We have reached the goals we set at the start of this project. These were to use and expand on what we've learned throughout our bachelor in IT and information systems, gain knowledge and experience with HoloLens and AR, and experience how it is to work in a professional setting. We are very satisfied with the project and what we've learned and achieved throughout its course.

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Appendices

Appendix 1 - Statement from Employer

The scope of the project was to develop a demonstration application presenting how HoloLens could be used in an industrial environment.
Main features selected were to report a Deviation; take a snapshot, record a short video or audio using the HoloLens. Second major part of the project was to ensure that the HoloLens app is communication with the Effera Insight platform ensuring that what is reported from the HoloLens app is available for use by other apps on the platform.

We are very satisfied with the outcome of the project - all major features are in place and we now have a HoloLens application that we can use to demonstrate usability of new technology in the industry.

We are pleased with the team’s ability to work independently, and deliver the project on-time and with good quality. The team was able to work with our own resources, including UX, in a productive manner. The team showed an ability to communicate clearly and timely with the company, and got quickly up to speed with the project planning and delivery.

Frank Wehus
CEO

Appendix 2 - Self Evaluation from Group Members

Self Evaluation

Due to the previous experience the group has working together, we have been able to work in unity on most tasks. Collaborative tasks have included but not been limited to: writing the report (writing the content, quality assurance in form of feedback on content and collective read-throughs), project management, and in some cases even pair programming. We consider our co-operation in this project to be highly satisfactory and successful.

Arild Høyland

My main contributions to the project has been been planning, designing and implementation of UI and UX for our application and writing large parts of this report. Both of these tasks has been close collaborations with Gilje and to a lesser extent Ranestad. I have also been responsible for some functionality, such as displaying captured photographs in the application and most of the transitions between different windows. I have also been the main contact for our group for most of our communication with co-operators, although I wish to underline that this is something we've done in unity as much as possible.

Håkon Gilje

During the course of the project my main contribution has been planning, designing and implementation of UI and UX for our application, as well as researching and at times implementing new technical solutions. These functions include but are not limited to the cursor, moving windows with the user's gaze, group toggling of windows, scanning QR codes and voice commands . A lot of the UI/UX have been worked on in close collaboration with Høyland. At times I've also worked with Ranestad when looking through technical solutions and ensuring quality.

Yngve O. Ranestad

In March I got a job at Go Mobile where I develop mobile applications using C# and .NET. This has helped me get even more experience with the technology used in this project and because of this I was able to write code with better quality and standards, and pass this into the project.

My role in the project has been focused on networking and the connection to Effera Insight. Because of my role I've been in frequent contact with our main contact, Bjellås, in regards to discussing the product's requirements to Effera Insight's REST API and in earlier stages the SignalR connection. The most prominent issues I've solved during the project is the networking connections and JSON serialisation with the restrictions Unity enforces on .NET and C#.

Appendix 3 - Stakeholders Meetings

Appendix 3.1 - First Stakeholders Meeting Agenda

Møteinnkallelse onsdag 15. februar 2017

Første styringsmøte - Avviksrapportering med Hololens, IS-304-prosjekt våren 2017

Møtet skal være en informasjon- og kommunikasjonsarena mellom oppdragsgiver, prosjektgruppe og veileder ved Universitetet i Agder. Prosjektgruppa vil presentere en gjennomgang av status og fremdrift så langt, planer og prioriteringer fremover og andre relevante temaer for prosjektets videre drift. Etter denne presentasjonen vil det være tid til spørsmål, tilbakemeldinger og diskusjon.

Tid og sted

Møtet vil finne sted i Effera sine lokaler (Gyldenløves gate 2), onsdag 15. februar 2017 kl. 14.00. Det er satt av én time til møtet.

Saksliste

Møtedeltakere må gjerne tilføye saker til denne sakslisten om ønskelig, gjerne etter pkt. 3 eller under pkt. 4.

Prosjektets status og fremdrift til nå

a. Forberedelse og oppsett
b. Grunnleggende funksjonalitet og grensesnitt
c. Nettverk (SignalR)

Videre plan og prioriteringer

d. Planlagt videre arbeid
e. Tidsbruk

Kvalitetssikring

Spørsmål, kommentarer, diskusjon og evt. møtekritikk

Appendix 3.2 - First Stakeholders Meeting Summary

Avviksrapportering med Hololens - Referat fra første styringsmøte - 15.02.2017

Vårt første styringsmøte fant sted den 15.02.2017 i Effera sine lokaler (Gyldenløves gate 2, Kristiansand).
Tilstede ved møtet var følgende:

- Samtlige i prosjektgruppa: Håkon Gilje, Arild Høyland og Yngve O. Ranestad
- Veileder ved UiA: Hallgeir Nilsen
- Fra Effera: Frank Wehus, Sondre Bjellås og Steffen Urdal Vetrhus

Møteinnkallelse ble sendt ut til Frank Wehus, Sondre Bjellås og Hallgeir Nilsen den 13.02.2017. Sakslista for møtet var som følger:

1. **Prosjektets status og fremdrift til nå**
    a. Forberedelse og oppsett
    b. Grunnleggende funksjonalitet og grensesnitt
    c. Nettverk (SignalR)
2. **Videre plan og prioriteringer**
    a. Planlagt videre arbeid
    b. Tidsbruk
3. **Kvalitetssikring**
4. **Spørsmål, kommentarer, diskusjon og evt. møtekritikk**

Møtet varte i ca. 50 minutter, etterfulgt av noen minutter samtale med veileder.

Vedtak og beslutninger:

- Det ble bestemt å ha et møte mellom prosjektgruppa, Frank Wehus og evt. andre hos oppdragsgiver, neste uke (20-24 februar). Temaet for møte er blant annet å sette fokus på kommersielle aspekter ved prosjektet og produktet, sørge for at prosjektet har konkrete mål som kan kommersialiseres osv.

Vedtak rundt produktet:

- **Utbedringer av det grafiske brukergrensesnittet som ble påpekt/anbefalt:**
    - I kvitteringsvindu, legg inn sone (standardvalg er aktiv sone, med mulighet for valg av annen sone hvis nødvendig)
    - Støtte for å legge til flere bilder pr. avvik
    - Sondre (Bjellås) ønsker også å sette oss i kontakt med UIX-ansvarlige hos Effera, for å få samkjørt produktets grafiske profil med Effera sine standarder. Dette forslaget fikk sterk støtte fra prosjektgruppa.

- **Beslutninger angående implementasjon av nettverkskoblinger (WebSockets m.m.):**
    - Foreløpig utforskning/prøving av WebSockets settes på vent. I følge Sondre (Bjellås) har vi kommet så langt at det skal være mulig å få til, men foreløpig har det vært vanskelig for oss å komme helt i mål med dette.
    - REST API vil være aktuelt å bruke uansett status på Websockets, og det er noe vi dermed legger til prioriteringslista over fremtidig utvikling/implementasjon.
- **Forslag/ønsker om ny funksjonalitet:**

    - Oppdragsgiver ytret ønske om funksjonalitet for å kunne skanne en QR-kode, automatisk hente opp sjekkliste for skannet kode (som refererer til ett spesifikt utstyr/en maskin) og automatisk sende dette inn. Vi foreslo å implementere dette som et selvstendig valg i applikasjonens hovedmeny, og fikk støtte for dette forslaget.

Vedtak rundt prosjektstyring:

Vedtak om leveranser og kvalitetskontroll:

- Oppdragsgiver foreslo at vi følger et lignende løp som oppdragsgiver gjør, med regelmessige leveranser/demonstrasjoner. Det ble foreslått at vi hver 14. dag (fredag) demonstrerer det som er utviklet siden sist demonstrasjon (utviklet/produsert siste to uker). Dette forslaget fikk sterk støtte fra prosjektgruppa.
- Kvalitetskontroll skal i større grad følge Effera sine rutiner og standarder. Vi vil få større støtte og oppfølging når det kommer til kodegjennomgang (*code review*), og å sørge for at produktet utvikles på en måte som ivaretar fremtidige utviklingsmuligheter.
- Etter innspill fra veileder (og i forbindelse med avtale om demonstrasjoner hver 14. dag) har vi i prosjektgruppa besluttet å *låne* noen aspekter ved Scrum. Vi vil kjøre sprinter på to uker, og i forkant av dette planlegge hva som skal demonstreres i slutten av sprinten (sprint planning). Halvveis i sprinten vil vi vurdere progresjon og evt. gjøre justeringer/opplyse om forsinkelser osv. Etter hver sprint vil vi gjennomføre en evaluering (sprint review).

Møtekritikk:

- Vi må sørge for å gi et overordnet innblikk i prosjektet, og ikke gå inn i tekniske detaljer ved prosjektet for fort.
- Viktigheten av å presentere det store bildet og ca. hvor langten er kommet ble presisert, samt viktigheten av å kunne beskrive rutiner og prosedyrer som følges for å sørge for kontroll i prosjektet.

Kristiansand, 16.02.2017 Arild Høyland

Appendix 3.3 - Second Stakeholders Meeting Agenda

Møteinnkallelse onsdag 5. april 2017

Andre styringsmøte - Avviksrapportering med Hololens, IS-304-prosjekt våren 2017

Møtet skal være en informasjon- og kommunikasjonsarena mellom oppdragsgiver, prosjektgruppe og veileder ved Universitetet i Agder. Prosjektgruppa vil presentere en gjennomgang av status og fremdrift så langt, planer og prioriteringer fremover og andre relevante temaer for prosjektets videre drift. Etter denne presentasjonen vil det være tid til spørsmål, tilbakemeldinger og diskusjon.

Tid og sted

Møtet vil finne sted i Effera sine lokaler (Gyldenløves gate 2), onsdag 5. april 2017 kl. 09.30. Det er satt av én time til møtet.

Saksliste

Møtedeltakere må gjerne tilføye saker til denne sakslisten om ønskelig, gjerne etter pkt. 3 eller under pkt. 4.

1. Produktets status og fremdrift til nå
   a. Demo - film eller direkte demonstrasjon
   b. Innspill fra demonstrasjoner

2. Videre plan og prioriteringer
   a. Brukertesting
   b. Test i forskjellige miljøer

3. Utfordringer
   a. Kommunikasjon, samarbeid med oppdragsgiver
   b. Nettverk

4. Spørsmål, kommentarer, diskusjon og evt. møtekritikk
   a. Dokumentasjon rundt overlevering av produkt/prosjekt

Appendix 3.4 - Second Stakeholders Meeting Summary

Avviksrapportering med Hololens - Referat fra andre styringsmøte - 05.04.2017

Vårt andre styringsmøte fant sted den 05.04.2017 i Effera sine lokaler (Gyldenløves gate 2, Kristiansand).

Tilstede ved møtet var følgende:

- Samtlige i prosjektgruppa: Håkon Gilje, Arild Høyland og Yngve O. Ranestad
- Veileder ved UiA: Hallgeir Nilsen
- Fra Effera: Frank Wehus

Møteinnkallelse ble sendt ut til Frank Wehus, Sondre Bjellås og Hallgeir Nilsen den 31.03.2017. Sakslista for møtet var som følger:

1. **Produktets status og fremdrift til nå**
    a. Demo - film eller direkte demonstrasjon
    b. Innspill fra demonstrasjoner

2. **Videre plan og prioriteringer**
    a. Brukertesting
    b. Test i forskjellige miljøer

3. **Utfordringer**
    a. Kommunikasjon, samarbeid med oppdragsgiver
    b. Nettverk

4. **Spørsmål, kommentarer, diskusjon og evt. møtekritikk**
    a. Dokumentasjon rundt overlevering av produkt/prosjekt

Møtet varte i ca. 40 minutter, etterfulgt av 20 minutter samtale med veileder.

Vedtak og beslutninger

Det ble bestemt å ha et møte med prosjektgruppa og flere representanter fra oppdragsgiver den 19. april. I dette møtet vil utfordringer vi i gruppa har rapportert om tas videre med oppdragsgiver - med fokus på tilgang til ressurser, en avklaring rundt lisens for utviklingsmiljø og plan for dokumentasjon og overlevering av produkt.

Vedtak om produktet

Det ble ikke fattet noen nye vedtak omkring produktet i dette møtet. Eventuelle nye vedtak vil bli fattet i møtet den 19.04.

Vedtak om prosjektstyring

Det ble ikke fattet noen nye vedtak omkring styring av prosjektet i dette møtet.
Vi fikk innspill fra veileder om at en omtrentlig oversikt på hva våre arbeidstimer går til kan være en nyttig å undersøke.

Møtekritikk

Vi fikk gode tilbakemeldinger på gjennomføringen av møtet, og det ble ikke gitt noen konkret kritikk eller innspill til fremtidige møter.

Kristiansand, 05.04.2017 Arild Høyland

Appendix 4 - Group Contract

Gruppekontrakt

Mål

- Gruppas mål er å levere et sluttresultat alle har bidratt med og er fornøyd med.
- Overholde tidsfrister som er gitt ved møter/innleveringer
- God stemning og godt arbeidsmiljø innenfor gruppa
- Holde gruppa informert til enhver tid på valgte kommunikasjonskanaler (Facebook, telefon osv.)
- Gi alle en sjanse til å bidra, for å unngå *sosial loffing*
- Generelle valg blir gjort demokratisk

Kap. 1 Kommunikasjon og kommunikasjonskanaler

§1) Gruppa har i fellesskap vedtatt at all kommunikasjon finner sted via følgende kanaler:

§1a) Viktig informasjon legges ut på gruppas Facebook-gruppe *IS-304 - Bachelorprosjekt.* Dette er eneste akseptable kanal for viktige beskjeder (primærkanal).[2]

§1b) For henvendelser eller spørsmål av liten viktighetsgrad, eller som ikke angår samtlige gruppemedlemmer og/eller prosjektets utvikling osv., benyttes gruppechatten på Facebook *IS-304 - Bachelorprosjekt* (sekundærkanal).

§1c) Hvis nødvendig kan gruppemedlemmer kontaktes på telefon.

§2) Gruppas medlemmer plikter å være tilgjengelig på de kommunikasjonskanaler som er beskrevet i §1, og skal regelmessig sjekke og holde disse oppdatert.

§2a) Det forventes at kommunikasjonskanaler sjekkes regelmessig nok til å unngå urimelig lange responstider. Dette fastsettes ikke i detalj, men bør være omtrentlig slik (eller oftere):

1) I ukedagene: sjekk av kommunikasjonskanaler morgen/tidlig dag, midt på dagen/tidlig ettermiddag og sen ettermiddag/kveld
2) I helger/ferier forventes det sjekk av kommunikasjonskanaler en gang i døgnet.

§2b) Unntak fra §2a er akseptabelt hvis disse er varslet på forhånd, eller hvis de faller på tidspunkt der det forventes lavere behov for kommunikasjon (helger, ferier osv.).

a) Unntak fra §2b kan inntreffe i forbindelse med innleveringsfrister og lignende forhold.

§3) Gruppa vil benytte Google Disk som dokument- og administrasjonsverktøy. Alt av dokumentasjon og andre administrative ressurser vil lagres her, med mindre annet spesifiseres.[3]

Kap. 2 Gruppemedlemmers ansvar

[2] https://www.facebook.com/groups/1231305560263818/

[3] https://drive.google.com/drive/folders/0B3DOTCH6DY0lQXktTWFMNU5fVHc

§1) Hvert gruppemedlem har ansvar for å sørge for et godt arbeidsmiljø og gode arbeidsforhold både innad i gruppa og i samarbeid med veileder, prosjektleder og oppdragsgiver. Prosjektet skal først og fremst være en læringsprosess, og det er viktig at gruppas medlemmer er rause med hverandre og setter læring og egenutvikling i fokus. Selv om det stilles krav til hvert gruppemedlem skal det være lav terskel for å spørre om hjelp eller støtte, uansett type eller form.

§2) Gruppemedlemmer plikter å vise stort engasjement og stor grad av selvstendighet og initiativtakning. Dette er viktig for å sørge for en jevn progresjon i prosjektet og unngå for stor forskjell eller avstand mellom gruppemedlemmenes kompetanse, erfaring og progresjon.

> §2a) Dersom et gruppemedlem av ulike grunner ikke leverer eller presterer på ønsket nivå må dette tas opp så fort som mulig i gruppa. Dette kan gjøres både av gruppemedlemmet selv og av andre gruppemedlemmer. Konsekvensen av dette vil bli tatt opp med veileder.

§3) Ut i fra gruppas mål om å gjennomføre ett årsverk á 1750 arbeidstimer, må hvert gruppemedlem tilstrebe å bruke samtlige tilmålte arbeidstimer pr. uke til arbeid, læring og/eller egenutvikling som kommer prosjektet til gode. Arbeidstimer pr. uke pr. medlem vil være ca. 29 (1750 timer / 3 / 20 uker). Det presiseres at noen av disse timene vil bli brukt til forelesninger og obligatoriske gruppemøter med veiledere, prosjektledere og/eller oppdragsgiver.

> §3a) Ut i fra målet om stort engasjement og initiativ som beskrevet i §2 vil det være fullt mulig for gruppemedlemmer å arbeide utover det timetallet som er beskrevet i §3. Det understrekes at dette arbeidet må være av frivillig karakter. Slikt arbeid kan ikke tillegges vekt i sammenligninger eller evalueringer av gruppemedlemmers arbeidsinnsats og bidrag i prosjektet.
>
> §3b) Dersom uforutsette forhold fører til at et gruppemedlem ikke er i stand til å oppnå ønsket antall arbeidstimer pr. uke gjentatte ganger eller over lenger tid må dette tas opp med gruppa så fort som mulig. Hvis aktuelt/nødvendig kan også veileder og/eller prosjektleder ved UiA og/eller oppdragsgiver kobles inn.

§4) Gruppemedlemmer forplikter seg til å møte opp til alle avtalte tidspunkt i god tid.

> §4a) Det legges spesielt vekt på at samtlige gruppemedlemmer møter opp i god tid til alle møter med veileder, prosjektleder og oppdragsgiver.
>
> §4b) Ved forsentkomming skal dette varsles så fort som mulig via en av de tre vedtatte kommunikasjonskanalene.
>
> §4c) Avbud (både planlagt og uforutsett) skal meldes så fort som overhodet mulig via gruppas primærkanal.
>
> §4d) Ved fravær er det gjeldende gruppemedlemmet pliktig til å holde seg oppdatert på hva som har skjedd på gruppemøtet.
>
> §4e) Ved gjentatt fravær og upresist oppmøte må dette tas opp med gjeldende medlem.

§5) Gruppemedlemmer skal alltid være forberedt til gruppemøter. Dette er spesielt viktig ved gruppemøter som omhandler spesifikke temaer eller oppgaver. Gruppemedlemmer skal gå gjennom relevant materiale i forkant av slike møter.

> §5a) Det legges særlig vekt på slik forberedelse til møter med veileder, prosjektleder og oppdragsgiver.

§5b) Dette vil være særlig viktig ved møter som omhandler krav til innlevering, diskusjon av kravspesifikasjon og lignende forhold som har stor betydning for prosjektets videre planlegging og utvikling.

Kap 3. Gruppas struktur og oppbygging

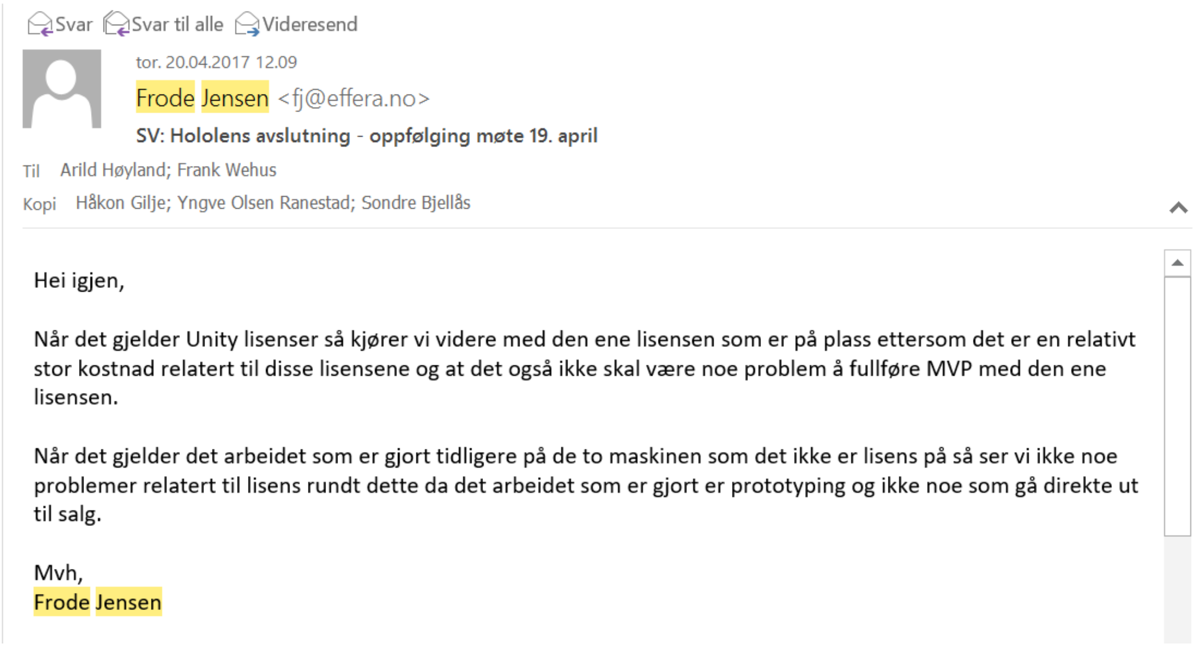
Gruppa vil ha en flat struktur uten en formell gruppeleder. Vi kjenner hverandre godt og samarbeidet går enkelt og effektivt, og vi ser ikke behov for en gruppeleder. Vi er også en relativt liten gruppe, og anser det dermed som viktig at alle har oversikt over prosjektet.

Kristiansand, 10.01.2017

Arild Høyland	Håkon Gilje	Yngve
Arild Høyland	Håkon Gilje	Yngve O. Ranestad

Appendix 5 - Important Emails

Appendix 5.1 - Final Decision about Unity License



tor. 20.04.2017 12.09

Frode Jensen <fj@effera.no>

SV: Hololens avslutning - oppfølging møte 19. april

Til Arild Høyland; Frank Wehus

Kopi Håkon Gilje; Yngve Olsen Ranestad; Sondre Bjellås

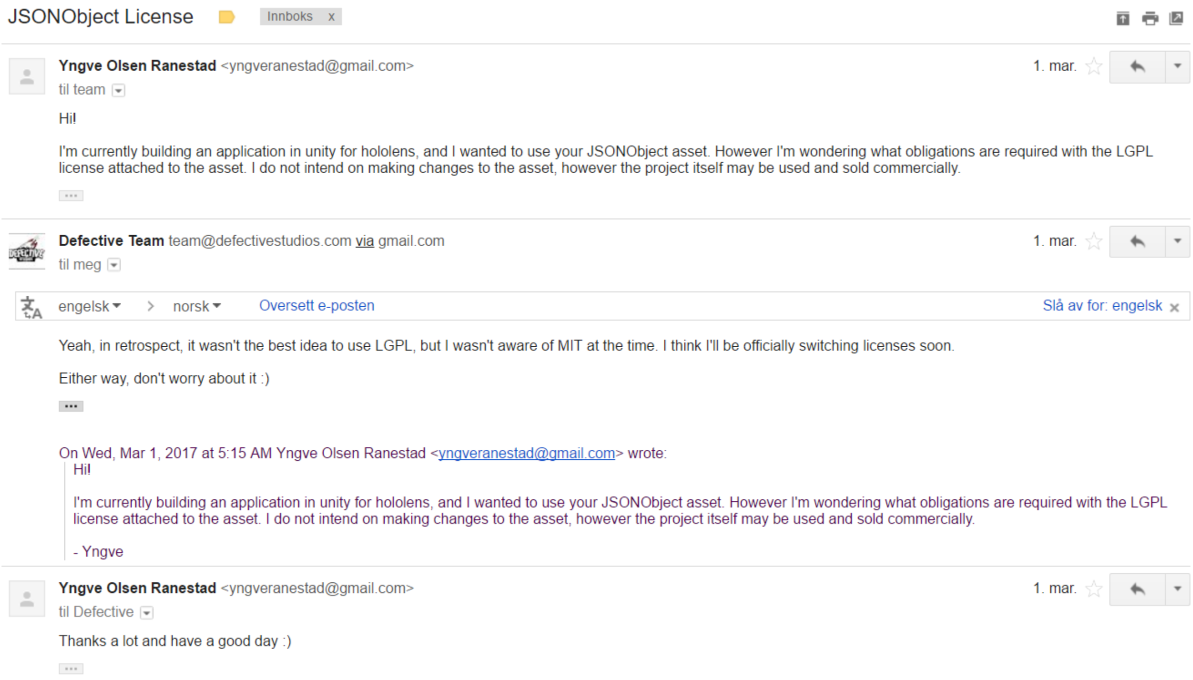
Hei igjen,

Når det gjelder Unity lisenser så kjører vi videre med den ene lisensen som er på plass ettersom det er en relativt stor kostnad relatert til disse lisensene og at det også ikke skal være noe problem å fullføre MVP med den ene lisensen.

Når det gjelder det arbeidet som er gjort tidligere på de to maskinen som det ikke er lisens på så ser vi ikke noe problemer relatert til lisens rundt dette da det arbeidet som er gjort er prototyping og ikke noe som gå direkte ut til salg.

Mvh,
Frode Jensen

Appendix 5.2 - JSONObject License Email



JSONObject License

Yngve Olsen Ranestad <yngveranestad@gmail.com> 1. mar.

til team

Hi!

I'm currently building an application in unity for hololens, and I wanted to use your JSONObject asset. However I'm wondering what obligations are required with the LGPL license attached to the asset. I do not intend on making changes to the asset, however the project itself may be used and sold commercially.

Defective Team team@defectivestudios.com via gmail.com 1. mar.

til meg

engelsk > norsk Oversett e-posten Slå av for: engelsk

Yeah, in retrospect, it wasn't the best idea to use LGPL, but I wasn't aware of MIT at the time. I think I'll be officially switching licenses soon.

Either way, don't worry about it :)

On Wed, Mar 1, 2017 at 5:15 AM Yngve Olsen Ranestad <yngveranestad@gmail.com> wrote:

> Hi!
>
> I'm currently building an application in unity for hololens, and I wanted to use your JSONObject asset. However I'm wondering what obligations are required with the LGPL license attached to the asset. I do not intend on making changes to the asset, however the project itself may be used and sold commercially.
>
> - Yngve

Yngve Olsen Ranestad <yngveranestad@gmail.com> 1. mar.

til Defective

Thanks a lot and have a good day :)