BIMplimentation, BIMtergration

A research to the implementation and integration of BIM as a building process for existing buildings.

Building Technology
Graduation studio

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Focus and restrictions – This thesis focusses on how to implement and integrate BIM as a building process for existing buildings on a social and organizational level. The research has been conducted through a case study at VolkerWessels Bouw Schiphol, during the project upgrade Wortel g-pier. The results of this case study have been generalized to be applicable on all building projects where there is an existing building at the start of the project. This research does not focus on the implementation and integration of BIM as a building process for new buildings.

Abstract – How is BIM implemented and integrated as a building process for existing buildings on a social and organizational level? By researching the building process at Schiphol during the project upgrade Wortel g-pier and combining these results with theoretical knowledge of BIM, a hypothesis could be written with a potential method of implementing and integrating BIM. This hypothesis could then be implemented and tested for the project upgrade Wortel g-pier at Schiphol Airport. The results of the implementation of the hypothesis could then be generalized to all projects where there would be an existing building.

Key words – BIM, Building process, Schiphol, Existing buildings, BIM circle,

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Preface

The last step in gaining a master's degree in the field of Building Technology at Delft University of Technology, is to write a thesis on a subject of choice, within the boundaries Building Technology. Whilst most people decide to research topics like new materials or new production methods, I decided to tackle a more current topic, BIM. I felt that this topic fit perfectly in the field of Computational Engineering and Construction. With this idea and a personal affection for airports I decided to approach VolkerWessels Bouw Schiphol for the possibility of doing research on this topic.

I want to thank Ricardo de Leeuw, Jorn Kwee from Volker Wessels Bouw Schiphol and Emiel Reniers from Visser&Smit Bouw, for their time and dedication in assisting me during my research. Thanks to them I was able to witness the way projects are executed at Schiphol.

I also want to thank all interviewed staff from the different departments and companies for the available time, their honest opinions and views on the topic of BIM.

Finally, I would like to thank Boris Bahre and Frank Schnater from the Delft University of Technology for the time and dedication they have given in helping me complete this research and thesis.

I hope this thesis will give better insight as to how projects are executed at Schiphol, how this can be done better and how renovation and upgrade projects in general can be executed more efficient through social and organizational implementation and integration of BIM as a building process.

Introduction to Research

While the Building Technology master thesis is a chance to research a topic, which can have impact in the future, it also provides a chance to research a more actual topic. The choice was made research the topic of BIM. "BIM is a topical theme in the Netherlands. (CAD-Magazine, 2016) BIM introduces a new way for companies to work together improving productivity and efficiency via enhanced collaboration and integration.
(Fakhimi, Majrouhi Sardroud, & Azhar, 2016)

With technology making it possible and affordable to do so, the greatest challenge is to convince architects, engineers and contractors that this process, together with its tools is future proof and makes the actual building process, more affordable and more efficient.

For BIM to succeed it is very important to realize that not only the tools must be understood, BIM also incorporates a new method of working together. The biggest problem with BIM is not the development of software or technology, as a matter of fact, the biggest problem is that field experts get stuck on traditional building methods when they should have moved on to more modern methods like BIM. (Aish & Bredella, 2017)

This is a challenge which VolkerWessels Bouw Schiphol (VWBS) is confronted with while executing projects at Schiphol. VWBS considers itself to be a company willing to invest time and resources in implanting and integrating BIM as a building process. This statement can be backed up by personal experience in the company. The Information, Digitalisation en Technology (ID&T) team of Visser&Smit Bouw (VSB) which is part of VWBS is working hard to implement BIM as a building process within the company. VSB has been showing good results implementing BIM in different design and built projects.

Unfortunately, the Schiphol division (Volker Wessels Bouw Schiphol) of parent company Volker Wessels has had difficulties implementing and integrating BIM in the upgrade and renovation projects at Schiphol. While discussing a potential research topic in the field of BIM, this issue kept reoccurring. Upon further debate, the decision was made to research why the implementation and integration of BIM is so challenging at Schiphol. The results would then be used to create a roadmap for general upgrade and renovation projects. The choice was made to specifically research the issues occurring with the upgrade of the Wortel G-pier at Schiphol making it possible dig deeper into the challenges this project was faced with. While having attempted to integrate BIM at Schiphol before, the upgrade Wortel G-pier had proven to be extra challenging because of the involved companies and the way the project came to be.

Figure 0: Render of upgrade Wortel G-pier (tenderned)

The research would consist of different steps to figure out why the implementation and integration of BIM was so challenging for this project, explain how the implementation and integration of BIM should have been and provide a directory with information on how to correctly implement BIM within renovations and upgrade projects in general. In the methodology chapter the research process will be elaborated.

VSB and VWBS

To be able to gain all the information needed, half of the research would be conducted at the VWBS office at Schiphol in the department which was tasked with the work preparation. This department was chosen because of the stage in which the project was at the time of the research and because this department had the most contact with all external teams tasked with this project. Conducting research from this position made it possible to attend all the project meetings personally. Furthermore, it gave a good insight into the way the engineers in charge of the work preparations worked.

The other half of the research was spent at the VSB office in Rotterdam. This because the ID&T department worked from the VSB office in Rotterdam. I was personally guided by the BIM manager at the VSB office. This was also the person who could answer any questions about the BIM process at Schiphol and the intended BIM process according to VWBS.

Research questions

With the general idea of the research in place, the following research question was introduced, and discussed:

"How can BIM be optimally used as a building process when considering a building which already exists and is constantly being transformed?"

To further get a grip on this question 10 sub questions were introduced to help answer the main question.

1. How does Schiphol currently decide when a renovation or upgrade project is required?

2. Which team decides what the renovation and/or will look like? Is this a linear process or a circular process?

3. What happens with any objects in the project location? Re-use?

4. Where can BIM assist in the traditional process to increase the level of ease?

5. How can BIM be integrated step by step and what preparations need to be taken?

6. At what point can BIM take over the "traditional" process as the main process?

7. What will the BIM process look like when it is completely integrated in Schiphol?

8. What are the benefits of a fully integrated BIM process?

9. What are the potential risks of integrating BIM?

10. Which process is the most realistic for Schiphol?

Methodology

When considering a new building process, there are a lot of steps which need to be taken. As will be explained in the next chapter, it isn't only the integration of new software and technology which make BIM successful. The fact that building projects are executed by people plays a major role. The mentality of people towards BIM, the expertise in the field of BIM and the willingness to try out something different, play a much more important role in the success of implementing and integrating BIM than the availability of software and technology. Often the implementation and integration of BIM creates a shift in the hierarchy of traditional building processes, giving some teams more power and some teams less power.

To find out what was going on at Schiphol with the upgrade Wortel G-pier project and the implementation and integration of BIM, first the theory behind BIM had to be researched. This was done acquiring information and data from scientific sources like: scientific magazines, scientific articles, books, journals and websites. This way the personal knowledge of BIM could be increased to a level which was needed to conduct this research.

The current situation

The next step was to find out how the project upgrade Wortel g-pier was currently executed. In the first week at VWBS it became apparent that there was a difference between BIM as building process and the way BIM was being used at Schiphol. To gain better knowledge as to why this difference existed, it was important to first find out which companies were involved with this project and what their role was in this project.

After finding out all the companies that were involved, the next step was to figure out how they communicated with each other. This because BIM requires a very open way of communicating. For BIM to succeed, all teams should be open and willing to ask questions and be asked questions throughout a project. It became apparent in the early stages of the research that communication was being conducted through a traditional hierarchy, making receiving information challenging at times. Why this communication hierarchy and the difficulty receiving information existed would be further researched and explained.

Another question which also needed to be researched was, what the vision of every involved company was in the are of BIM. This vision would have to include the definition of BIM and the way these companies envisioned the collaboration between each other.

These questions were answered through interviews with experts of every company. These experts consisted of people who were directly involved with the BIM process, BIM modelers, Project leaders, work preparers, architects, etc. Because every company played a different role in the project, a different question set was

created for every team. These questions were based on the role of each team in the building process.

The interviews

To try and unlock more information from every team the choice was made not to conduct the interviews through question and answer. The interviews were done in conjunction with a PowerPoint presentation (appendix B). This presentation included the current building process and a hypothetical building process. The choice to present information beforehand was to attempt to dig deeper into the reality of the situation. The belief was that a person will have more to say about something that is presented to them rather than answering a blank question.

In practice this worked out well. Most experts had a very clear opinion on what was presented in the PowerPoint presentation and often wanted to go back to certain slides to better state their vision. The statements and points shown in the slides would be discussed extensively. This was very valuable to the research, to a point where a company even admitted having made mistakes. One can imagine that in a straight up interview a company will not be quick to admit it makes mistakes but try and pin this on another company, but when presented with statements based on prior research it is forced to comment on the reality, by either explaining why a statement is true or not.

A quick review of the interviews made it become apparent how different the visions in BIM were of every team. These differences in opinion about BIM reflected the challenges during the project. Most teams claimed that they were using BIM in the sense of a process, but where mostly only using BIM as a tool.

The hypotheses

Schiphol is a unique case. Being the third busiest airport in Europe, this building handled 68.5 million passengers last year on 496748 flights. (EgonZehnder, 2017) Renovation and upgrade projects at Schiphol are difficult because the airport is open 24/7 and it is impossible to close even part of the airport to execute these projects. Therefore, close cooperation between all teams involved with these projects is important.

Based on the theory which is researched in the introduction to BIM chapter and the problems that came forward in the interviews, a hypothesis was made. Seeing the challenges faced at Schiphol and the fact that building already exists, some aspects of the standard BIM theory have been altered to better suit this specific situation.

Testing the hypotheses, theory vs practice

The next step in the research was to test the hypotheses. During this stage two levels of research would come together. Theory versus practice. This was partly done by showing the theoretical BIM process to every involved team and asking them what they taught of it. By doing the BIM process could be debated with every

company, comparing the theoretic process to the real-life situation. The results from the debate would then be considered and a hypothesis would be created.

Organization vs. Object based

To further test the hypothesis versus the reality a choice was made to not only look at the organizational scheme, but also to look at some real-life issues which were dealt with during the research. Even though there were different issues during the entire project, a choice was made to further elaborate three issues. These three issues each occur in a different stage of the BIM process. This way it became clear that issues occurred during the entire project, not only during a certain stage. Every issue also has a different cause. For all these issues a solution is shown of how this issue could have been prevented if the BIM process had been implemented and integrated successfully.

Scheme

The scheme below shows the above explained process, from finding out what the current situation is at Schiphol to the making of the report.

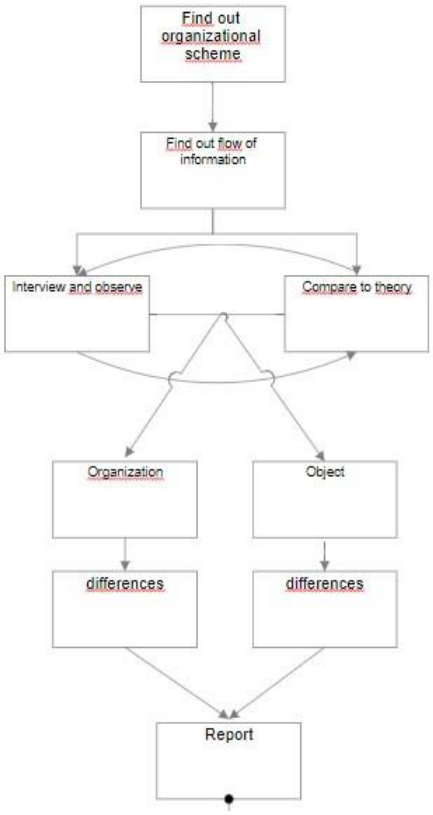

Figure 2: Methodology Scheme

Introduction to BIM

Building Information Modeling (BIM) is the process of creating and managing 3D building data during its development. BIM is a complex multiphase process that gathers input from team members to model the components and tools that will be used during the construction process to create a unique perspective of the building process. (Khochare & Warhmare, 2018)

The 3D process is aimed at achieving savings through collaboration and visualization of building components into an early design process that will dictate changes and modifications to the actual construction process. It is a very powerful tool that when used properly will save money, time and simplify the construction process. (Rodriguez, 2018)

In the first paragraph of this paper BIM is clearly defined as a process. It is very important to understand that BIM is a **process** and not a **product,** Building Information Modelling versus a Building Information Model. In this paper when the abbreviation BIM is used, it is always referred to as the **process,** unless stated otherwise.

History of BIM

The concept of BIM has existed since the 1970s. It wasn't however until the 1990s before BIM started gaining in popularity and the acronym BIM started being used more mainstream. (Eastman, Teicholz, Sacks, & Liston, 2008) In 2002 Autodesk released a whitepaper titled "Building Information Modeling" sparking other software vendors to also start to assert their involvement in the field. In 2003 Jerry Laiserin made sure that BIM became the standard to what was previously a scatter of different standards and software packages such as "Virtual Building" and "Integrated project models". (Laiserin, 2003)

It was thanks to previous developments such as RUCAPS, Sonata and Reflex that BIM was developed. It is important to mention one specific company, Graphisoft, that provided possibly the most important role in the existence of BIM. Graphisoft had been developing such solutions for longer than its competitors. Especially the development of ArchiCad, which was regarded back then as "one of the most mature BIM solutions on the market". (Laiserin, 2003b)

The BIM dimensions

In the Netherlands BIM is becoming more mainstream in the building industry because of the way BIM deals with the sharing of information between different stages of the construction process. (Vos, 2018) As explained earlier BIM stands for Building Information Modelling. This means that it stands for the generation and management of the physical and functional information of a project through collaboration and visualization. Put in simple terms, how information is managed within objects and how this information is shared between different teams within a company.

Now the output of this process, thus the generation and management of physical and functional information of a project, is what we refer to as Building Information Models. These Building Information Models contain all aspects of a project and support decision making throughout a project cycle. (Goubau, 2018)

Unfortunately, the public often thinks that Building Information Models only contain visual 3D objects. For this reason, BIM models are often confused with 3D models. BIM models contain much more than 3D data (width, Height and depth). They also contain further, data related, dimensions such as material (3D), time (4D), cost (5D) and even as-built operation (6D). (Smith, 2014) In recent years there has even been debate as to integrate a seventh dimension to BIM. This new dimension would contain all sustainability information.

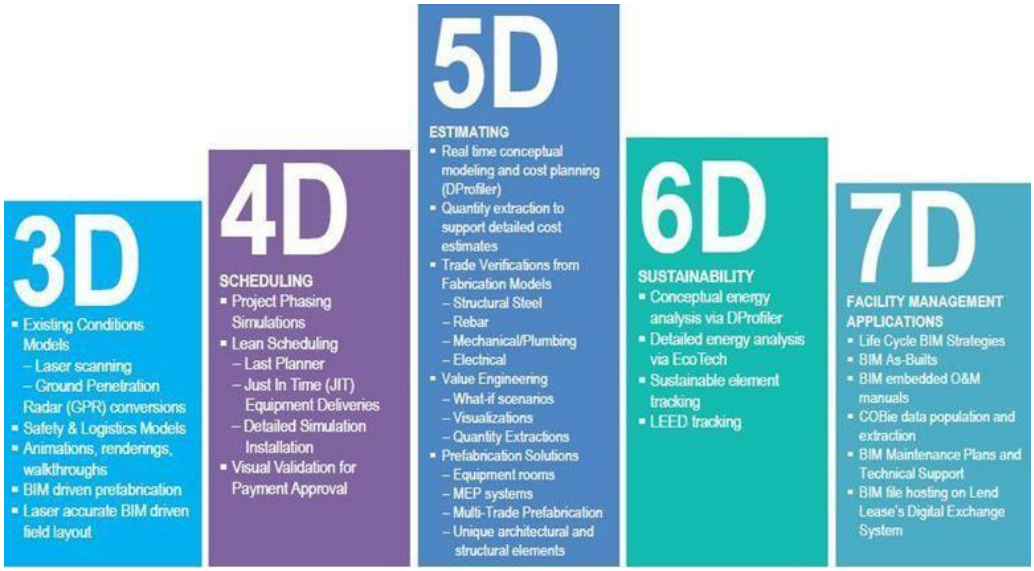

Figure 3: 7D BIM. (http://www.bimpanzee.com/bim-3d-4d--5d--6d---7d.html)

The BIM process

The next step to understanding BIM is to find out how the BIM process works. This can be done by looking at the BIM circle and the level of detail (LOD) of the BIM model.

The BIM circle is made up of all building stages in a building process. This circle goes around continuously throughout the lifecycle of the building until it reaches the point of demolition. During this process all involved teams play a role in each stage of the circle. The team executing one of the stages plays a lead role, being continuously assisted by all other teams, who give advice.

For example: In the image below the Conceptual stage is chosen. During this stage the architect will start creating a concept design based on the programming. During this stage the architect is constantly given advice by the contractor who

oversees fabrication or te client who helped set up the programming. As the design matures, through each stage, more information is added to the model and shared.

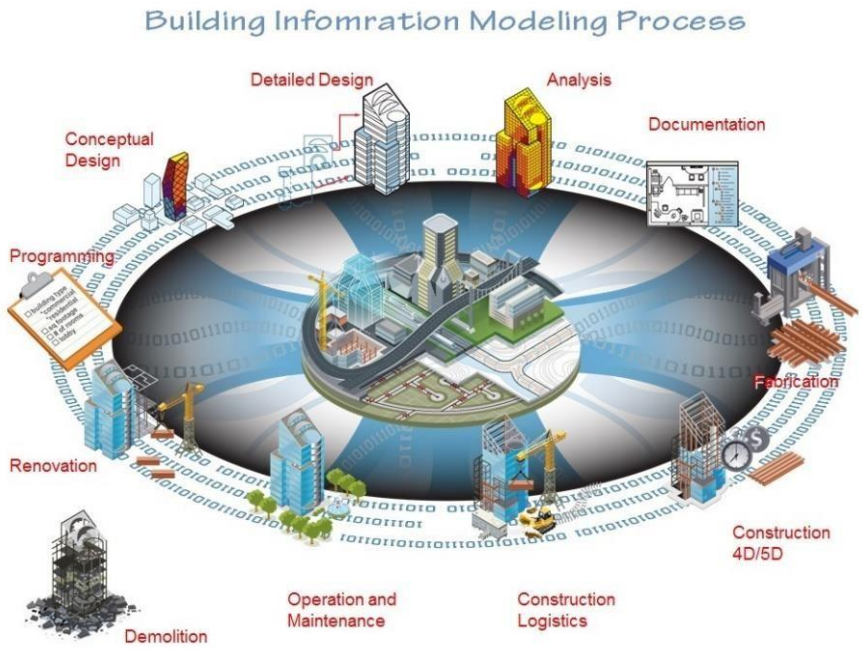

Figure 4: Building Information Modeling Process. (http://aecdsl.com/the-key-bim-terms-you-need-to-know/)

When a change is required, the process goes back to the stage where that change becomes apparent. For example, if the architect has designed a window of 5 x 5-meters, and in the construction stage it becomes apparent that a 5 x 5-meter window is impossible to construct the design goes back to the Detailed design stage and goes through every stage after that before returning to the construction stage.

The strength of BIM however, assures that this will be a rare occurrence. If the BIM process is executed successfully the construction team should have given advice on the make-ability of the window in the Detailed design stage. This is what makes the BIM process so strong. The early involvement of specialists throughout the building process ensures that issues can be solved before the construction phase. (Ishak, 2012)

To further understand this process, the Level Of Detail (LOD) scheme is also explained. The LOD scheme put in simple terms, determines what Level Of Detail is required from each stage of the process as can be seen in figure 3. This scheme works two ways. While making sure each stage reaches a required level of detail it also prevents a too high level of detail from being reached to early on. This prevention is also important to prevent teams from making decisions too early on. (Het Nationaal BIM platform, n.d.)

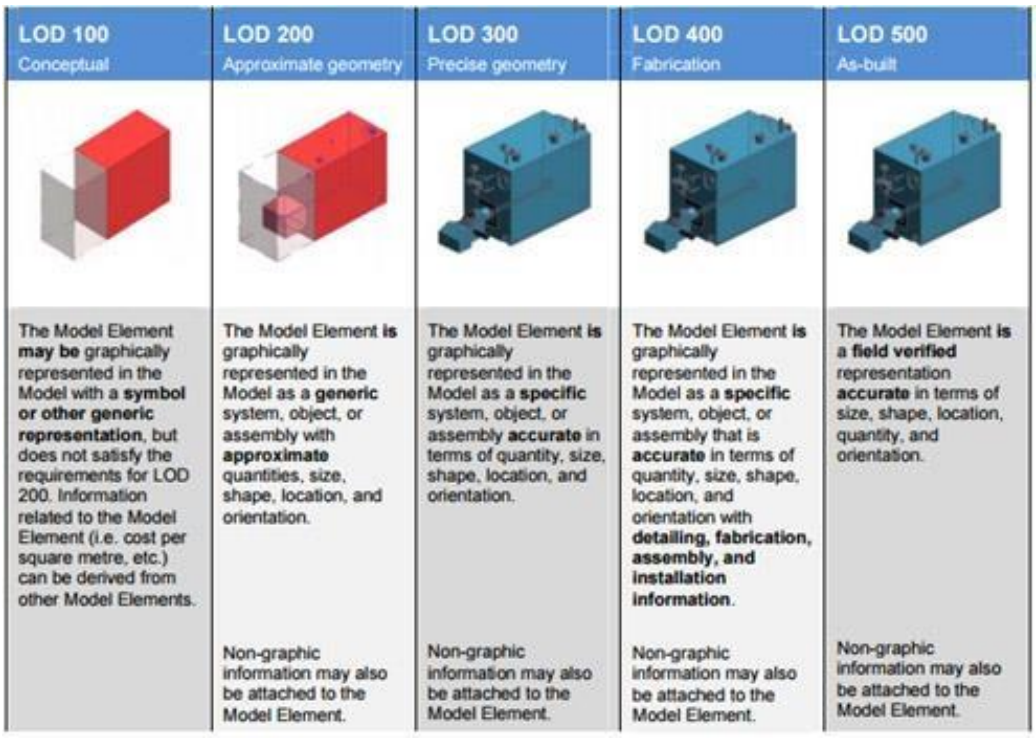

Figure 5: BIM LOD (https://www.bimandco.com/Content/images/screenshots/fr/lod-types.jpg)

Note that the image above, which describes the LOD for a specific project, clearly states that starting at LOD200 non-graphic information may also be added. This is one of the aspects where BIM modelling sets itself apart from 3D modelling. In the image below, it is visible that the selected beam isn't only modeled as a beam (LOD 300 or 400) But also includes object related information added to a BIM database consisting of for example, production company, fire rating, strength class, etc. (BIM&CO, n.d.)

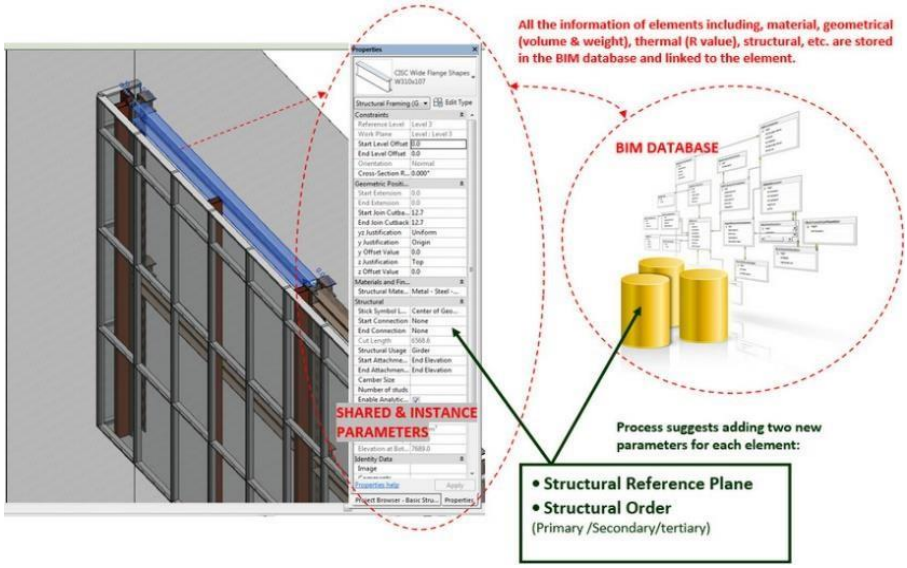

Figure 6: BIM object. (https://www.researchgate.net/figure/11-Illustration-of-proposed-changes-in-BIM-design-authoring-GUIElement-Property-Grid_fig38_317387472)

Interviews with involved companies

As explained in the Methodology chapter, to gain better knowledge on all the companies and their ideas and vision towards BIM the decision was made to interview every company and set up a dialog based on a PowerPoint presentation (appendix B). A range of questions were asked after the presentation about the current building process and the theoretical BIM process. The reason the presentation was shown before the questions were asked was to make sure the dialog would be deeper and more focused on the goal of the research.

To make the thesis more appealing the choice was made to summarize the interviews. This way the interviews become more readable and understandable. Every company is first introduced before the summary of the interview is given. It is important to realize that all statements made in the in summaries are statements made by the involved companies themselves and will in certain cases not reflect the authors statements. The comments of the author on the interview will be elaborated in the implementation of the hypotheses chapter.

A total of thirteen companies were interviewed. All these companies where/are involved in some stage of the project. Some companies had only a small role in this project, but all these companies play in a key role in the realization of different renovation/upgrade projects within Schiphol. So even if the role for this specific project was small, these companies will work together on more than this project alone, so all questions regarding BIM are still relevant to the research.

Schiphol Group

Schiphol group is the owner of Schiphol Airport. This company is in its turn owned by the Dutch ministry of finance (69,77%), the municipalities of Amsterdam (20,03%) and Rotterdam (2,2%) and Airports de Paris (8,0%). (EgonZehnder, 2017) Schiphol group consists of an array of sub-divisions who each manage a part of Schiphol. To get a better insight into how the upgrade Wortel g-pier project came to be, some of these companies were interviewed. The five companies who played a key role in the project upgrade Wortel g-pier are, Schiphol ASM, Schiphol Consumers, Schiphol Security, Schiphol OPS and PLuS.

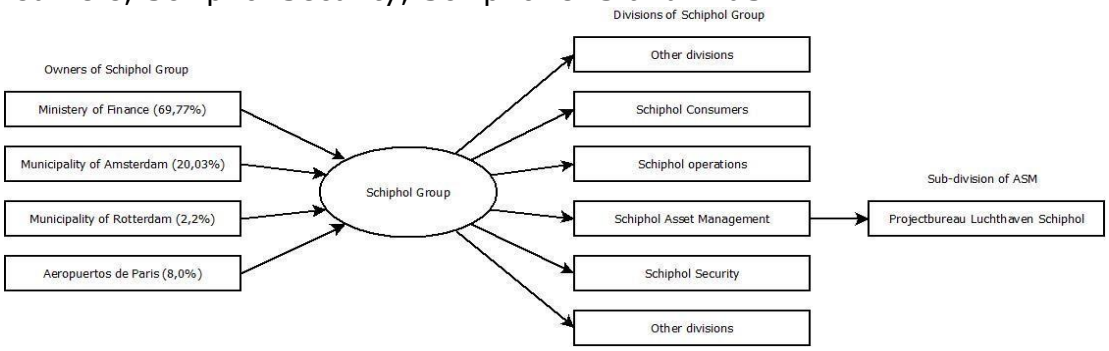

Figure 12: Scheme of Royal Schiphol Group

Schiphol Asset Management (ASM)

Schiphol ASM manages every object that Schiphol group owns. Essentially this means that ASM documents every object in a database and periodically checks when objects need maintenance, upgrading, replacing, etc. ASM does this for every object within the terminal, but also everything outside of the terminal within the gates of the Schiphol terrain. ASM also monitors the quality of Schiphol overall. So, when Schiphol security made a big change in 2015 converting Schiphol from gate security to central security, ASM decided to upgrade and remodel all the piers to keep up with the changes.

Usually ASM will decide when a project is initiated. This decision is based on changes within Schiphol or is part of the masterplan ASM maintains regarding maintenance and upgrades. As soon as ASM decides to initiate a project where unallocated space is available it is mandatory to inform all other departments of this project. In the case of the upgrade Wortel g-pier, which is part of a bigger renovation project, unallocated space became available where security had previously set up their checkpoints. Together with Consumers, OPS and Security, ASM will work on setting up program requirements. These program requirements were formed through debate and discussion.

When the program requirements were completed, ASM tasked PLuS with the realization of the project. This was initially done through a European tender as the project upgrade Wortel g-pier was part of a bigger project named upgrade pier F + G. In a later stage the decision was made to split the project into smaller pieces and using the Wortel g-pier upgrade as a pilot executed by the main contractors.

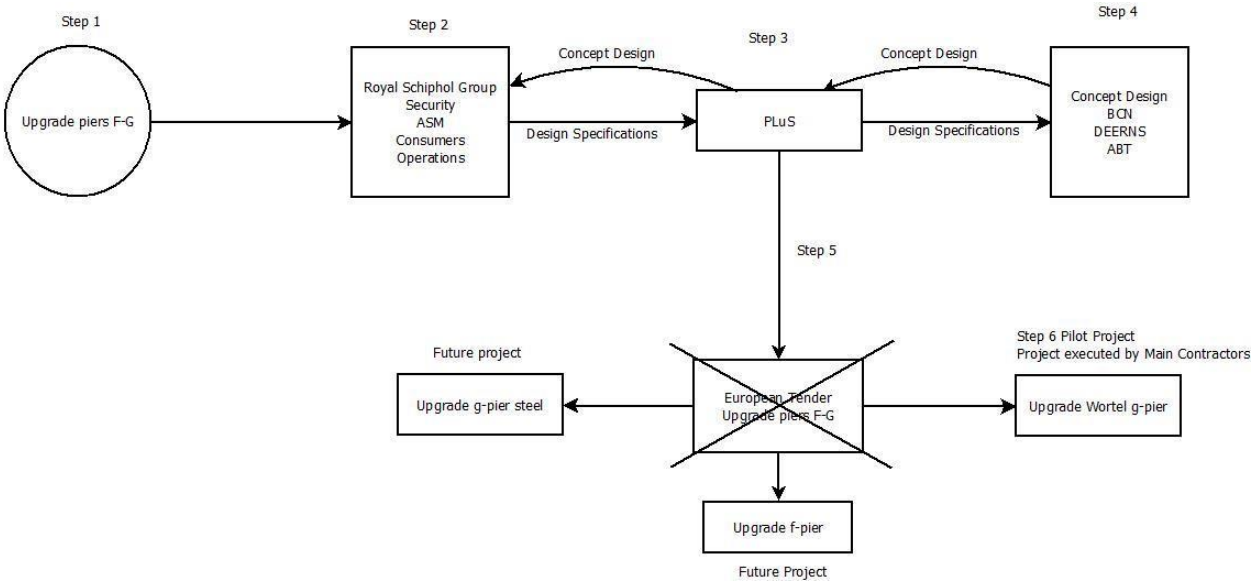

Figure 20: Scheme of initiation of project upgrade Wortel g-pier

The BIM manager of ASM explains: ASM is one of the teams who has been and is currently working hard on implementing BIM within Schiphol Group. ASM sees the benefit of BIM models for asset management and is trying to advance to a point

where they can use BIM models for asset management. Currently unfortunately the BIM models cannot be used for asset management because the data in the BIM models is not complete.

In the last years ASM has been working on an IDM document (information delivery manual) as explained in the current situation chapter, which is a guidebook/rulebook in which all conditions of a BIM model are specified. This because ASM needs certain data to be able to use BIM for asset management. Essentially the main goal of ASM is to receive data for management. So not only a model with dimensions is needed but also data on every object in the model. For example. If an object in a model is a roller shutter, ASM wants to know the size of the roller shutter, so dimension, but ASM also wants to know:

- Who placed the roller shutter? (company)
- When was it placed? (date)
- What is the fire code? (safety)
- How long is shutter under warranty? (date)
- What hinges were used?
- What latch is used?

And so on. This data is important to ASM because only with this data ASM can manage the object. This data is needed for every object within Schiphol and needs to be maintained in the BIM model. So basically, ASM is not interested in a model with a very high level of detail in design but ASM is very interested in a model with a high level of detail in data. With this dada ASM can create an object related database. The wish of ASM is to be able to code every object in Schiphol with for example a QR code, so the building manager can scan an object and retrieve all the data directly from the database eliminating the need to search for information in an archive.

One of the major challenges ASM is confronted with, is the project manager PLuS. PLuS has until now been unable to deliver proper as-built models which contain all the information needed by ASM. ASM has learned that PLuS has been distilling the IDM to make projects more appealing to contractors and because PLuS has yet to reach the level of BIM which ASM wants to reach, PLuS doesn't understand the consequences of this action. By simplifying the IDM PLuS thinks it can execute projects easier and relieve themselves of intense coordination of the BIM model.

Another big question ASM deals with is trying to figure out how to convert its archive which consists for the most part of 2D data and non-digital object information to a BIM model. Schiphol is considered the largest building in the Netherlands so converting all this data is a very big task. ASM has been trying to solve this by obligating all teams who are involved in projects at Schiphol to digitally document the current situation by using documents from the archive. Unfortunately, the archive ASM has is not complete or not completely up to date. This means that there are deviations between what the real current situation is and what the

documented situation is. Apart from that, in the project upgrade Wortel g-pier, PLuS decided that documenting the current situation of the HVAC, security and fire safety was not necessary. This will unfortunately mean that after this project the Wortel g-pier will still not be properly documented and ASM will be unable to completely implement the BIM model for management.

ASM has recently also been trying to convince Schiphol to change the wat building projects are executed. Schiphol has always used a very traditional project method. Where a project is split into stages, and another stage of the project is only initiated after the previous stage is finalized. This has made it difficult to implement BIM, as BIM theoretically requires all involved teams to collaborate throughout a project. ASM is trying hard to eliminate this traditional way of thinking.

Authors perspective

What amazes the author is the fact that ASM as a client does not demand a specific project execution method. ASM clearly just places the project in the lap of PLuS and expects a result based on the design specifications. As a client and in charge of operation and management ASM should be much more involved in the project.

ASM clearly states that it has not been satisfied with the way PLuS executes projects, however AMS still keeps employing PLuS in the same method. ASM should be much more involved with PLuS so it can monitor better what is going on.

Schiphol Consumers

Schiphol consumers is a department within Schiphol group in charge of managing everything related to consumers. Essentially this means that everything that has to do with food and beverage, retail and shops, kiosks and hotels. Consumers manages all available retail space within Schiphol. The board of Schiphol Consumers consists of Schiphol representatives and representatives of all shops within Schiphol. Schiphol consumers is a very important and powerful department within Schiphol because they are responsible for a very large part of Operating results for Schiphol.

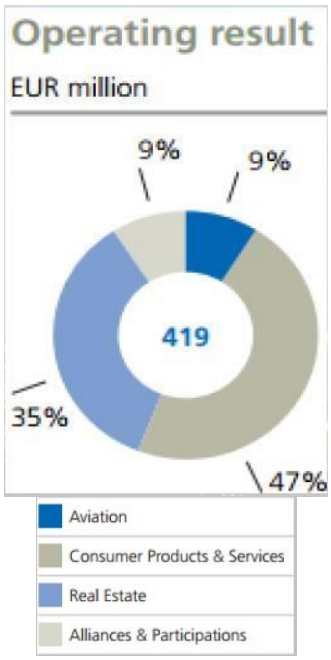

Figure 21: Schiphol operating result (Egon Zehnder)

When the upgrade Wortel g-pier project was announced by Schiphol group, Schiphol consumers played a vital role in creating the program requirements. This had to do largely with the fact that with change from gate security to central security in 2015, a large amount of space had become available on the g-pier. As consumers is one of the departments which creates a lot of revenue and profit for Schiphol as can be seen in the figure above, they have a large saying in what happens with unallocated space.

For each project, consumer specialists of Schiphol Consumers, discusses the opportunities for shop owners within a space, to decide what the consumer program will look like. The goal is to place the correct companies in the right locations making it more intriguing for passengers to buy products. The way consumers can predict passenger behavior is by using the data from check-in till boarding to find out how much time passengers have. Consumers is also able to read passenger behavior when passengers use the Schiphol Wi-Fi account and finally camera images are also used to predict how busy certain areas will be.

Figure 22: Your Pharmacy at Schiphol plaza (https://spotschiphol.nl/nl/news/your-pharmacy-at-schiphol-plaza)

After the program requirements have been completed and the concept design is being made, Schiphol Consumers and Schiphol ASM require the design to include clear separations between Consumer zone and ASM zone. This is done by applying a physical division line in the design. This way Schiphol consumers argue they can split liability and maintenance cost clearly. By rule all stores can use 1 meter in front of their store openings to place non-permanent objects. In the above image the black tile line is visible marking this separation.

Schiphol Security

Schiphol security is the department of Schiphol Group in charge of security. This department also plays a role in the making of the program requirements. Security will always debate what is possible and impossible when considering upgrades within Schiphol. As the decision was made in 2015 to convert the departure lounge from a non-secure to a secure zone a lot of changes were made regarding the way Schiphol Security operates. Where before 2015 every departure gate had its own security checkpoint, with the new construction security was centralized to 5 main security hubs. The benefit of this system is that primarily the whole departure lounge essentially becomes a secure zone because every passenger has already been security cleared. Secondly, this means that not every departure gate needs a security checkpoint. The downside to this system is that transfer passengers are not allowed to enter the departure lounge before being security cleared.

When the decision was made to convert to centralized security Schiphol Security moved the security hubs from each gate to the main entrance of the departure lounge. This meant that all the space that was initially reserved for security became available to other departments within Schiphol. For this reason, the role of Schiphol Security within the Wortel g-pier upgrade was very small as the whole zone is already within the secure zone of Schiphol and Schiphol security did not need any allocated space within this project location.

Schiphol Operations (OPS)

Schiphol operations is the department responsible for everything regarding Airport operations, meaning everything that has to do with movement of passengers, baggage and aircraft. Essentially OPS do not have any physical property inside of the terminal. They do own all the jet-ways. OPS play a vital role when discussing program requirements as the primary goal of the airport is to move passengers, aircraft and luggage as efficiently as possible through the airport, whilst also making sure passengers get triggered as much as possible to make use of any leisure (shops, food/beverage, lounges). Every decision made by ASM and Consumers is based on advice from OPS. OPS will discuss allocation of jet ways, location of transfer portals, etc.

In the case of project upgrade Wortel g-pier OPS had a very small role, as the G-pier is an existing pier and there were no changes in allocation of jet-ways, OPS only gave advice on passenger flow to and from the jet-ways. OPS is also responsible for allocating the correct signage for passengers to find the proper gates and or utilities.

Authors perspective

For Schiphol Consumers, Operations and Security, the goal should be to review progress more often. Currently these sub-companies are only involved with the design specifications. After this stage these sub-companies play no further role in the project. As clients these sub-companies should also keep monitoring progress and making sure that their requirements are integrated and remain integrated in the project. Basically, acting like quality control. They can also continuously give advice on issues that involve them.

Projectbureau Luchthaven Schiphol (PLuS)

PLuS is a company which has been set-up to manage all medium to large scale projects for Schiphol. The task of PLuS is to turn the program requirements which are set by ASM, Consumers, OPS and security into a realized project which is then handed back to ASM.

To be able to realize a project PLuS splits the process into three stages:

1. The stakeholder stage
2. The design stage
3. The build stage

With these three steps PLuS tries to simplify the process, using a top down organization. When PLuS receives the program requirements, they send these requirements to Benthem Crouwel NACO (BCN). After this step in the case of project upgrade Wortel g-pier the project went to Deerns and ABT for architectural design and RHDHV for Structural and HVAC design.

Deerns and ABT both worked on project upgrade F + G pier during the concept design, this because Schiphol group wasn't certain what they wanted to do with the project. ABT designed a green solution for the project which was later denied because of financial reasons and unity within the whole terminal. After failing to get a contractor for the upgrade F + G pier, ASM chose to split the project and start with the project upgrade Wortel g-pier which would be built by the main contractors. AMS assigned PLuS to execute this project. After this Deerns redid the concept design to a more budget friendly one. After the concept design was done BCN took over and finalized the architectural design with RHDHV, who did the structural design and the HVAC design.

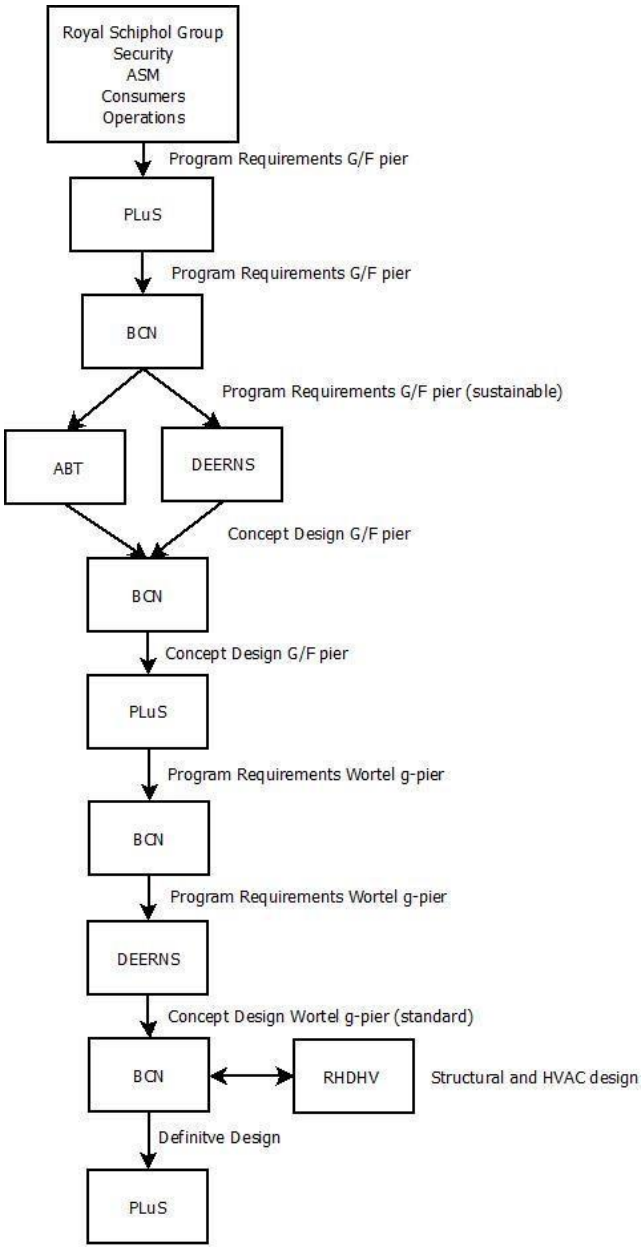

Figure 23: Schematic of Design process

After the design phase was closed and the definitive design (DO) and execution design (UO) were approved by ASM, the project then entered the build phase. In this phase PLuS gave the project specifications (bestek) to VWBS, BAM, ENGIE and KONE. After this PLuS gave each company a different distilled IDM and negotiated a contract which each team separately. It was now up to the four companies to work together and realize the project while PLuS oversaw and coordinated the work.

During this process PluS did not share the specification of every separate contract to every team. This resulted in conflict between the teams as to what was to be expected from each of them. Since VWBS had to hand in a model of the current situation (architecturally) and ENGIE did not have to hand in a model of the current

situation (HVAC). This led to discussion between the teams during the project. PLuS failed to address these conflicts because it did not feel the need to intervene in the BIM process between the different teams.

PLuS, had made very clear that they did not see the need to commit to the IDM that ASM had set-up because they thought it was far to comprehensive. PLuS decided to distill the IDM without consulting ASM. They did this mostly from a financial point of view. The more comprehensive the IDM is the more work needs to be checked, the more man hours it takes, making the coordination process more expensive. With the distilling of the IDM the amount of work that PLuS had to manage became significantly less.

In a second interview with PLuS it became apparent that the way of thinking inside the department had significantly changed. PLuS was able to admit it had made mistakes during this project mostly due to a lack of communication and a lack of strong leadership as a project manager and BIM coordinator.

The problem according to PLuS had to do with the fact that the building teams and themselves had a difficult time working in a BIM environment. It required a completely different way of working together. The goal would ultimately be that there is one coordination model which would be in control of PLuS. This model should be upgraded weekly with new models from every construction team. This way PLuS could continuously check for issues in the model and decide what potential solutions could be.

Next to that it was also important that PLuS used the complete IDM as was made by ASM, because only this was ASM would be able to use the information of the as-built model. For the project upgrade Wortel g-pier that became very difficult because in the early stages PLuS had already decided that the documentation of the current situation, for HVAC was not needed. This meant that the as-built model would never be complete.
This problem would ultimately be partially solved by scanning the building. This way PLuS felt that about 90% of the missing HVAC could be documented.

This was not the way PluS wanted to have done the project. PLuS's opinion is that a project manager should focus much more on making sure everything is designed before it is built. This of course being much more in line with the BIM way of thinking. When the BIM coordination model is properly built and set-up, revision should not be a big job. The more objects missing in the BIM model, the more revision is needed.

The opinion of PLuS was that the failure of a smooth project was not only their fault. They felt that ASM should have had a much bigger role for the BIM part of the project. This because ultimately ASM is the team which needs the BIM data to be able to create a good asset management database. This could only be realized if ASM took a more prominent role as client.

Authors perspective

It is clearly visible that a project manager which is not capable of executing a project in BIM creates problems. After having interviewed PLuS for the first time, it became clear that PLuS had no idea how BIM works. Stating that BIM is only a tool used on the side and not allowing open communication between companies made it apparent why this project was so problematic.

The way PLuS blames other companies for mistakes that they should have prevented proves how problematic the situation at PLuS is. To be able to create a healthy BIM environment PLuS should have much greater knowledge of BIM and be much firmer in making sure a project is executed according to the principles of BIM.

In the second interview with PLuS, the company already showed progress, however when a BIM project is started up in a wrong way it is impossible to correct this in a later stage. It is very important to understand that BIM is a process which should be executed correctly from the beginning.

The author can however agree with PLuS on the fact that the failure of executing this project in BIM is not solely their fault. All companies who claim to be working according to BIM but aren't doing so should be blamed. BIM is a team sport.

Benthem Crouwel NACO (BCN)

Benthem Crouwel NACO (BCN) has been the master architect for Schiphol since the 1986. BCN consists of a teamwork between Benthem Crouwel architects and NACO, a company of Royal Haskoning DHV. This department has been set up specifically to create and design a masterplan for Schiphol. Apart from being responsible for the masterplan of Schiphol airport, BCN is also responsible for translating the ideas of Schiphol group into concept designs. So essentially converting ideas into to 3D models.

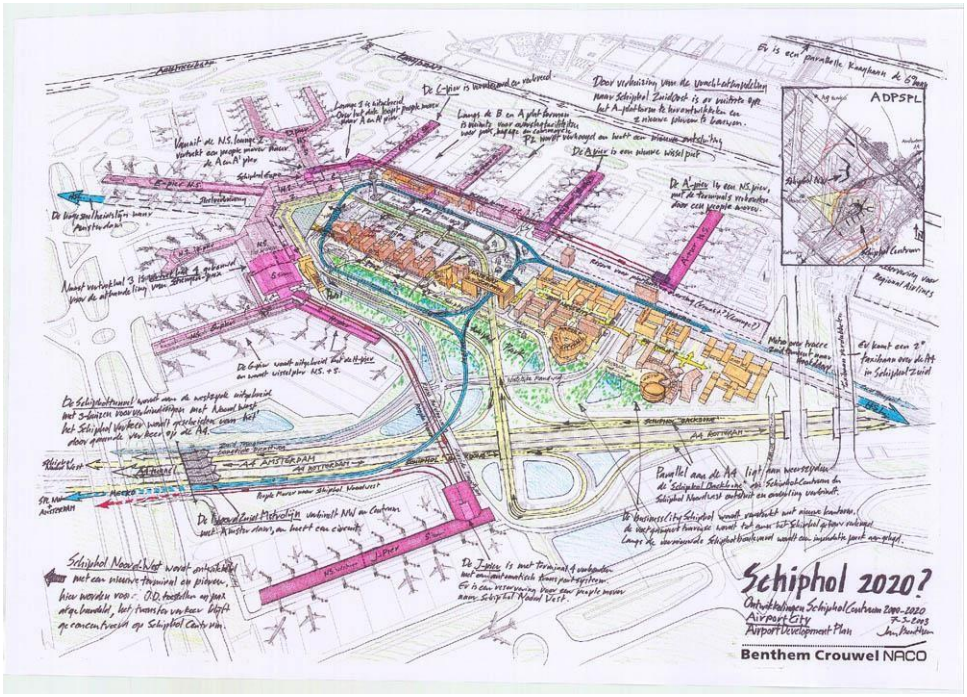

Figure 24: Masterplan Amsterdam Schiphol Airport (https://www.bna.nl/project/amsterdam-airport-schiphol/)

Apart from having designed a master plan for Schiphol and translating the ideas from Schiphol group into preliminary designs, BCN is also in charge of safeguarding and enforcing a quality standard for Schiphol based on the program requirements set by Schiphol group. This is mostly to ensure continuity within the Schiphol building.

After having completed the preliminary design and the tender phase has been completed BCN can be entitled to further advancing the architectural design of Schiphol. If this is not the case BCN will remain a part of the design phase as a coordinating team. The coordinating role of BCN will remain up to the project specifications. When the project specifications are completed the project is handed over to PLuS.

Apart from coordinating the project BCN also coordinates the BIM process during the design phase. According to the interviewed BCN architect, BIM is an important part of their daily work. They perceive BIM to be a logical development towards the future and fully support the progress BIM has been making in recent

years in software as well as standardizing the process. BCN admits that they are yet to catch up to the latest BIM standards shown in figure 25. BCN explains that they are currently modelling all Schiphol related designs in 3D. It is only in a later phase that information (data regarding objects) is added to the 3D model essentially starting the process into converting it to a BIM model. BCN argues that this is more 3D modelling plus rather than actual BIM.

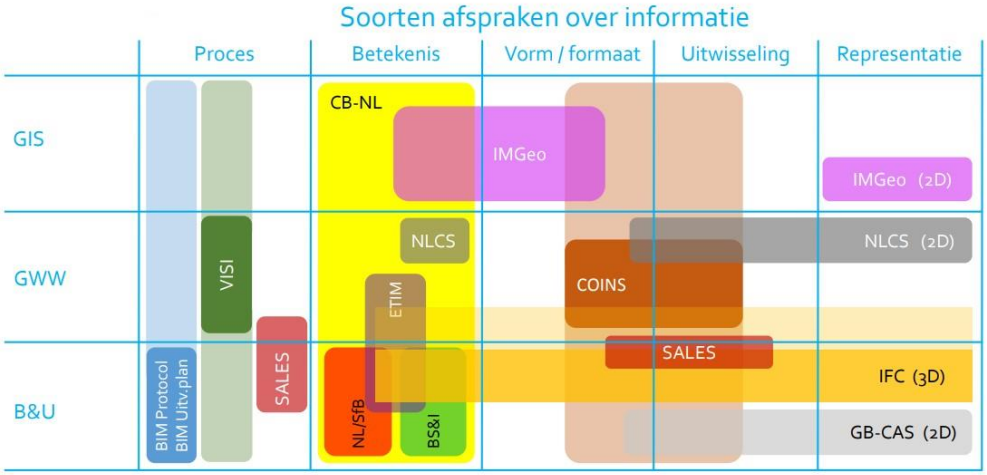

Figure 25: Schematic of latest BIM standards (https://www.bimloket.nl/upload/documents/downloads/Standaarden/Atlas%20Open%20BIM%20Standaarden%20v1.3.pdf)

What makes designing for Schiphol extra difficult is the fact that Schiphol is an already existing building. Apart from being an already existing building it is also a very complex one. The question is how to translate all the current documentation of Schiphol, which is almost completely 2D and partially not even digital, to a 3D BIM model.
Some important questions that must be asked are:

1. How correct is the documentation?
2. What part of the documentation is necessary, important, not important?
3. What is the source?

The answers to these questions must be given before any 3D BIM model of Schiphol can be built. Over the years Schiphol has undergone a lot of small, medium and large upgrades and renovations. Not all of these have been documented correctly or even at all. Secondly not all the information documented is necessary. For example, Schiphol has documented the upgrade of all television screens within the building over the years. This information is very complete, but not important according to BCN. Finally, there is the matter of what is the source and which source to use. BCN believes that for architectural design it is better to use the definitive design documents. They believe for structural design it is far better to use the as-built model.

For the project upgrade Wortel g-pier the situation is worse than the above-mentioned situation. The biggest problem with this project is that there are too many sub-contractors still working in 2D and attempting to translate their 2D data into the 3D model. The problem with this is that 2D data tends to miss information when attempting to translate this into 3D.

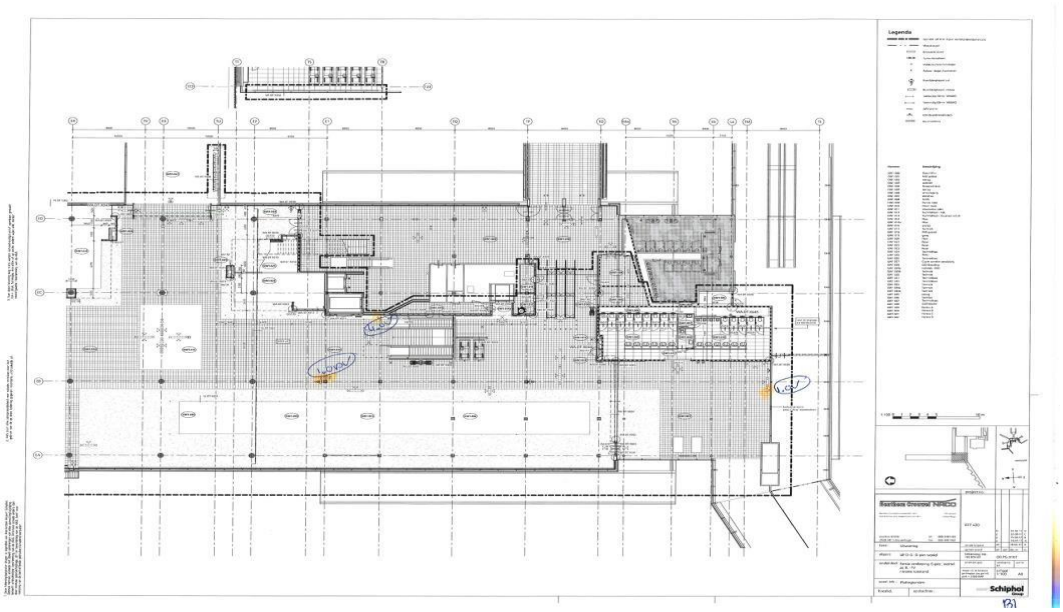

Figure 26: 2D drawing used for placement of monitors.

Another problem occurring with the upgrade Wortel g-pier project is that the team who is responsible for coordinating the project is falling short. This lack of coordination of the project as well as BIM causes unnecessary friction between the different teams who take part in this project. Some teams are trying to take over the coordination while other teams either disapprove of this shift in coordination and some go as far as to refuse working together.

In this case VWBS is attempting to take over the role of BIM coordination. BCN does not approve of this shift and wants either PLuS or ASM to retake control. BCN is especially critical towards ASM because they believe that ASM should play a more centralized role within every project instead of taking an overseeing position. ASM as client should demand that PLuS performs. If PLuS doesn't perform, BCN feels that they should become in charge of coordination. Their arguments for this are since they know Schiphol better than any other team and that because they are already in charge of coordination and quality control in the design phase, they can also do this for the building phase.

Apart from that, HVAC consultants are not reading the architectural 3D model causing major conflicts in the coordination model. According to BCN a large part of this problem has to do with the mentality of the HVAC consultants and the fact that the HVAC companies are yet to catch up to the latest 3D BIM software. Most HVAC companies are very reserved towards new trends. One of the causes of this

reservation has to do with protection of intellectual property. HVAC companies have worked hard to optimizing and perfecting their own products. They fear that in a BIM model their information becomes available to too many teams. A way to solve this is to generically design the coordination model and separate the specific models. The two benefits created in this situation are that HVAC companies will be more willing to release their models and the coordination model becomes easier to read.

Authors perspective

BCN is according to the author one of the most dangerous companies in this project. BCN is a company with a lot of power at Schiphol. BCN is also not afraid to use this power to their advantage. When interviewing this company certain statements made by them really showed how this company was attempting to manipulate the BIM process.

As the lead architect for this project BCN should have kept busy with the preliminary, final design and advisory role for this project. However, apart from that BCN was also very preoccupied with making sure that their power within Schiphol remained intact.

With BIM a shift in power is inherent. Some companies will gain power whilst others will lose power. BCN being a very powerful company within Schiphol realized quickly that converting projects to BIM they would stand to lose a lot of power. When VWBS tried to take control of BIM coordination, BCN made sure that this didn't happen.

BCN during the interviews clearly stated that they did not wish to communicate according to the BIM principles. Being more preoccupied with losing intellectual property, the author feels that BCN could have instead of blocking the flow of data, made themselves indispensable by sharing all the data they have. This way they could have had a much more prominent position in the BIM circle by providing data which other companies don't have and cannot get their hands on

Royal Haskoning DHV (RHDHV) structural

Seeing as Schiphol is an already existing building, the task of the structural designer is not designing the structural components of the building. The primary task is to make sure that the quality of the pre-existing construction remains intact. For this process to be efficient a good BIM coordination model is necessary. The reasoning behind this, is that RHDHV can monitor changes in the BIM model and react to them. The structure of the building was not changed during the upgrade Wortel g-pier project, so the only thing RHDHV was tasked with was to make sure that the structural situation and calculations remained intact and correct.

One of the biggest problems RHDHV ran into during this project was the fact that PLuS on occasion did not forward advice and information to either RHDHV or in return to other teams. There have been instances where a structural advice from RHDHV was not forwarded for three months. This of course leads to frustration during a project because other teams are under the impression that RHDHV has not performed its duty.

Because of this break in information sharing some teams have tried to work with RHDHV directly, bypassing PLuS. This has been to the discontent of PLuS and RHDHV. The mentality of RHDHV is that all information must go through the project leader. If teams start requesting information directly the flow of information becomes disturbed and with the structure being a critical part of a building RHDHV cannot permit itself to share information directly to other teams, without first sharing information with PLuS.

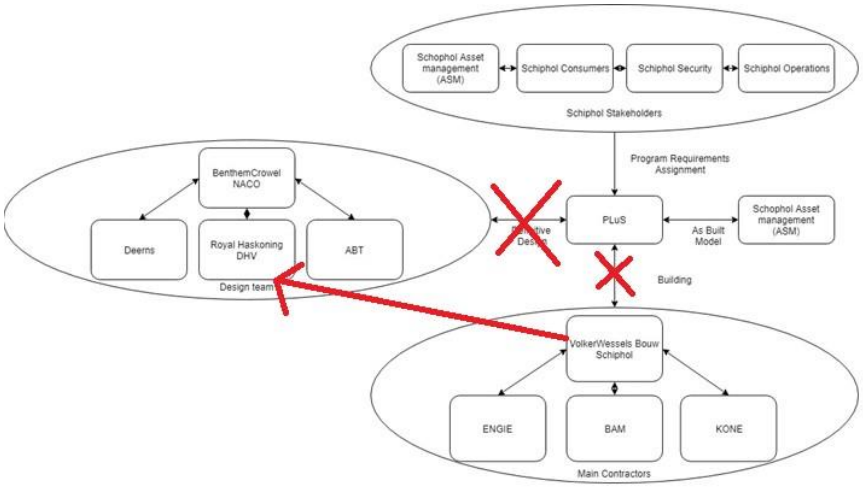

Figure 27: Unwanted communication break requested by VWBS

RHDHV also discusses the point of an as-built model. The statement RHDHV makes is that the definitive is leading for them. This is because the definitive model is the model calculated by RHDHV. Any major deviation of this structural model, major being more than 1cm, cannot be accepted for the as-

built model. So essentially for RHDHV the definitive model is the only truthful model on which they can further calculate any changes in the structure.

Royal Haskoning DHV (RHDHV) HVAC

RHDHV being a multidisciplinary company, they are also tasked with designing the HVAC system to fit the new project specifications. The way RHDHV approaches this is by first gaining knowledge on the current system, by reading current documentation and prior calculations on the system. RHDHV only documents the capacity of the HVAC generator and the main ducts. Based on the old calculations and the demands for the new system RHDHV creates HVAC specific project specifications. RHDHV mostly tries to use the current main ducts as these were often designed larger then needed, so provide ample overcapacity. This way there is also no need to install new main ducts which can vary in size from 600x600mm all the way up to 1000x2000mm.

For this process the BIM coordination model is barely used. Essentially RHDHV uses the concept design in projected in 2D, together with height information. With this information capacity calculations and schematics are made. These calculations are then added to the ender documents. It is up to the HVAC installation company to further elaborate on the system by adding duct dimensions and HVAC components where needed.

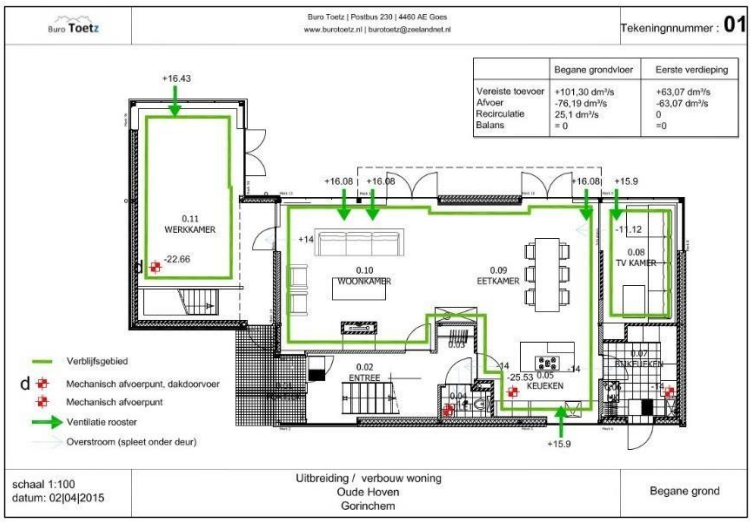

Figure 28: Example of ventilation Scheme (https://www.burotoetz.nl/album/fotogalerij-bouwbesluit-toetz/ventilatieschemajpg/)

Authors perspective

RHDHV structural as well as HVAC take a passive role in the Schiphol project. The author believes that RHDHV has knowledge on the BIM process on all aspects but chooses to not participate in integrating BIM as a process. This partially has to do with the cooperation with BCN, but also the way PLuS created the contracts.

RHDHV chooses to continue the traditional hierarchy because it is a known way of working and RHDHV does not feel the need to change anything because they are not confronted with the problems further along the project.

Deerns

For the project upgrade pier F + G Deerns had been involved with the concept design. In a later stage, after the project was split up into the project upgrade Wortel g-pier, Deerns returned to further work on the definitive design.

Together with BCN, Deerns is one of the permanent architects for Schiphol. The benefit of this is that Deerns is very aware of the demands of Schiphol and knows what to expect with every project. One of the problems is that not all companies who have long term contract with Schiphol can work in a BIM environment. This lack of ability creates a problem early on during every project with documentation.

A lot of documentation on Schiphol is still either in 2D CAD form or in paper form. This makes the transition to 3D BIM models difficult as this documentation must first be converted. This process requires a separate budget which up until now has been difficult to acquire from PLuS and/or ASM. This is in a way perpendicular to the desire of ASM to asset manage Schiphol from a 3D BIM environment.

Apart from most of the documentation still being 2D CAD, a lot of this documentation has not been revised and updated throughout the years. This means that parts of the documentation cannot be used for design. To cope with this problem, BCN chooses to use their design documentation as an underlay for every new project. This bypasses the fact that the Schiphol documentation is in CAD form, because BCN has already converted large parts of their documentation to 3D. BCN does not use as-built models for their documentation. This means there are often discrepancies between BCN models, Schiphol CAD models and the as-built models.

To cope with this issue according to DEERNS, ASM should enforce their IDM and BIM protocol much more intensively. Also, ASM and PluS, should make extra budget available to better document the as-built situation of Schiphol in a BIM model. This can be done by means of 3D scanning the project site before demolition, during demolition and after demolition. These costs can be mostly recovered by means of failure cost reduction. This is of course in line with the BIM way of thinking, where more costs are made up front for proper documentation, the setting up of a proper BIM environment and a proper IDM and BIM protocol. In exchange for this higher star-up cost, the long-term costs for building mistakes, excess material purchase and a loose planning are less.

Authors perspective

Deerns is a company who was tasked with concept design by BCN, for this Deerns did not have a lot of influence on the BIM process. With BCN maintaining the traditional hierarchy Deerns performed its tasks to the liking of BCN. The author does however agree with Deerns, that ASM should take a much more prominent role in defending the IDM and BIM protocol and making sure that all companies receive contracts based on the BIM principle.

ABT

For ABT the project upgrade Wortel g-pier was not very major. ABT had only participated during the concept design phase of the project upgrade F + G pier. They did so before the project was segmented. ABT explains that the design phase of the project didn't encounter big issues with BIM modeling. The teams who are involved with the designs of Schiphol have been working together for years already and all have experience with BIM models. ABT has been working with BIM models for at least 10 years and therefore knows what is expected.

ABT believes that BIM is the future and has invested time and resources to make sure they keep up with the latest trends in BIM software and the previously mentioned BIM standards. BIM is a mandatory piece of knowledge every design and construction should have. What is important is that ABT believes that BIM is just a step in a better future. ABT will always be open to take the next step in the world of digital design and construction.

Where ABT thinks the problems start, is when the finalized designs are handed over to the client, project manager and construction teams. The way PLuS sets up the contracts inevitably leads to issues. Apart from that a lot of times the assignment is not clear. This means that not every team knows exactly what needs to be delivered. This has to do with the fact that the IDM is not complete because It is distilled by PLuS.

Another issue Schiphol deals with, as mentioned before is size. The building is so big and has gone so many small, medium and large transformations that there is no way the documentation and the archives are up to date. Schiphol has about 2 miles of archives. The questions one must ask are:

1. How does one find what is needed?
2. Are the documents up to date?
3. Are the documents available?

The questions can be solved with a BIM model, but the steps needed to get there are not easy.

Authors perspective

What I didnt understand as author of these interviews is why ABT as well as Deerns, speaking so clearly on BIM and understanding what is needed for BIM, are afraid of taking the necessary steps to promote the social aspects of BIM by working with companies like VWBS and ENGIE directly, surpassing the power of BCN.

It is the wait and see attitude that made this project so problematic. Everyone blames someone else for not doing what is expected instead of taking measures into their own hands. If more companies would execute what is needed, then other companies are forced to join.

VolkerWessels Bouw Schiphol (VWBS)

As one of the main contractors for Schiphol VWBS is responsible for realizing all medium scale projects on an architectural level. Together with ENGIE (who is responsible for HVAC), BAM (who is responsible for security and fire safety) and KONE (elevators, escalators and moving walkways) these four companies are responsible for building the execution plans. For VWBS upgrade Wortel g-pier has been a challenging project.

Most of these challenges unfortunately were caused by a poor BIM organization. It all started with the tender phase. VWBS had offered to take responsibility for the BIM coordination of the project. They had budgeted about €100000,- for BIM management. ASM found this to be too expensive and chose for PluS to be responsible for BIM management. PLuS, had budgeted about €60000,-. One must question where the big difference in budget comes from. A large part of this difference in budget came from how the IDM was distilled and executed.

VWBS believed that it would be very important to start with a strong BIM model of the current situation in which all upgrades and changes could be modeled. PLuS, did not share this belief. So, this project took off with a BIM model based on the model used by the design team. This design model was again based on the models which BCN owned. These were not the as-built models, and these models had not been updated over the years. This led to quite some discrepancies between the model and the reality.

The next problem which quickly became apparent was the way all the construction teams worked on their models based on their contract. Where each team was unaware of each other’s contract, every team worked out their respective parts with different conditions. ENGIE was not obligated to model the existing HVAC, BAM was also not obligated to model the existing sprinkler system. This created issues for VWBS when modeling what was to be built because VWBS was not able be sure whether objects would fit during installation, based on the current situation.

These issues would often be fiercely discussed between the construction team teams due to absence of the project manager (PluS). This meant that the issues would mostly remain unresolved, because the BIM modelers, who sat together every other week didn't have the authority to make decisions. For example, when a ventilation duct, a sprinkler main line and a façade conflict in a model, who gets right of way to place their object? This is an obvious example where the BIM modelers will never agree because they are not in a position to make decisions.

Another issue VWBS had to deal with was the way the involved teams communicated. For example, if a person from the construction team needed information from the design team this had to go through the project manager, being PLuS. This often took quite long and occasionally the information never came through to the correct person. This obviously led to frustrations.

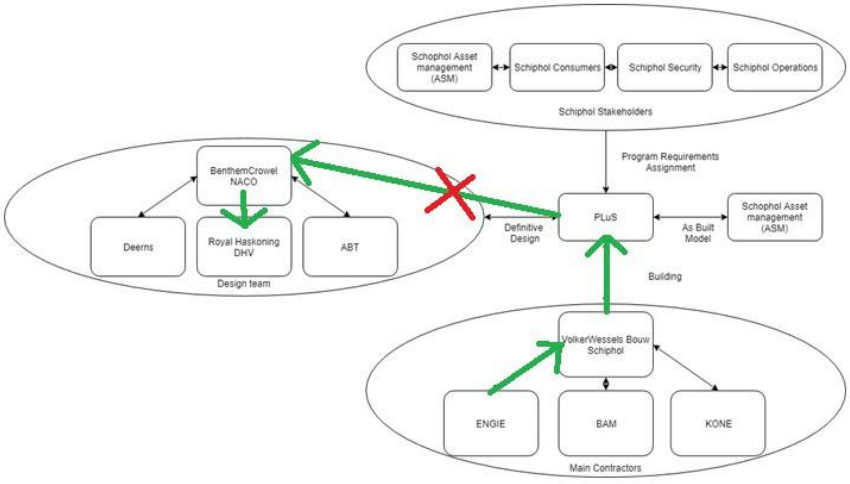

Figure 29: Communication break

VWBS believes that it could have done a much better work at organizing the BIM environment and coordinating the BIM model. The BIM department at VWBS works very hard to keep up with the latest BIM trends, and keeps its personnel's knowledge up to date. Apart from that VWBS has also been rewriting the IDM in consultation ASM, further elaborating on it, making it more practical.

Another step which VWBS felt it was forced to take, was to take over the BIM management within the construction team. This because PluS was continuously absent during BIM coordination sessions. VWBS created the coordination models and took care of coordination between all the construction teams. These coordination models were later handed over to PLuS.

Authors perspective

Being on the wrong end of the failed BIM process VWBS was faced with the issues the design team left behind. With the project specifications having been changed so many times before the project reached the contractors VWBS was faced with building a design which was not checked with the reality.

Because of the late involvement of the contractors and VWBS not having checked the design before agreeing to the terms of construction that this project was so challenging. VWBS should have put more pressure on PLuS and the design team making sure potential issues were dealt with before accepting to build the design.

ENGIE

ENGIE is another main contractor responsible for realization/installation of all HVAC systems for medium scale projects at Schiphol. Together with VWBS, BAM and KONE these four companies are responsible for executing all medium scale projects.

For ENGIE the collaboration with VWBS and BAM has proven to be a difficult one. Unaware differences in contract, ENGIE has had to defend their statements throughout the project. ENGIE felt like it had not been taken seriously during discussions about modeling the current situation in the BIM model. ENGIE occasionally had to defend the fact that in its contract there was no clause for modeling the current situation of the Wortel g-pier.

ENGIE believes that if projects are organized correctly in BIM, results can be achieved easier. ENGIE does not feel obliged to participate in this environment if it is not contractually obligated to. With this statement ENGIE aims to prevent contractual issues due to ambiguity within a contract. ENGIE explains that on occasion it had to fall back to the building specification document. This because PluS had set up the contracts based on this document and not the BIM coordination model.

The issue is that ENGIE has had to deal with non-BIM data to begin with. RHDHV had not delivered any BIM models for the HVAC. All the documents which ENGIE received were 2D models and specification sheets. ENGIE chose to not implement this information in the coordination model. Instead ENGIE modeled only the new installations in the coordination model. In a later stage PLuS had requested that also the connections to the existing systems be modeled. ENGIE did also provide this data in the coordination model.

The biggest discussion ENGIE kept having, was the discussion with VWBS, who had taken over the coordination. VWBS demanded that at least all existing HVAC objects which overlapped any new civil or fire security and safety object had to be modeled. ENGIE was contractually not obliged to do so. For this reason, ENGIE refused to do so, until PLuS made funding available.

ENGIE also argues that in this project the building specifications were the leading document. Occasionally there were differences between this document and the coordination model. This also led to unnecessary discussions because according to them VWBS was in breach of contract when stating that the coordination model was leading.

Authors perspective

What was most interesting when interviewing ENGIE was that it became very apparent that the BIM modelers where on a completely different level than the

project manager. This came forword on numerous occasions where the BIM modelers of ENGIE and VWBS tried solving issues together whilst the project managers did not allow for this working together because the contracts did not mandate this.

This created a situation where BIM could have been a solution to a lot of problems but on a management level companies did not want to work together because the contracts did not demand this. A lot of problems could have been prevented by setting aside differences and attempting to work together and solving issues together.

BAM

Overseeing fire safety and security BAM stated immediately that it had a strong position during the construction and building phase. According to BAM, their expertise was leading over every other aspect. This meant that whenever there would be a discussion during a BIM session on a clash, VWBS and ENGIE had to make way for their systems.

When being asked what the vision of BAM on BIM was, the answer was very straightforward. BAM will only model all main objects, for example main fire extinguishing pipes, and main security communication lines. All secondary objects BAM would not model because firstly, it was not contractually obliged to do so and secondly because according to BAM, the secondary connections, like secondary fire extinguishing pipes which connect the main pipes to the sprinklers would be made on site to the liking of the mechanic. Therefore, it would be useless to model these.

Also, the modelling of the existing pipes and objects was unnecessary according to BAM because they would not alter these anyways. Apart from that BAM defended that it already had the capacity calculations and therefore knew whether it could add any sprinklers to the existing system without risk.

BAM also had a strong opinion against the coordination role of VWBS. According to them it was not the task of VWBS to coordinate the BIM model. Therefore, any request of VWBS to BAM would automatically be transferred to PLuS.

BAM does believe that there is a future in BIM, but at the moment does not feel like PLuS is ready to commit to BIM. Therefore, BAM was happy that their contract was based on the Building specifications document and not the coordination model.

Authors perspective:

The project manager of BAM clearly did not have a very good idea of what the benefits of BIM were. Stating that it would model the complete fire safety system because it did not feel this is necessary. Also, BAM clearly stated that it would not

discuss any changes stating that fire safety and security has a higher priority than anything else.

With these statements and the unwillingness to cooperate and communicate, it became very clear that BAM was not yet on a BIM level needed to successfully complete a project in BIM.

KONE

The role of KONE was a very small one during the project upgrade Wortel g-pier. All KONE had to do was refurbish some existing infrastructure. KONE claims that it is already modeling its objects in BIM. During the project, it quickly became apparent that KONE had not modeled their object in the coordination model.

KONE commented that it was not contractually obliged to do so and therefore would not invest any time in updating the coordination model with its object information. KONE explained that it had committed to its contract and performed all the tasks which were contractually obliged.

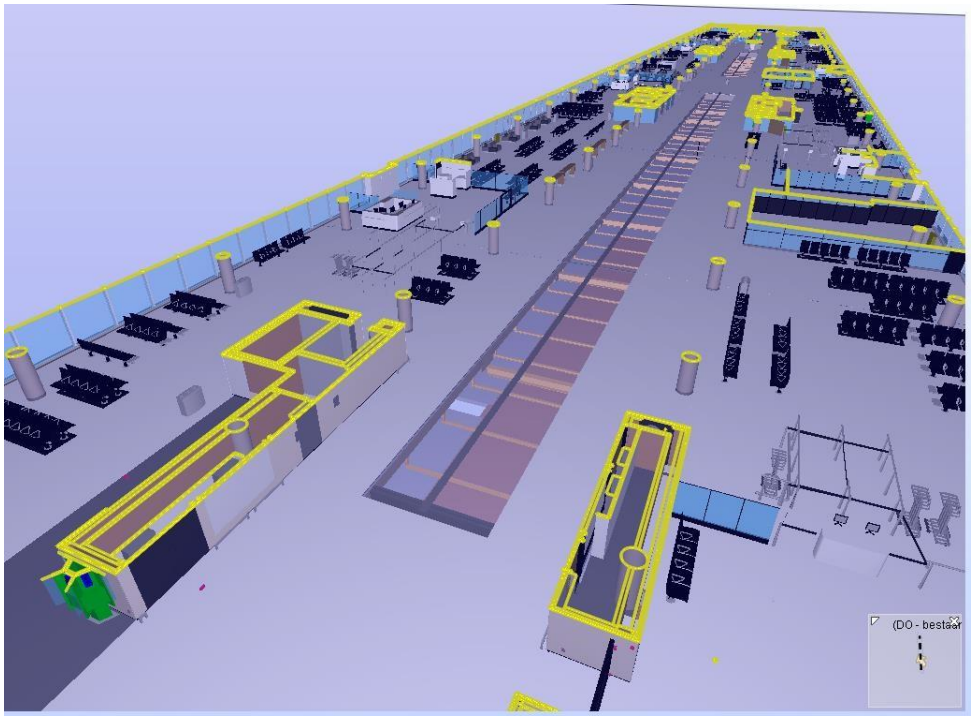

Figure 30: Example of missing walkway (Coordination model VWBS dec 2017)

Authors perspective

KONE should have had a much more prominent role in advising other contractors to what was needed to correctly implement their systems in real life. Kone was never part of any meeting or discussion stating that they had done their job and did not feel any further intervention was needed.

Weirdly when checking the coordination model the statements made did not match the reality. In BIM it is important that every company does it's work before the deadline to be able to further progress and debate.

The actual situation

Based on the knowledge and information acquired from the interviews, combined with the information and knowledge gained from taking part in meetings, it became possible to explain how the project upgrade Wortel g-pier came to be and was currently being executed

In 2013 Schiphol Group made the decision to change its security system completely. From now on all passengers would have to go through one of five central security hubs instead of a security checkpoint at each gate. This choice was made because of the ever-increasing passenger numbers and the inability to further expand the terminal to further accommodate the passenger experience in the form of better shopping, more comfortable lounges and a better food and beverage experience. Apart from this the amount of long-haul flights was also increasing, making the waiting areas behind the gate security checkpoint too small to accommodate all departing passengers. (The Flying Dutchboy, 2015)

Figure 7: Gate security at Schiphol (https://theblogbyjavier.com/2010/09/29/is-a-hassle-free-airport-possible/)

This also meant that the number of security personnel could be optimized because there was no more need to have security personnel at a gate checkpoint for every departing flight and personnel would not have to continuously move around from gate to gate.

With the above-mentioned optimization Schiphol decided to convert from gate security to central security. With this conversion Schiphol had to completely rethink the logistics of passengers. This meant that in some areas a whole new floor level had to be created and in some areas a mezzanine had to be constructed. In exchange for this new construction, a lot of space would become available on the existing piers, which meant that there would be more space for shops, food and beverage and lounges all created to make the general experience of the passengers much better.
(The Flying Dutchboy, 2015)

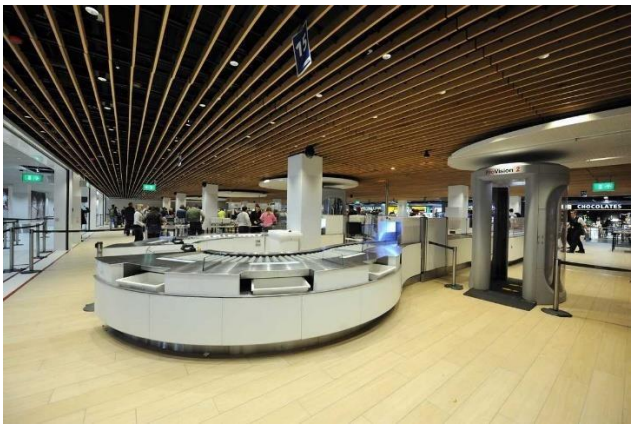

Figure 8: New central security hub at Schiphol airport (https://www.heijmans.nl/nl/nieuws/e-en-f-pier-op-schiphol-opgeleverd/)

The first step of this project was to build the new security hubs and all the infrastructure needed for the new security to work. In 2015 this first step was completed. The next step was to upgrade all the piers within Schiphol to keep up with this major change. There was a lot of new space available which was not allocated. This because the gate security had disappeared altogether. Schiphol decided to organize one very large project to start converting all piers. The first step was to upgrade piers D to G. (Schiphol Group, n.d.) This project had the following goals:

- Respond to the new central security system
- Start as a Gate Process Innovation (GPI)
- Redesign the boarding process
- Completely remodel piers D, E, F and G
- Convert the piers from a closed to an open character
- Convert the piers from a traffic zone to a lodging zone
- Sustainability and innovation

These steps would then lead to the following projected results:

- Increase passenger experience on the piers
- Give the piers a commercial impulse with new products and services
- Increase the satisfaction of airline companies and business partners.

Initially Schiphol wanted to start with part of the project, this part would be the upgrade F and G pier. With this idea in mind Schiphol created a task force consisting of Schiphol Consumers, Schiphol Security, Schiphol Asset Management (ASM) and Schiphol Operations. This task force was charged with developing the design specifications for this project. Initially this task force chose for a very innovative and sustainable solution.

The project manager

When Schiphol is faced with medium to large projects, where more than one sub-department of Schiphol (i.e. Consumers, Operations, Security, Asset management) are part of, Schiphol automatically tasks Projectbureau Luchthaven Schiphol (PLuS) with project management. PLuS is a sub-company of Schiphol Group, in charge of project management for medium to large scale projects. While this sub-company is not directly related to Schiphol, Schiphol is its only customer.

In case of the project upgrade F and G pier, PLuS tasked BenthemCrowell NACO (BCN), DEERNS and ABT with creating a conceptual design for this project. BCN as the main architect for Schiphol since the 1960's was tasked with guaranteeing the quality and architectural standards of Schiphol. DEERNS and ABT was tasked with creating a concept design for the F and G pier.

Within a few months DEERNS and ABT made a conceptual design for this project which was approved by BCN. After this, the Conceptual design was returned to PLuS who in its turn sent the design to the Schiphol task force for approval.

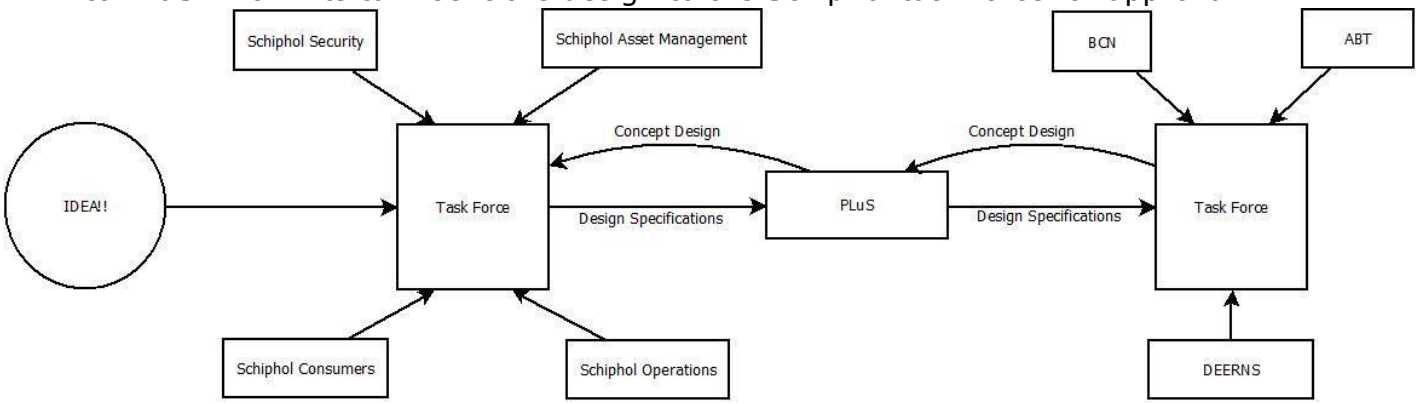

Figure 9: Schematic of Concept design Phase

After the concept design was approved, the next phase of the project was to organize a European public tender. This was s a mandatory step because of the nature of the project. A European public tender is mandatory when a project is part of a government building and has an estimated cost of more than € 5.225.000. Seeing as Schiphol is owned partially by the Dutch government and this project having been estimated to cost far over the minimum budget of € 5.225.000. The project had to go through this process. In 2015 the Building sector was still in dire straits and there was little interest in this large and demanding project.

During this time Schiphol group also started questioning if the sustainable solution, which was part of the design specifications, was the right choice for such a large part of the terminal. Before the deadline for the European tender Schiphol decided to cancel the project and asked PLuS to reassign the architectural task force with redeveloping a more cost-efficient conceptual design. Next to that Schiphol wanted to split the project into smaller segments to under the € 5.225.000 cost limit

and assign the in-house contractors to upgrade the first part of the project, this being the Wortel G-pier. In which Wortel stands for the connection of the pier to the terminal.

After the new concept design was approved by Schiphol, Royal Haskoning DHV was added to the design task force to help integrate Structural and HVAC components into the design. With this task force being well acquainted with BIM, the obvious choice was made to make the detailed design in BIM. BCN provided BIM models from its own database and spread those through the task force.

Contractors

As the project had now become smaller, it was up to the in-house contractors to execute the plans. The in-house contractors for Schiphol at the time of this project were the following:

1. VolkerWessels Bouw Schiphol (general contractor)
2. ENGIE (HVAC contractor)
3. BAM (Fire safety and security contractor)
4. KONE (Escalators and elevators)

It was now up to PLuS to coordinate the construction phase of the project. PLuS was tasked with the coordination role after it had won the coordination tender from VWBS. VWBS had budgeted the coordination of the project to the estimated value of about € 100.000. PLuS had budgeted the coordination to about € 60.000. With the budget in mind Schiphol quickly decided to allow PLuS to take on the coordination role.

This meant that PLuS oversaw contracts, BIM coordination and project coordination in general. PLuS set this project up according to a traditional building process, where they were in the center of the whole process making all communication and data go through them. Apart from that, the project was split up into steps where companies were only involved during specific steps.

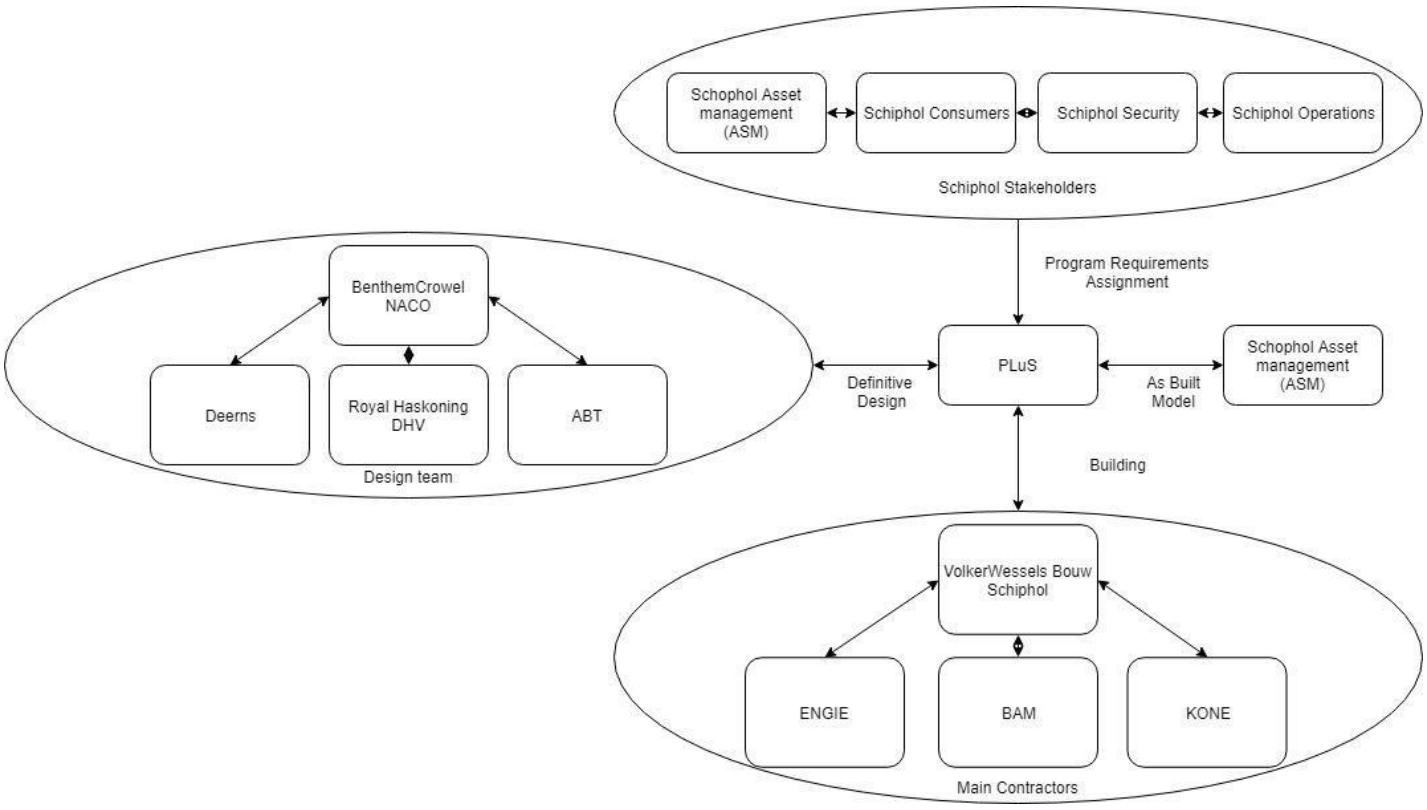

Figure 9: Project coordination through PluS

In the above Schematic the complete building process is shown as intended by PLuS. By making themselves the center of communication PLuS expected to have the most control.

The construction phase

The construction phase is also the phase where the problems started to occur. During the work preparation, it quickly became clear that the design team had not considered small renovations and upgrades that had been executed over the years in the g-pier. The design was based on a digital model which BCN had stored in its own database, and not the model which was provided by Schiphol Asset Management (ASM). This created problems with construction phase because different parts of the design interfered with prior changes in the pier which were not considered during the design. Some of these changes had such a big impact on the design that it would be impossible to construct them without interference.

When this issue was further researched it also became apparent that the model provided by ASM was also not up to date according to the real-life situation. DEERNS, ABT and RHDHV defended their positions by stating that they had been assigned to make the conceptual and definitive models based on the model provided by BCN. BCN defended itself by stating it had not received any models from PLuS and therefore was forced to make the decision of using the models from their own database which were not as-built models. PluS defended itself by stating that it had also not received any models from ASM and that ASM would have not had the latest

updated model ready yet by the time the design was made, so it would have not been of any use anyways.

In the meantime, VWBS had decided to start documenting the as-built situation as contracted. What VWBS did not expect was that the design was not based on the as-built model and therefore having to find out where construction problems would become apparent and how to potentially solve the problems. For this action resources were needed, and resources always translate into money. Schiphol was not prepared to pay the bill for a mistake not caused by them. VWBS continued to document the as-built situation to be able to carry out the necessary work.

This step required a lot of communication between themselves as contractor and BCN as architect. Unfortunately, PLuS was not allowing these communications to be carried out directly in fear of losing the coordination position. BCN was also not willing to breach the contract it had with PluS which stated that all communications had to go through PLuS. Next to that BCN was also not willing to invest energy and resources to correct these problems because the project was already finalized for them, as contractually all they had to do was to develop the plans to a definitive model.

In the meantime, within the construction team progress was slowly being made even though information was scarce. With the models being continuously updated and the project slowly moving forward there was still continuous discussion between the construction team and PLuS. Therefore, VWBS had taken it upon themselves to relieve PLuS from their coordination role within the construction team. VWBS now had control over this team and started to coordinate the BIM trajectory. With direct communication and regular meetings between the BIM modelers of VWBS, BAM and ENGIE slowly differences between the as-built situation and the final design were being solved. During this process some issues kept continuously returning. One of the issues vital to this process was how to deal with the as-built situation of the different specialties namely civil, structural, HVAC, security and fire safety. VWBS had contractually been obliged to model the existing situation on a civil level. BAM and ENGIE, did not have a clause in their contract obliging them to model the current state of HVAC and Fire safety and security.

Now one can imagine that with the current contract and the lack of as-built information of HVAC, fire safety and security, problems during construction would become imminent due to the unknown factor of where the current objects are. Unknown to the construction team, every contractor had a unique contract with different prerequisites. So, while VWBS taught BAM and ENGIE were unwilling to assist in modeling the current state of the building, thinking this was a breach of contract, BAM and ENGIE taught VWBS was forcing them to do work they were not contracted to do. It soon became clear that PLuS had failed to mention what was contractually expected from each contractor.

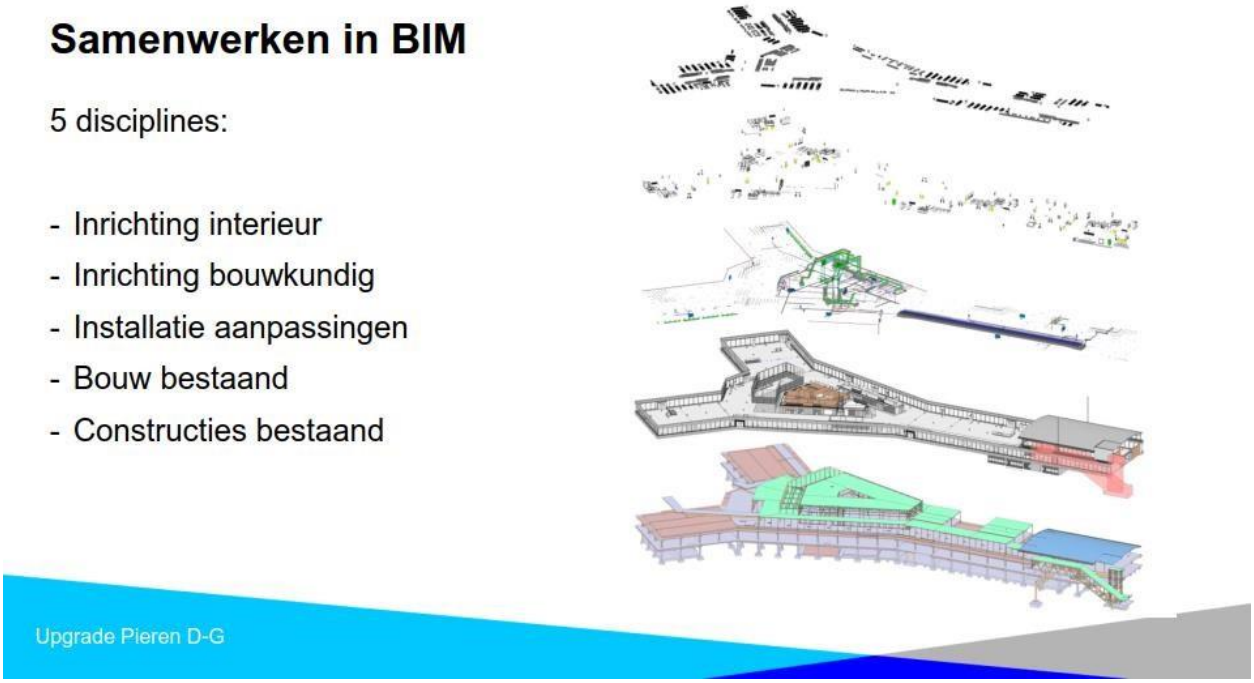

Figure 10: Expected disciplines for contractors (presentation from PLuS)

In the above slide which was part of a presentation of PLuS, it is clearly visible what was expected from the main contractors.

- Fitment of the interior
- Fitment of the civil objects
- Changes to installations
- Existing civil objects
- Existing construction

The documentation of the existing installations is clearly not a requirement. This is strange because in the process of gaining information it became clear that ASM does require complete as-built documentation from the contractors. This means that all existing object should be documented and updated. This is extremely important to ASM, because with these models ASM is attempting to create a digital asset management environment.

BIM IDM

In recent years ASM has been putting a lot of effort into developing a digital asset management environment as came forward in the interviews. The goal is to eventually manage all Schiphol assets from a digital environment. This means that every object Schiphol owns will be digitally documented, from landing strip to roller shutter switch. To be able to effectively do so, ASM has created a so-called IDM (information delivery manual) in which all requirements for handing over digital models and data is described. (McPartland, 2017) This manual consists of different chapters for different projects. This because not all assets require the same data.

Imagine a fence needs different data than a check-in counter. This manual is very extensive and includes information on the data needed for every kind of object. It is very important that the requirements of this manual are complied with, otherwise it is impossible for ASM to use the as-built models for asset management.

In the process of assigning this project to the main contractors PLuS took it upon themselves to distill the manual to the points only they found necessary and logic. This caused confusion between the contractors as to what was demanded, because all contractors received the IDM from ASM, but also received the distilled version as part of their contract from PLuS. Logically each contractor chose to use the PLuS IDM because it was far less work to comply with.

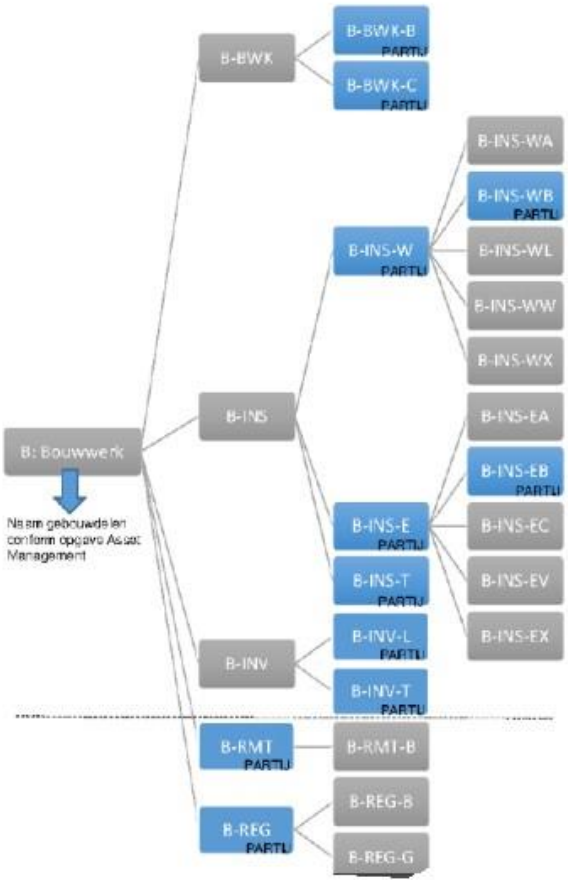

Figure 11: PLuS requirements (blue) and ASM requirements (blue and grey) (presentation by PLuS)

Construction group coordination

Within the construction group VWBS, as mentioned before, attempted to take over the role of coordination to try and keep the project moving forward. To further help with managing the issues, VWBS chose to adapt the IDM from ASM and elaborate on it by adding and slightly modifying the requirements to attempt to get as close as possible to the actual requirements whilst still being realistic. The BIM modelers from BAM and ENGIE initially agreed to these terms and the three contractors, BAM, ENGIE and VWBS moved forward with this IDM. KONE did not

take part in this agreement, as its role in this project was quite small, only having to refurbish some electric walkways and escalators.

With the BIM modelers on board the next step was to try and get the decision-making people also on board. The problem was that even though the BIM modelers were on the same page, realizing they could work a lot more efficient working together, the project leaders were on a completely different page. They were more preoccupied with what the contract stated, together with the building specification document (which was contractually binding). This meant that some issues which came forward in the coordination sessions could not be solved because approval from the project leaders was required. This was a problem because the project leaders would not attend these coordination sessions, so decisions could not be made. Whilst VWBS had requested the other contractors to make the BIM model the leading document in all discussions, numerous times BAM and ENGIE fell back on the Building Specification document, which meant that even though issues were spotted in the model, they would not be solved because they were not stated in the Building Specification document.

Hypotheses

Even though most problems with this project started showing during the construction phase, making it seem obvious that the plans were wrong, the root of these problems can all be retraced to the way communication was set up. Schiphol clearly had the desire to execute this complete project in BIM. When this project was handed to PLuS, PLuS chose a traditional method of working in a BIM environment. This step created a lot of ambiguity.

When considering BIM as the way to execute a project it is very important to realize that BIM requires, as explained in the BIM theory chapter, not only a change in the way of working (software and tools), but also a change in structure and organization. BIM requires people to work together and to invest time throughout the project, even when it reaches a stage where a team is no longer in charge, but solely giving advice.

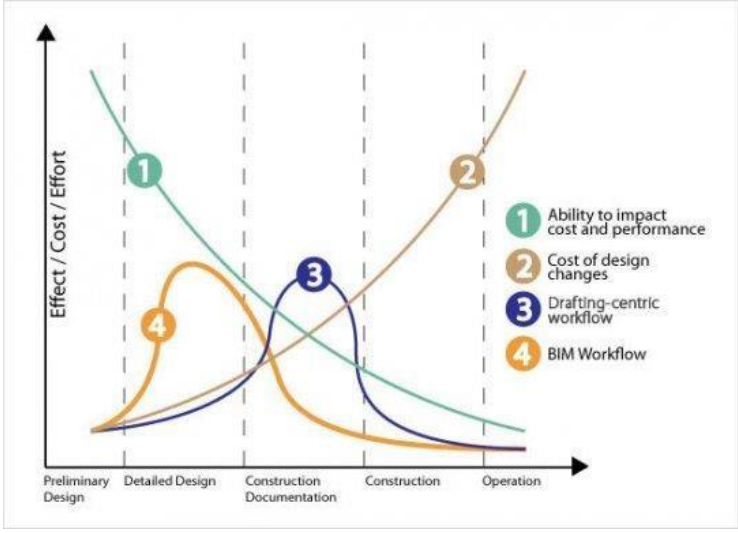

Figure 12: BIM chart (http://www.monaghans.co.uk/building-information-modelling-bim.php)

In the above chart an attempt was made to display the benefits of BIM versus traditional building. Now people often think that BIM should make things easier and time saving. This is usually not the case. The biggest benefit of BIM is the ability to reduce the cost of design changes by tackling most major design issues in the early stages of a project. By dry building sessions, and virtual building and modeling, issues can be traced and repaired in the design stage of a project instead of the construction stage, where design changes are far costlier. SO essentially BIM creates a more intense design period, where problems can be solved digitally with minimal loss during the construction period. Whilst traditional building creates a faster design stage and more issues during construction. ("Building Information Modelling (BIM) - Monaghans - Inspiring Built Environments", n.d.)

To create an accurate hypothesis, the first step is to figure out which company plays what role in the BIM circle. This is important to realize when which team plays a vital role in the overall BIM process. Filling in the different teams in the BIM circle creates the following scheme:

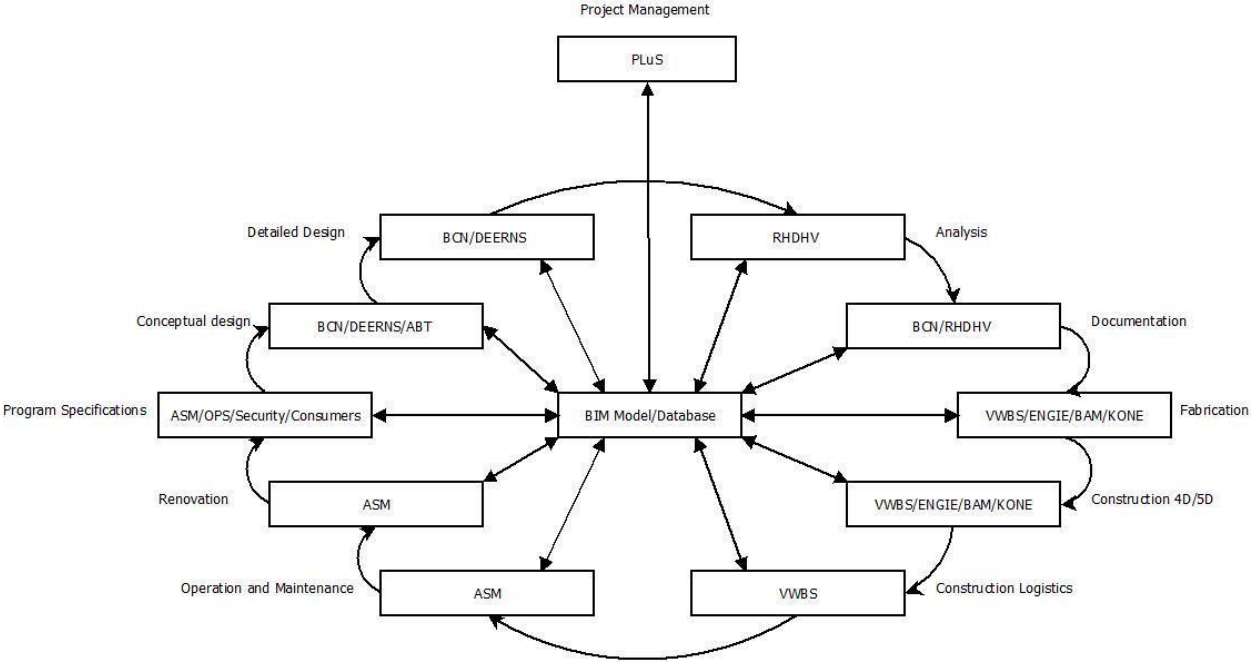

Figure 13: Scheme with involved teams

What is important to realize is that this scheme displays the different stages of the project, with the team that is likely to oversee that step. The steps are worked off systematically from left to right starting with the PvE, which stand for the design specifications. Whenever an issue occurs at a step, the idea is to go backwards to the first step which is influenced by this issue. So, for example when a company during the fabrication runs into an issue, which has effect on the definitive model, the process goes back to that step.

At the same time, all teams are responsible for checking and advising each other to help mature the project as efficient as possible. S0, essentially if the fabrication teams did their work of checking and advising correctly then it should not be necessary to go back to the Definitive model stage as the advice should have already been given during that stage.

This means that every team is involved in a project in a more or less manner from beginning till the end of a project. Every team helps another one to achieve the wishes which were set by the client.

The second point the scheme addresses is the point that everyone works in a centralized BIM environment. This means that from the first day of a project all the way to the last day, there is **one!** model which is leading. This model is called the coordination model. Obviously to prevent this model from becoming to overloaded,

this model also serves as a link to multiple other models and other information stored within a database. The coordination database.

It is furthermore important to understand that with the technology available today it is very possible to update this model in real-time. Which means that multiple teams can access and modify the model at the same time. In the past the choice had been made to update the coordination model on a weekly basis or sometimes even every two weeks. While this may seem like a good idea, because it allows people to continue their work without immediately clashing, this means that every time the coordination model is update the possibility exists that a whole week's work for one or more teams can be undone.

To make sure that every team knows what the project rules are, a BIM coordinator is tasked with setting priority rules. This means that for example a structural modeler has right of way over an HVAC modeler because a building's structure is far more critical than the replacement of a HVAC-duct. Same goes for a window company deciding that smaller windows are better while the architect explicitly designed large windows. The best situation is a situation where the BIM coordinator is unbiased.

Figuring out importance

The next step is to figure out what the importance of each team is in the whole project. Obviously, the team in charge of installing escalators has far less to do with the project over the team who oversees the architectural design. So, the next step was to rate every team to their importance during this project. This importance can somewhat be correlated with the amount of effort that needs to be put into continuously monitoring the progress of the coordination model. For example, in the design there is the need for two escalators. KONE who oversees escalators, will update the coordination model with the two escalators and all data needed. In theory, if the architect approves of the escalators, there is no need for KONE to check the model daily for changes. This makes the role of KONE smaller then for example VWBS who needs to build all the walls and ceilings.

Company Name	Project Importance
Schiphol ASM	High
Schiphol Consumers	Somewhat
Schiphol Security	Little
Schiphol Operations	Little
PLuS	High
BenthemCrouwell	High
DEERNS	Medium
ABT	Medium
RHDHV	Medium
VWBS	High
ENGIE	High
BAM	Medium
KONE	Little

Figure 14: Importance of every team in the BIM circle

The next step of the hypotheses is based on the information acquired early on during the internship. In a very early stage it already became apparent that PLuS was not performing the way which was expected from the other teams. Multiple conversations pointed towards PluS as the bottleneck. Now it is easy to point at another team and say it's their fault and immediately saying "I can do it better". The reality of the situation is that it is not smart to make a team in charge of another part of the process also oversee the BIM coordination, in other words the project management.

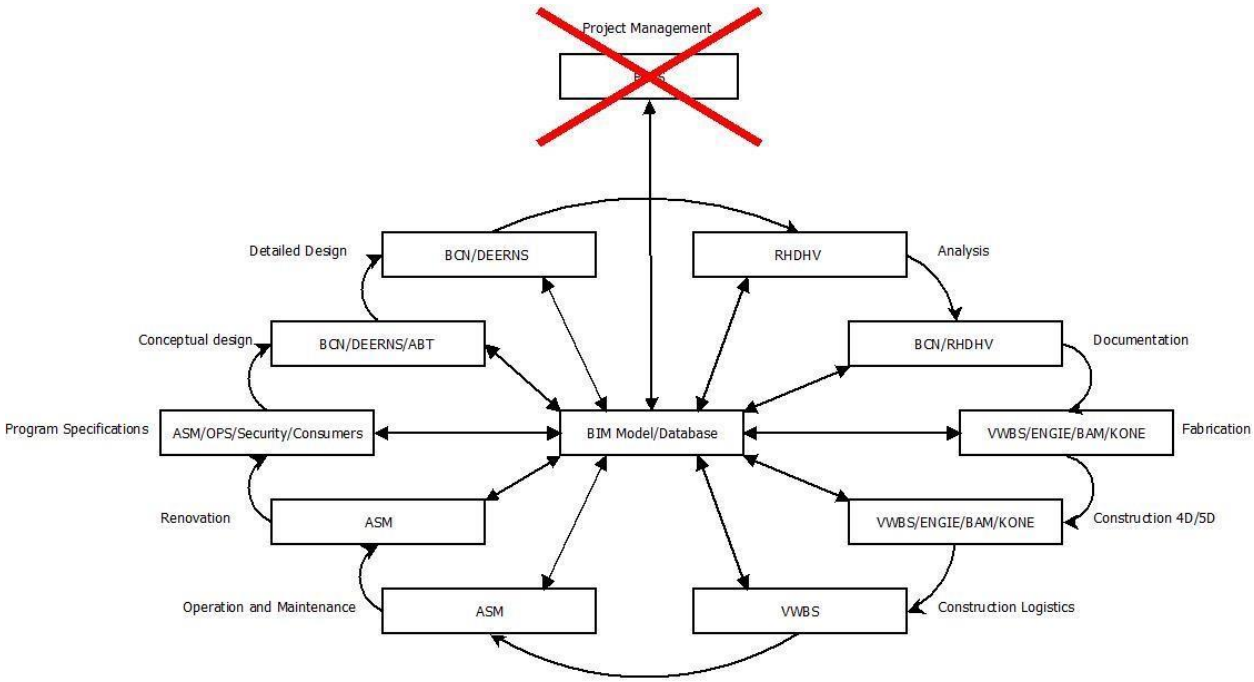

Figure 15: Hypotheses, imagine PLuS would be eliminated

A new project manager

The most logical solution would be to eliminate PLuS as the project management team. The issue is that PLuS does not operate the way it should in the current state. In eliminating PLuS the BIM coordination could be solved. During the internship multiple teams had indicated wanting to take over the BIM coordination role. As explained above this would not necessarily solve the issue. Imagine the case in the scheme on the next page where VWBS would become in charge of the BIM coordination.

This would mean that VWBS would be part of the project with two different roles. This would theoretically not be a problem. In practice, the problem would at a certain point become apparent. Imagine there is a clash in the Coordination model between VWBS and ENGIE. Where a main ventilation duct collides with the mounting for an information screen. If the priority rules would be set up correctly then realistically the HVAC would have right of way over a mounting. It would benefit VWBS more if the HVAC would move and the mounting would stay in place. This would obviously spark a discussion because VWBS has the power to alter the priority rules to its own benefit.

Now this issue would not only play a role in the case of VWBS, but could just as well happen with BCN, RHDHV, ASM, etc. So, it is important to understand that choosing for a situation where a team oversees a certain step in the BIM circle as well as the BIM coordination will most probably cause problems due to self-interest.

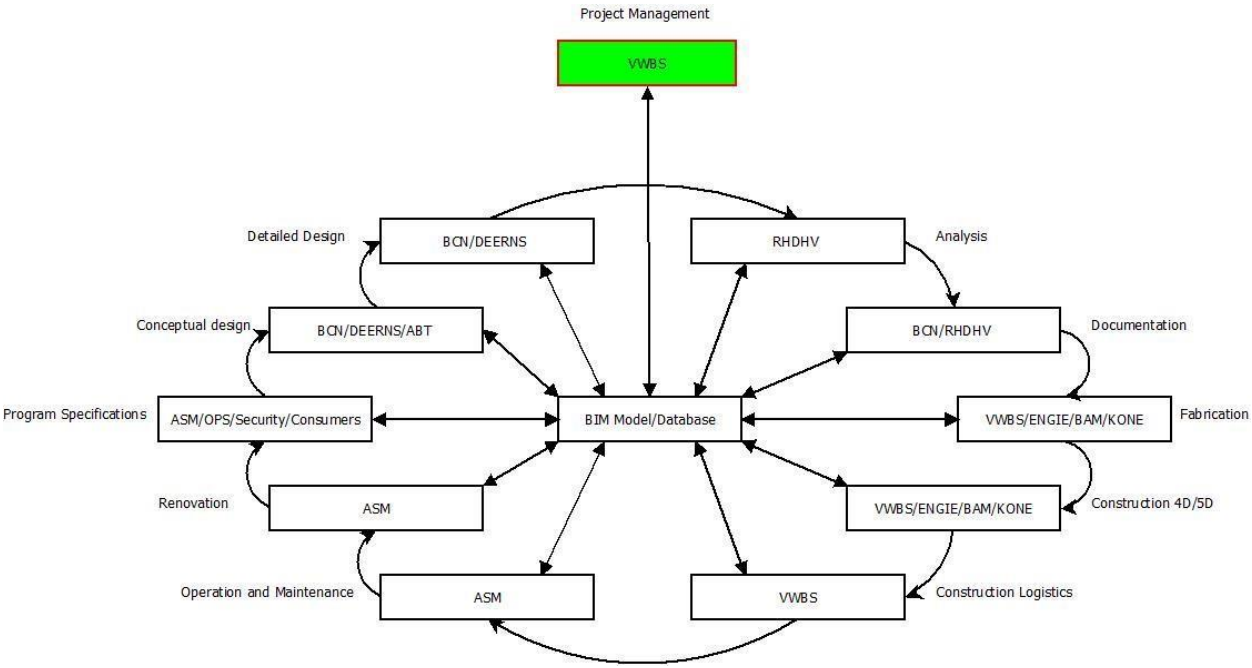

Figure 16: VWBS in charge of project management (BIM coordination)

The BIM collaboration

To make sure the BIM coordination is unbiased the proposal is to set up a collaboration between different teams. This collaboration should consist of BIM experts in every segment of the BIM circle. In every segment there is a team in charge. In the scheme below the BIM circle is split into four segments. Each segment serves a purpose. From left top clockwise:

1. Architectural design stage
2. Technical design stage
3. Building and Construction stage
4. Management and operation stage

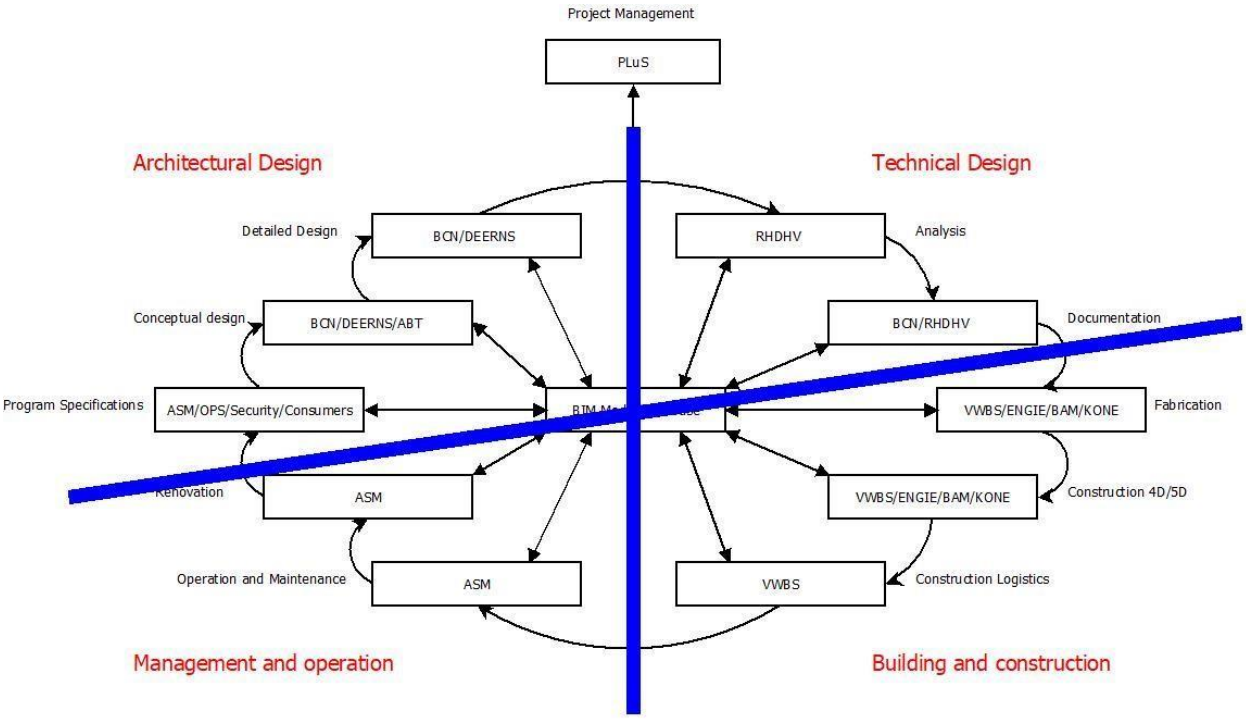

Figure 17: Four stages of the BIM circle

Every segment in the BIM circle demands different specifications from the BIM model. The architectural design stage is mostly built on generic modeling where visualization is key. The technical design stage is more based on model data, thus adding technical information to the visual objects, for example adding fire ratings to a roller shutter. The third stage, the building and construction stage modifies the model from generic objects to specific objects, for example a generic roller shutter becomes a roller shutter with a brand and model, combined with the technical requirements. The management and operation stage in its turn needs as-built information, service contracts, and lifespan information to perform adequate asset management.

With every aspect needing such different BIM specification it would be wise to have a BIM advisor which is specialized in the specific quadrat of the BIM circle. These for advisors which can be a BIM expert from a team, for example in quadrant one BCN, in quadrant two RHDHV, in quadrant three VWBS and in quadrant four ASM. These BIM experts can defend the BIM requirements of their quadrant in IDM. These experts collaborate under a BIM coordinator which in its turn warrantees the quality of the IDM. This expert can be an expert from PLuS or from any other company.

This hypothesis will convert project management from a single team, to a collaboration of four experts lead by a project manager who also has knowledge of BIM. This way the quality of the BIM model is guaranteed throughout the entire project, with the requirements of every quadrant defended by its BIM expert. Because the project management is now in the hands of a team of BIM experts,

there is also a lot more knowledge on the way all the teams communicate with each other, when teams are involved in discussions and what data is needed at what point during the project.

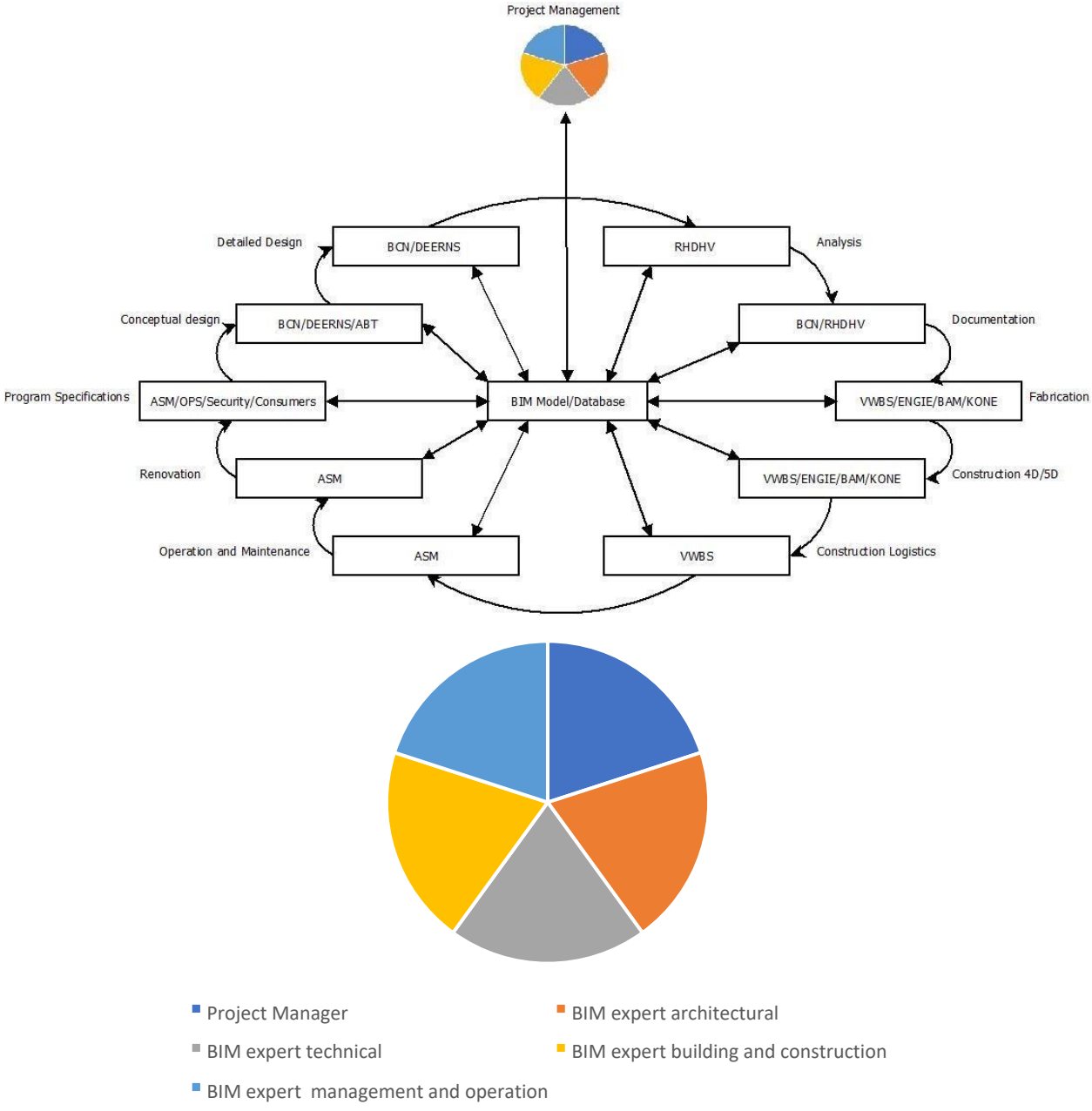

Figure 18: Project management through collaboration

Implementation of Hypotheses

After analyzing the information gained during the interviews the issues with this project can be summarized. The data can then be compared to the hypotheses. With the comparison it is possible to explain how to implement the hypotheses and what the benefits will be.

Summary of interviews

What can be seen immediately in the interviews is the fragmented vision as to what BIM is exactly. While some teams have a clear and correct idea of what BIM is, others refer to BIM as models and some have no idea what BIM is in general. The dissension as to what BIM is, is the root of all problems within this project. Everyone is speaking of BIM in a different way and expecting different things from each other.

Secondly, even though every team thinks they are working in a BIM scheme, they are in fact 3D modeling whilst still communicating top down. This has partially to do with the way the contracts are set up, but also partially because of the preference of certain teams.

In the first stage of the project, when the project specifications are set, it already becomes apparent that this project is not executed according to the BIM principles. The sub-teams of Schiphol group clearly only set the project specifications. These sub-teams do not return to any stage of the project. They assume that once the specifications have been set it is up to PLuS to further execute the project.

In the design team there is still a very clear hierarchy where BCN in the boss, whilst ABT, DEERNS and RHDHV must answer to the demands and wishes of BCN. BCN only communicates with PLuS and attempts to keep secondary communication between on one side ABT, DEERNS and RHDHV towards PLuS to a minimum without having themselves in-between. This is very clearly not the way communication should be according to the BIM theory explained earlier.

This hierarchy is also visible in the way the design team “hands over” the design to PLuS. When working in a BIM environment when a plan is handed over to the next step, it does not mean that the team involved with that stap is done with its work. It merely means the authority shifts from leading a step to advising the next step. The design team clearly states that when the design phase is done, the project is essentially completed for the design team.

When the project reaches the construction teams, PLuS makes sure that with the way the contracts are set-up, there is a clear hierarchy where all construction teams answer to PLuS, and any further questions about the design also must go through PLuS, before it reaches the design team.

Apart from that, the lack of coordination during this stage of the project creates more frustration. At this stage some teams try to solve this lack of coordination by taking over this role, this leads to different frustrations between the teams, because a team which is not in charge of coordination starts making decisions that are not theirs to make.

It is because of this hierarchy and the lack of communication between all teams that in the end the goals set are not met. While usually the project is completed, the secondary goals, for example the as built model, and the asset management documents are never completed. The reason these are not completed is because the difficulties during the project usually leads to teams going overbudget leaving no room to finish the project within budget.

How to implement

To be able to implement the hypotheses correctly a change in hierarchy must be demanded by the client, in this case Royal Schiphol Group. If a team is not willing to deal with this change in hierarchy then it should not be part of a project. While this measure might seem extreme, it is the most important step towards creating the BIM environment.

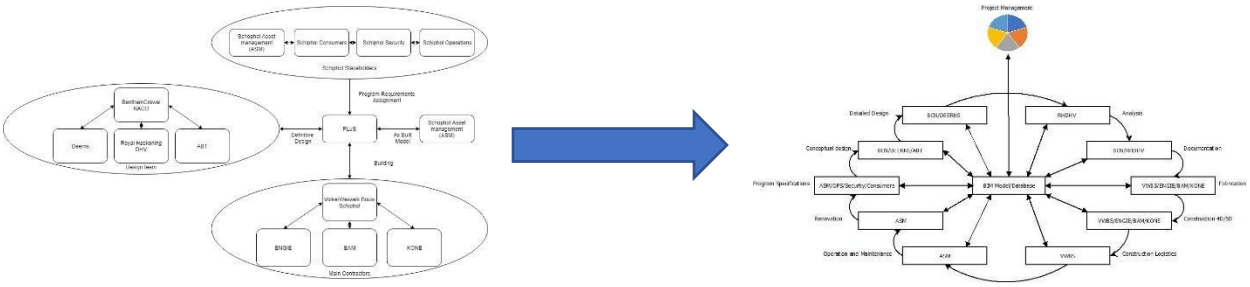

Figure 31: Top down to circular

This change in hierarchy forces all teams to help each other out when they are not in charge of a step during the BIM cycle. This means that teams should be contracted before a project starts. This way the expertise of teams who lead further down the way can be used during early stages of the design.

This change in hierarchy also requires a change in mentality. During the interview with BCN it quickly became apparent that BCN considers all data which they produce their intellectual property. With BIM, there is no intellectual property during the project. All data is shared between all teams during the entire project.

The argument of BCN and VWBS to take over coordination of the BIM model, should not be considered. It should never be allowed for a single company to have a team assigned with coordination and another step of the BIM circle, to prevent conflict of interest.

What is important is that every quadrant of the BIM circle assigns one BIM expert. The smartest solution would be to have an expert from a team which is most involved in the project.

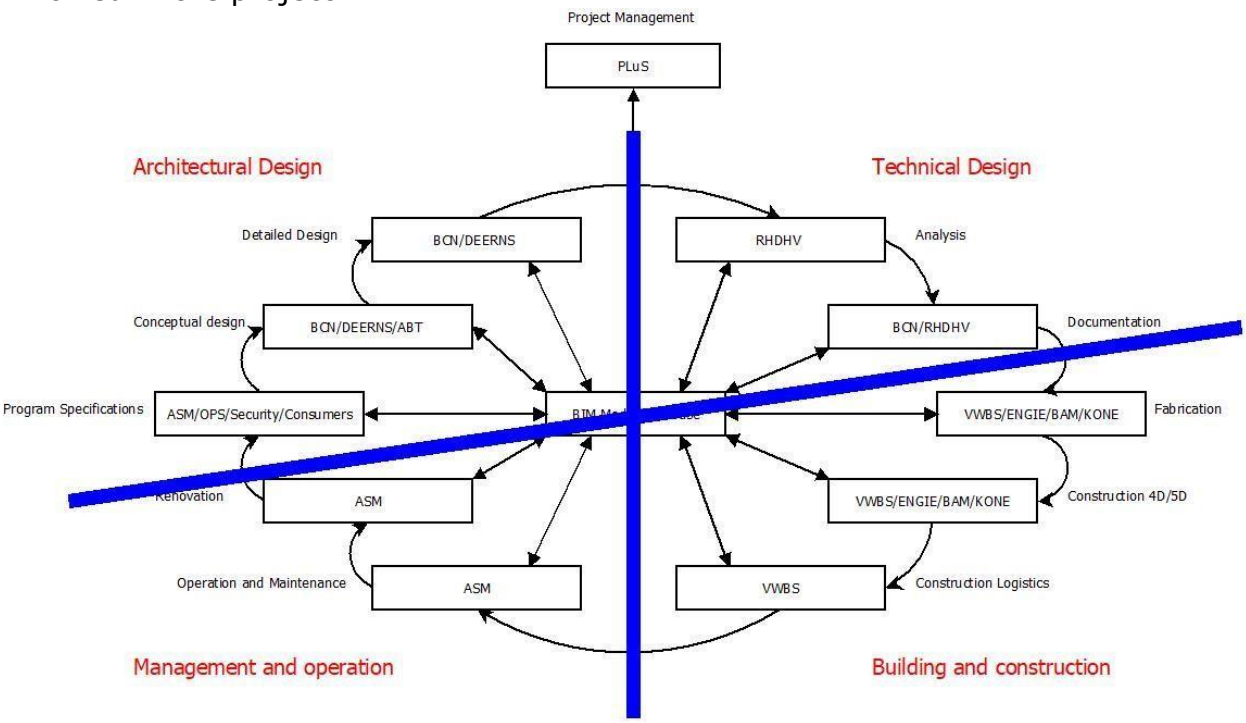

Figure 32: Quadrants of the BIM circle

In the case of this project it would be a smart idea to have a BIM expert from BCN be in charge of the left top quadrant (architectural design), a BIM expert from RHDHV be in charge of the top right quadrant (technical design), a BIM expert from VWBS be in charge of the right bottom quadrant (construction and building) and finally a BIM expert from ASM be in charge of the bottom left quadrant (management and operation). These four BIM experts should work together under leadership of an adequate BIM manager which can be provided by PLuS.

The next step is to make sure every team gets a contract with the same specifications. This way the project manager can make sure that all teams must commit to their stage and provide advice during other stages. The contract also includes the IDM which is created by the BIM team. Under no circumstance can a project have a project specification document as leading document. When working in a BIM environment the coordination model is always leading and should contain all information needed throughout the project.

Making the coordination model leading always forces all teams to work in this model and keep it updated. Certain deadlines can be set during the project to force all teams to commit to updating their work in a timely manner. During the internship at VWBS the coordination model for project upgrade Wortel g-pier was update on a weekly basis. Whilst this may seem like a good idea, to give all teams time to progress their work, with the current hardware and software capabilities, updating

the coordination model real-time is a much smarter idea. When the coordination model is updated in real time, all teams can continuously see progress of each other and solve clashes in the model before the weekly BIM sessions which should be organized to discuss progression and only clashes which are not straightforward.

Real-time updating of the coordination model requires a high level of commitment. Teams should understand the risks of working in a model in real-time. The inherent risk when working with real-time models is that these can become cluttered and heavy fast. Therefore, it is important to understand the database behind a model. This database essentially contains more information than the model itself. The BIM team is continuously checking the model and database for errors and must intervene as quickly as possible when it notices any errors.

The result

When the steps are taken into careful consideration, a pleasant cooperation between all teams can be created. Companies can start to earn money by budgeting their projects better because there is more information available at an earlier stage. The design team can create a more realistic architectural design, because the other teams are advising them on structural limitations and building limitations, the technical design is more optimal because the design and build teams give advice on architectural limitations and optimal building solutions, and the build team can work faster and more accurate because it knows what the wishes of the other teams are, and in continuously advised on the expected results.

With this teamwork through the coordination model, the final step, which is asset management is also achieved, because all teams know what the requirements for asset management are before the project starts. All teams are also continuously monitored by the BIM team to see if the required data is implemented in the BIM model and database.

The existing building

Another big problem this project dealt with was the fact that there was an existing building which this project started with, which was poorly documented. With most teams blaming each other for the poor documentation and PLuS and ASM not being willing to invest any funds in the documentation, problems became bigger and bigger as the project progressed.

It is important to understand that with a project which consists of a pre-existing structure it is very important that funds are made available for documentation of this situation. Whilst the hierarchic approach of the reality makes documentation a big issue, in a BIM environment, because all teams are part of the project from the beginning, they can all help with this documentation. For example, RHDHV can provide 3D BIM models of the existing structure which BCN can use during the architectural design. At the same time the construction team can start documenting the existing installations, so the technical team can use that data

making the work for them and the build team easier because the existing objects have been considered in the design phase.

BIM sessions

In the interviews it is very clear that the BIM sessions end up in discussion between teams. This has partially to do with the fact that BIM sessions should be attended by the project manager and the team managers, together with the BIM modelers. The BIM modelers themselves are not allowed to make any decisions regarding the project. Apart from that the unclear contracts and differences in contract were also cause of discussion during the BIM sessions.

If BIM is implemented correctly then BIM sessions should be sessions where advice is given to other teams on issues that arise, furthermore they should be presided by the BIM team. This way the priority rules can be respected, and discussions will not arise.

Figure 33: BIM session with experts (https://www.buildingsmart.org/news/bsi-awards-2016/)

Object related case studies

To be able to get a better idea of how the organization at Schiphol works, three case studies have been selected and further elaborated. These case studies are examples as to why the current hierarchy and way of working at Schiphol does not function correctly. These case studies are elaborated in three steps. First the situation occurred is explained, then the problem behind the situation is explained and then a potential solution is submitted. The three case studies each have a different origin and are of a different cause.

Fireproof roller shutter.

During the internship period at VWBS there were a lot of issues with fire compartmentation and to be more specific a fireproof roller shutter. This issue grabbed the attention because of the critical nature of these kind of details within a design. Fire compartmentation and fire routes are something that cannot be wrong. If they are wrong the safety of the users of the building cannot be guaranteed.

When presented with the execution model (UO) VWBS noticed that there were some issues with a fireproof roller shutter in the BIM model. According to VWBS, BCN had modeled the fireproof roller shutter to a specific type. It had done so because of prior experiences with this specific model, which is produced by a company called “Hoefnagels Branddeuren”. BCN has a good relationship with this company and therefore had made the choice, based on prior successes to assign Hoefnagels with the task of producing the fireproof roller shutters for this project.

The choice to do so is an odd one, because being the lead architect, BCN is not in charge of production and installation. This step is led by VWBS. Therefore, BCN is not allowed to take over this role and assign a company for production. The only task BCN has is to make sure that the quality and looks of the end-product fit the required specifications. Next to that BCN can also recommend VWBS to assign Hoefnagels Branddeuren.

While modeling the fireproof roller shutter, BCN also failed to take into consideration the technical requirements which were set for this fireproof roller shutter. This is a logical mistake because BCN modeled the roller shutter before the specifications became available to them. When looking back to the BIM circle, one can see that the definitive design is completed before the technical specifications are produced. Now it is only after the analysis and technical specifications that, VWBS could request an offer from a sub-contractor to produce a fireproof roller shutter modeled to the design standard and meeting the technical specifications.

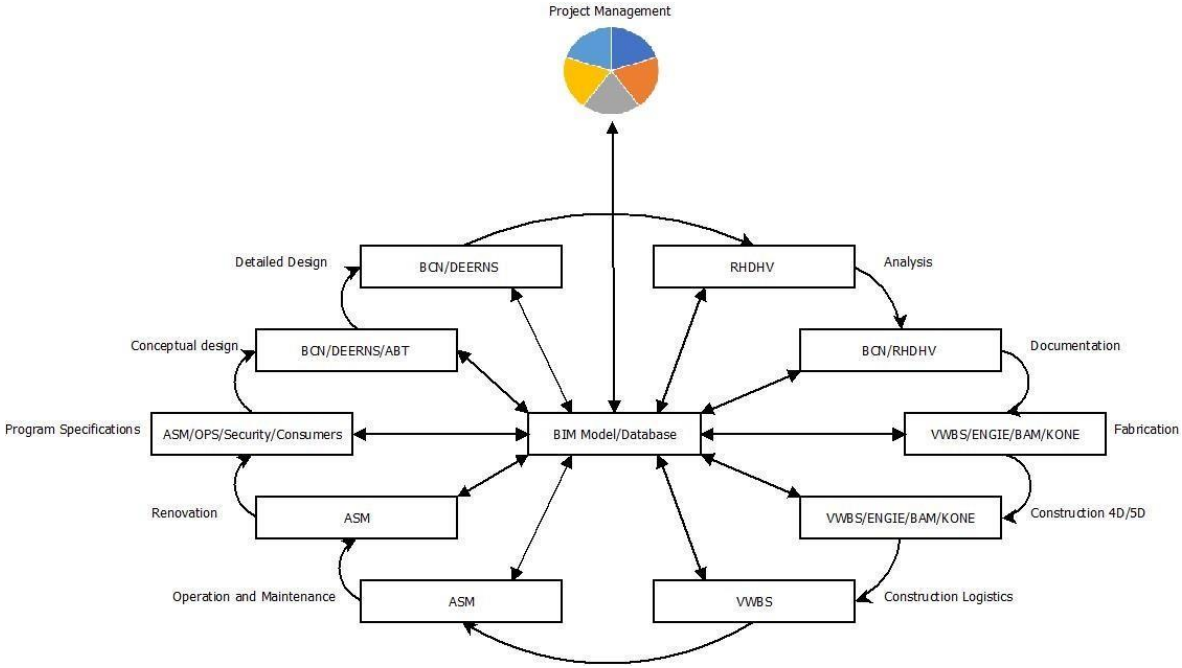

Figure 34: Bim circle with Detailed design before analysis

Confronted with the fact that BCN had already assigned Hoefnagels Branddeuren to produce the fireproof roller shutter, VWBS decided to check with Hoefnagels if the roller shutter fulfilled all the set design and technical specifications. It was at this point that VWBS realized that BCN had ordered the roller shutter to be made with the electric engine driving the opening and closing of the roller shutter on the wrong side.

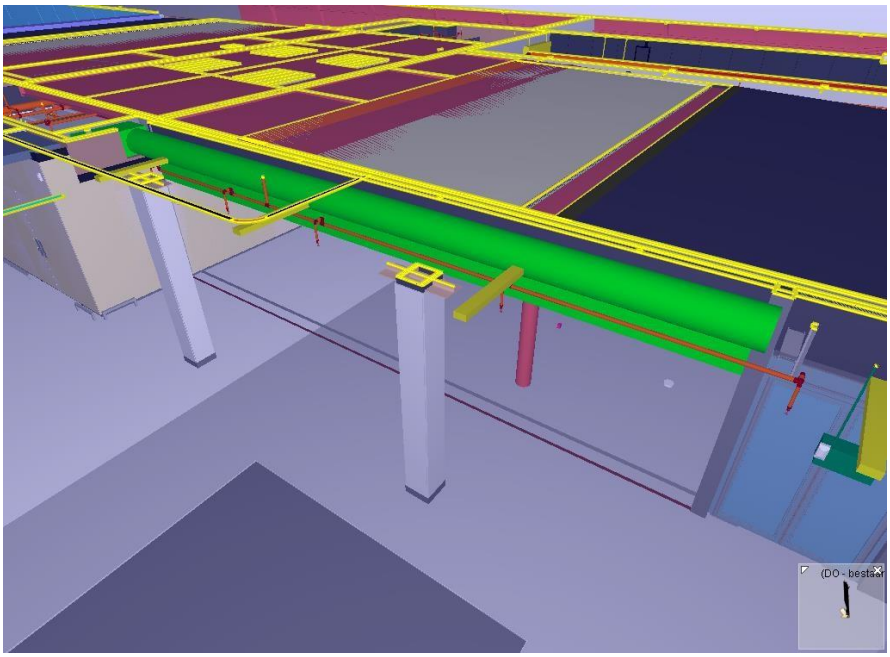

Figure 35: Coordination model with roller shutter in green correctly modeled by VWBS

In the end because of the alertness of VWBS in the coordination model, VWBS was able to catch the issue before the roller shutter was delivered and Hoefnagels was able to correct the issue with the motor without having to produce a completely new door.

The BIM approach

Theoretically the process from design to installation of the roller shutter should have been completely different. TO explain how it should have been, the process will be explained with the BIM circle.

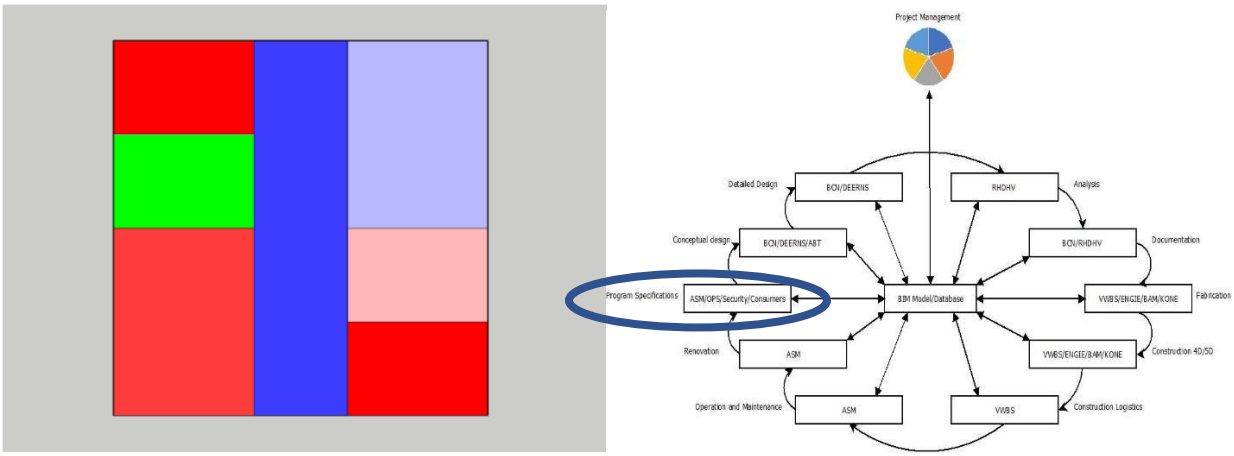

Figure 36: Zoning according to specification requirements

The first step is to present the architect with a list of specifications. These specifications often include a zoning plan. This zoning plan includes the wish of the client as to what is being placed where. In this case Schiphol Group will give information as to where Shops will come, where crucial routes are, where toilets come, where waiting lounges come.

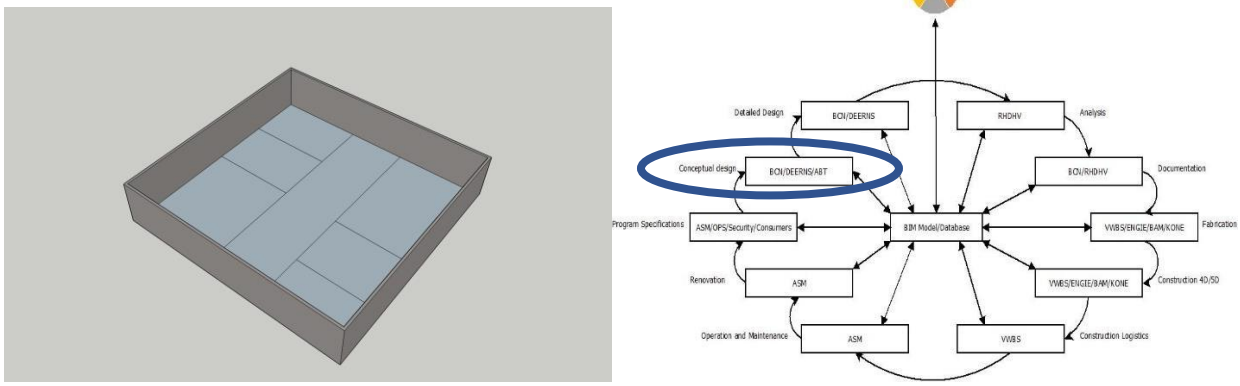

Figure 37: Conceptual design

The next step is for the architect to create a conceptual design in which these wishes are reflected. This first step is also an attempt of the architect to translate

the project specifications to a 3D model. This is the first time the client will be able to visually reflect on the project specifications.

The discussion between the architect and the client progresses the design until the definitive design is reached. At this point the architect finishes the model and all design specifications are finalized and integrated. From now forward essentially there are no further discussions on the architectural design between the client and the architect.

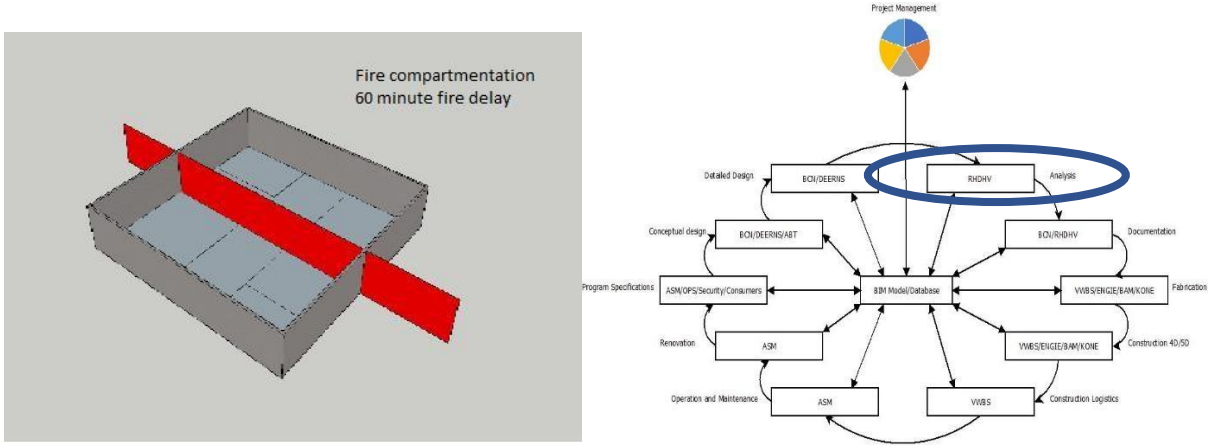

Figure 38: Analysis for technical specifications

During the analysis stage, the technical specifications are introduced to the design and the model. At this stage the model is not only visual, but data is also added to the model. This data includes for example the fire compartmentation, the ventilation levels, the amount of lighting needed, etc. These specifications are all added by specialists in their field.

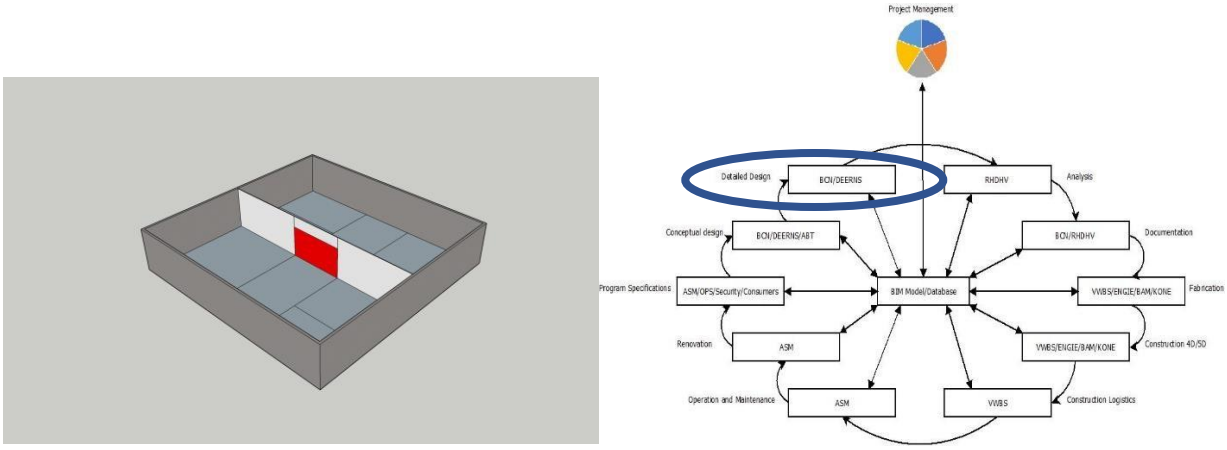

Figure 39: Integration of technical specifications

At this point the design goes back to the architect who can then implement the technical requirements into the design. This step is important because the fire technician is only in charge of compartmentation. It is up to the architect to make sure the compartments are intact and where needed openings in the compartments

can be created by the means of fire proof rolling shutters for example. These openings stay open until there is a fire and then close automatically.

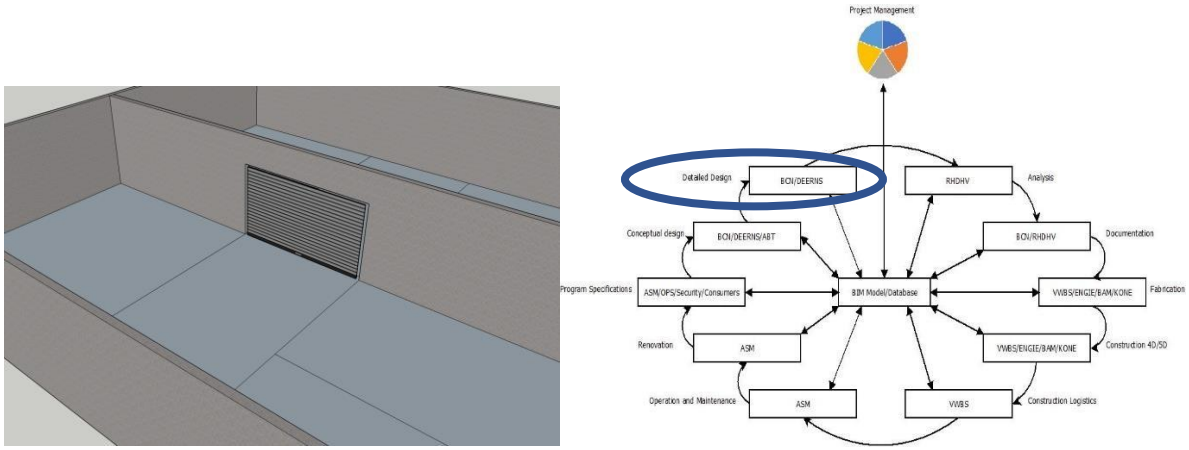

Figure 40: Fire proof rolling shutter for passageway between compartments

The design of these shutters can now be done. In this stage BCN, together with Deerns, decide how this passage should look. So, a design choice is made. Note that up until this point every step has been based on generic design. There has always been talk of **A** fire compartment, **AN** opening, **A** rolling shutter. This means that there is no specific product choice. It is merely an object with design specifications, and technical specifications, generic in other words.

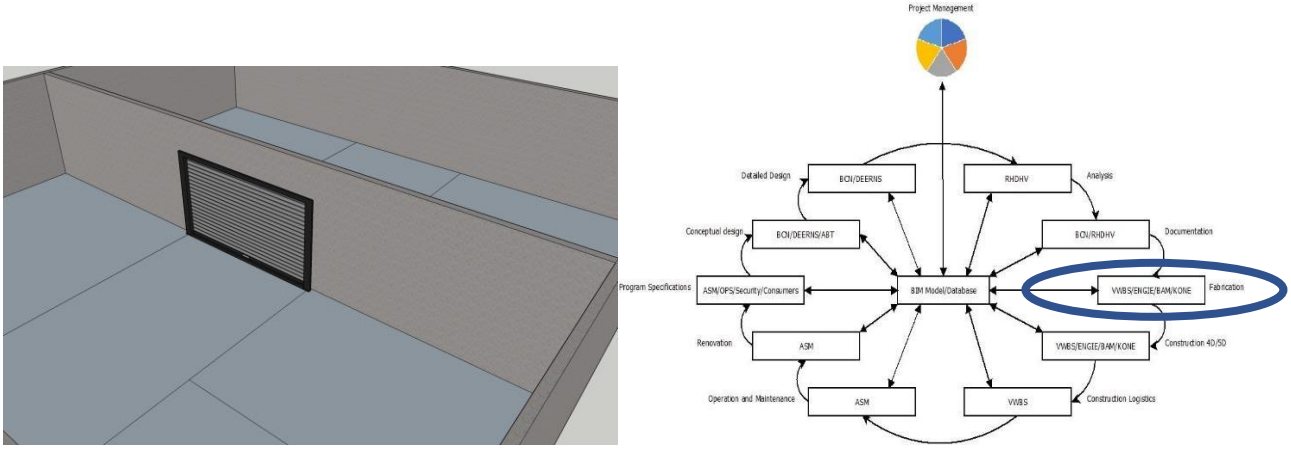

Figure 41: Preparing the object for fabrication

Whit the execution design ready and all the needed specifications available it is now up to fabrication, VWBS, to find the correct subcontractor who can fabricate this roller shutter. To find the right fabricator VWBS will ask multiple sub-contractors to make an offer and a design for this roller shutter. Each sub-contractor will provide a slightly different variation of the roller shutter based on their interpretation of the design, the specifications and the products and materials they have available. These variations will then be discussed in a BIM session, after which one is chosen.

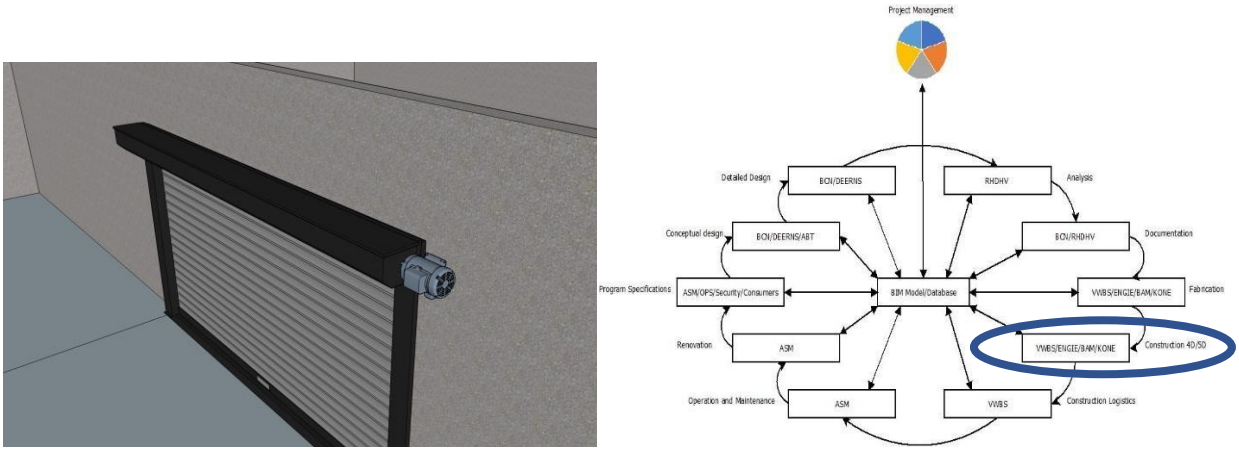

Figure 42: Installation of roller shutter

Finally, the correct roller shutter is modeled into the BIM model with all technical and product specifications added to the database. The product specifications include, production company, model number, guarantees, certification. AT this point the roller shutter is no longer a generic model but becomes a product specific object in the BIM model. The roller shutter is installed in in real life, and as built documentation is created.

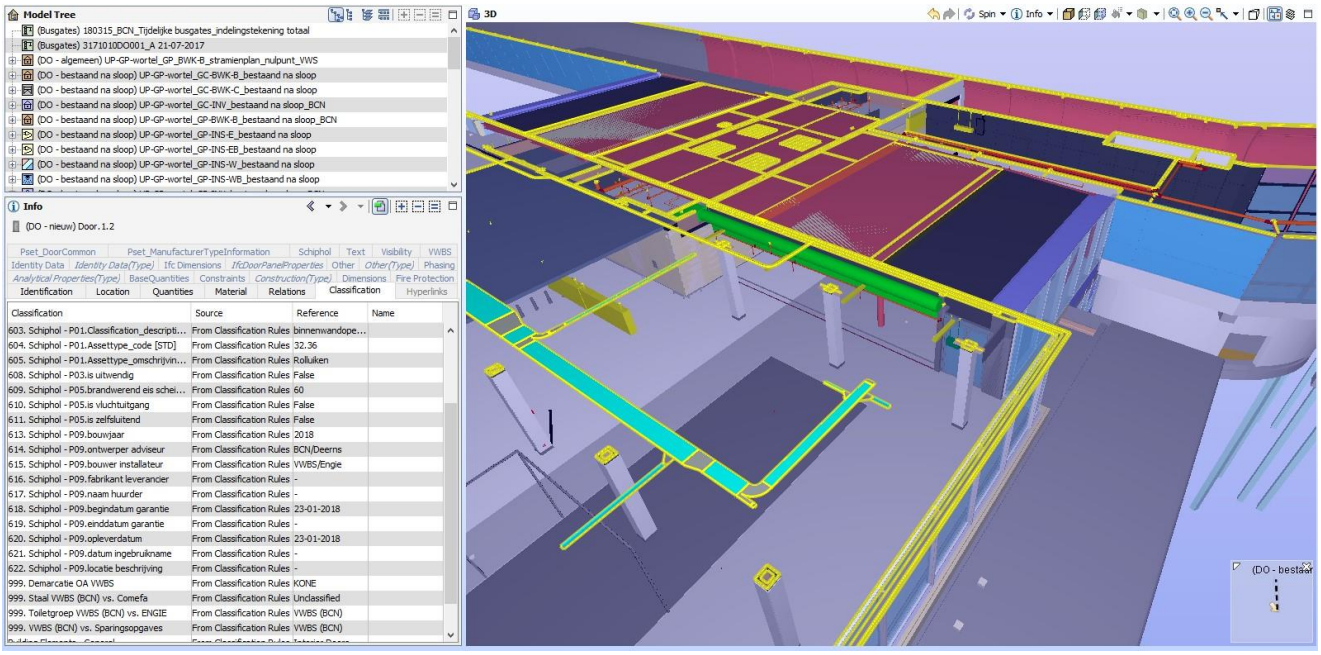

Figure 43: Roller Shutter (green) with data in left bottom

Roof opening for ventilation unit

When working with a 3D BIM model it is very important that information is drawn and documented correctly. This issue explains how a mistake in drawing can cause a problem when manufacturing and installing parts.

Placeholder design

Sometimes during the development process of the BIM model, placeholders are used. Placeholders are essentially bounding boxes which reserve space in the model before the actual object is modeled. This is a very handy tool in BIM because especially in early stages of a project, fabrication teams can for example assign placeholders to reserve space for HVAC units for example. This is very useful, because in early stages of a design, the HVAC installer does not have the exact design dimensions of the HVAC unit. With its expertise, the HVAC installer does know what the dimensions of the unit will approximately be.

Placeholder design can be very handy if executed correctly. The next shows how placeholder design can also create problems if not further elaborated during each step of the BIM process. In other words, a placeholder is only a placeholder until it reaches the step where the object should be defined and designed. Placeholders serve a temporary, not permanent role.

In the project upgrade Wortel g-pier ENGIE had drawn a placeholder for an opening in a roof measuring 600x600 mm. This space was reserved for installation of a fan unit through the roof. During the fabrication stage ENGIE modeled the fan unit which at this time had a final dimension of 400x450mm.

When considering working in BIM, it is extremely important that all teams who form part the BIM process communicate through the same mediums. The best way to organize this is by integrating communications into the coordination model. This way, other mediums, like e-mails, or phone calls can be eliminated, and all communication data is stored in the BIM model for the purpose of being able to retrace everything. Now as with this project the BIM agreements were not clear or even defined, communication was also an issue.

When further modeling the fan unit, ENGIE had failed to integrate a very important condition into the model. Namely, the fan unit needed an opening in the roof and all underlying structures of at least 600x600mm to be able to install it. With the placeholder only reserving space in the roof structure, and not in the underlying steel structure, VWBS modeled the steel structure below to accommodate the 400x450mm measured fan unit.

As the project progressed VWBS modeled the steel structure around the fan unit taking into account the 400x450 mm dimensions. VWBS also ordered the steel beams based on the specifications from the coordination model.

It was only after VWBS had ordered the steel beams for manufacturing that ENGIE noticed that the opening in the steel structure was only 400x450 mm.

Rendering it impossible to install the fan unit ENGIE claimed that VWBS had not considered the 600x600 mm placeholder which ENGIE had modeled in the coordination model.

VWBS defended themselves by stating that the placeholder only reserved space in the roof of the building, and not in the underlying steel structure. This can be seen in the image below. This meant that according to the coordination model, VWBS was right. It being unclear what form of commination was leading, ENGIE claimed that it had sent an e-mail to VWBS stating that for this fan unit there had to be an opening of at least 600x600 mm all the way to the connection to the ventilation duct below.

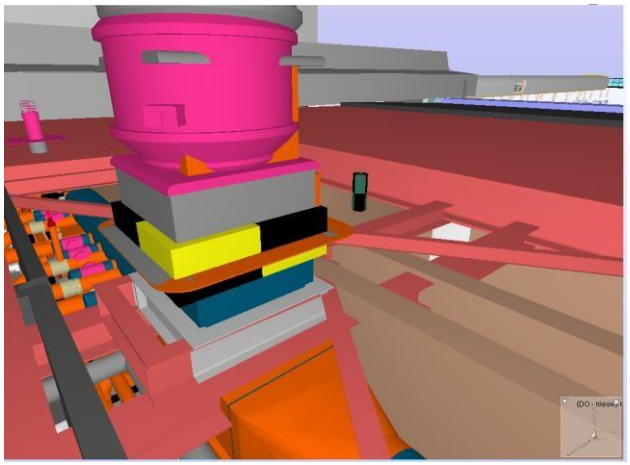

Figure 44: Location of placeholder in Yellow and Black

Communication in BIM

With technology giving more and more opportunity, communication should become easier. With so much different methods of communicating it has proven to be harder than ever to set up clear communication. The problem is that there are so many options when choosing how to communicate. For the project upgrade Wortel g-pier, primary communication was done using two methods, through e-mail, and through notes in the coordination model. With VWBS having taken over the coordination of the building stage, the preference was given to communicate through notes in the coordination model. This method of communicating was not contractually binding.

This issue could have been prevented by using the strength of BIM. The benefits of BIM for this issue, lay in the fact that BIM can integrate everything in one environment. With a whole project executed in one environment uncertainties can be eliminated. The BIM tools currently available on the market, offer integrated communication. This means that all communication within a project can be linked to the involved teams and to the involved objects. This was all prior communication can be retraced to, who communicated what, when, about what object. When making the coordination model the leading document, these issues can be solved

easily. In this case proving that ENGIE had made a mistake by not stating the boundary conditions correctly.

Thinking about how communications should have been, ENGIE would have not sent an e-mail to VWBS, but rather added a note to the coordination model with the boundary condition of 600x600 mm. VWBS would then in its turn have requested ENGIE to model the reserved space using a placeholder and placing it in the correct location. This way there would have been a boundary box in the steel structure with data on what it was for. Eliminating the discussion of who is right, when there is a discussion about communication.

Opening in ceiling for lighting fixtures

When choosing to do a project in a BIM environment it is important to understand that this can't be done only partially. While BIM is a very good method of designing and building, it is unsuitable for partial integration. In other words, a project is either done in BIM, or it is not. During the internship at VWBS a certain issue arose which clearly reflected that the project upgrade Wortel g-pier was not a BIM project rather more a traditional project with the help of 3D modelling.

During a BIM session, VWBS unveiled an issue with lighting fixtures. This issue had to do with the fact that in the coordination model, there were a couple of lighting fixtures which were pre-existing in the building. With the upgrade plans these lighting fixtures would become hidden above a newly to be installed ceiling. Now with VWBS living up to their statement about being onboard with BIM, brought attention to this issue. VWBS did so, to prevent additional work during a later stage of the project, having to remove, rework and reinstall the ceiling panels.

To be able to prevent this additional work, it needed to discuss with ENGIE what lighting fixtures would be installed, considering a design change, which would be apparent because the walkway underneath the ceiling would not have any light. This is a very clear example of how the lead role and the advising role in BIM, can help with solving issues before they arise during the construction phase. During this project, with the coordination model not being the leading document this was only cause for discussion.

According to the building specifications (bestek), there was no specification for new lighting fixtures in this area of the building. ENGIE, not wanting the extra work at this point during the project, quickly claimed that the building specifications were the leading document. Contractually unfortunately they were right.

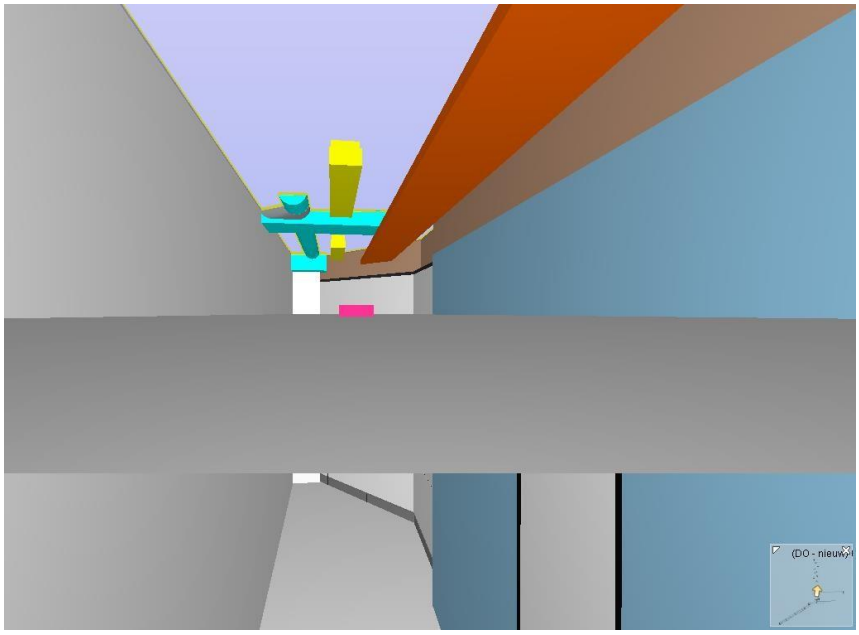

Figure 45: Lighting fixtures in Yellow above the ceiling halfway through the figure

Now this tradition way of thinking is perpendicular to the way BIM works. ENGIE realized that this "mistake" in the building specifications, meant that they were able to perform addition work, at a price of course. This additional work, in a lot of classic building processes is the means of making money. Because excess work falls outside of the agreed upon price. Making contractors able to underbid on project based on the amount of additional work they can find in the building specifications.

The strength of BIM is to prevent as much additional work as possible through the means of dry building sessions and virtual building. This means that contractors and for a matter a fact all teams that are part of a BIM process, can estimate their prices much better, preventing additional work and therefore additional time, realizing projects in a timelier manner.

With the issue of the lighting fixtures, initially ENGIE refused to undertake any action, claiming that there was nothing stated in the building specifications. Unfortunately for ENGIE, this issue also came to the attention of PLuS and later BCN. Realizing this issue would cause more work at a later stage of the project.

Building specifications vs coordination model

This comparison directly reflects the choice of organizing a project according to BIM or organizing a project traditionally. If the project upgrade Wortel g-pier had been set up according to BIM, there would have not been a building specification document, as all the data in this document would have been defined in the coordination model. With all these specifications in the coordination model, it would have been likely that a team which would be in an advising role, would have caught this issue early on. And as the project would have been budgeted according to the

BIM method, this team would have had more benefit in preventing this issue then correcting it afterwards.

This would mean that either ENGIE or VWBS would have caught this issue and present this to BCN directly requesting a statement or solution to this issue. This could have either been that the choice for no new lighting fixtures would have been a conscious choice, or as a matter a fact a mistake which needed to be corrected in the coordination model.

In this case because of the way the project was set up, this first caused discussion between VWBS and ENGIE. After that discussion VWBS decided to approach BCN on this issue, which did not want to comment, because PLuS was not first approached. VWBS having to approach PLuS with this issue. PLuS which during this project was notorious for not continuing the stream of communication, caused a delay in the communication flow. This caused VWBS and ENGIE to discuss this issue on numerous occasions before PLuS returned with an answer from BCN. This answer was ultimately that ENGIE had to place new lighting fixtures, for which VWBS needed to make openings in the ceiling panels.

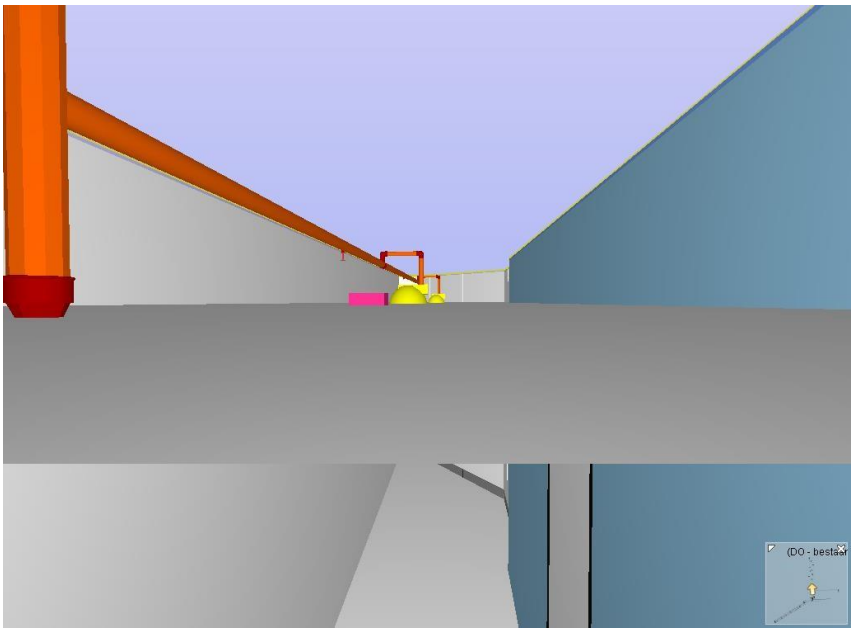

Figure 46: Corrected lighting fixtures in yellow, modeled by ENGIE

Conclusion

While all teams tasked with the upgrade Wortel-g pier project claim that they know BIM, and prefer to work in a BIM environment, the reality is that only a few companies actually know what BIM is and how to work in a BIM environment. It is not only the fault of the teams, but also of the client, that BIM is not currently process of choice when doing upgrade and renovation projects. This has mainly to do with the fact that the way the projects are set-up, is not in line with BIM. There is a very traditional hierarchy when executing projects since the same teams have been executing projects repeatedly. This repetition, which for some teams has been going on since the 1960's makes it very difficult to change processes and ideas on how projects are set up and realized.

The wanting of ASM to create an integrated digital asset management database is a very good first step to force other teams to start working in a BIM environment. Unfortunately, at this stage, this is mostly limited to the team's 3D modeling and adding data to a BIM model and database, but not actually working together in a BIM organization. Now during the interviews, it became very apparent that the blame was quickly put on PLuS because of the way the contracts are set up but diving deeper into the issue it became more apparent that whilst PluS was to blame for the bad contracting, teams were also not willing of working together according to the BIM method. In the building and construction segment, VWBS clearly attempted to create a BIM environment including the organization and communication, the other build and construction teams felt little for this idea and reverted to traditional methods whenever issues arose.

To conclude the interviews a scheme has been made showing the willingness of a team to work in a BIM environment and the general knowledge of a team on the topic of BIM.

Company Name	Willingnes to work in a BIM environment	General BIM knowledge
Schiphol ASM	HIGH	HIGH
Schiphol Consumers	-	NONE
Schiphol Security	-	NONE
Schiphol Operations	-	NONE
PLuS	LOW	MEDIUM
BenthemCrouwell	LOW	HIGH
DEERNS	HIGH	HIGH
ABT	MEDIUM	HIGH
RHDHV	MEDIUM	HIGH
VWBS	HIGH	HIGH
ENGIE	MEDIUM	HIGH
BAM	LOW	MEDIUM
KONE	LOW	LOW

Figure 47: Scheme of companies on the topic of BIM

This scheme clearly shows that while some companies have a very high knowledge on the area of BIM, they are unwilling to work in a BIM environment whilst doing projects at Schiphol. Most of this unwillingness coming from a fear of losing intellectual property and/or losing their position in the hierarchy at Schiphol.

Research Questions

To answer the main research question, "How can BIM be optimally used as a building process when considering a building which already exists and is constantly being transformed?", first the sub-questions will be answered.

1. How do VolkerWessels bouw Schiphol, BenthemCrouwell NACO and Schiphol Group currently go about deciding when an "object" needs replacement? Esentially Schiphol Group decided when an object needs replacement. The decision is made based on an array of points. First, the different teams of which Schiphol group exist, constantly debate and discuss how to further improve Schiphol airport. In the case of the upgrade Wortel g-pier, the decision to upgrade was based on the prior choice of Schiphol Security to convert from gate security to central security. The available space created the need to upgrade the Wortel g-pier.

2. Which party decides what the "replacement object" will look like? Is this a linear process or a circular process?

The process of deciding what the replacement will look like, is a circular one. Initially the teams of Schiphol group decide on project requirements. Stating where they want to see what. In the next step BCN is assigned to further elaborate on these requirements. Under the supervision of BCN, ABT and DEERNS made concept designs in which for the first time and idea of what the replacement object will look like is visually presented. This concept design is continually monitored by BCN, who as lead architect is tasked with securing the quality and looks Schiphol expects. When the concept design is completed, it is presented to the teams of Schiphol group, who discuss what is up to spec and what needs to change. This process is repeated until tasked teams of Schiphol Group ire satisfied.

3. What happens with any objects in the project location? Re-use?

When asking this question during the interview, most teams were unable to give an answer. According to ASM, Schiphol always tries to find new owners for their disused objects. The objects that Schiphol intends to reuse are refurbished and replaced. ASM is attempting to make this process easier and more efficient with the new asset management database. Soon this database will automatically remind ASM when objects need refurbishment or replacement.

4. Where can BIM assist in the traditional process to increase the level of ease?

What is currently already becoming apparent is that the 3D model and database which are currently being used during projects, is already making the traditional process easier, because data can be interchanged faster. Problems in the design become visible earlier in the project and can be dealt with before the actual building stage. With the organized "BIM" sessions in which the BIM modelers of the build and construction teams take part, are an example of an attempt to work in a BIM environment. The biggest problem is that the traditional ways of thinking and working stand in the way of progression.

5. How can BIM be integrated step by step and what preparations need to be taken?

The most important step towards integrating BIM as a process at Schiphol is to change the way contracts are set-up. As soon as teams are contractually obliged to work according to BIM standards and methods, it becomes much easier to defend the BIM process if problems occur. What is clearly visible in the current process is that teams claim to want to BIM, but as soon as challenges occur, quickly revert to traditional methods, which are contractual. The second point which will greatly assist in the integration of BIM, is to make sure that the project management is carried out by a collaboration of BIM experts. These experts can force the BIM organization of a project, making sure all involved teams are mandated to work according to what is expected from BIM

6. At what point can BIM take over the "traditional" process as the main process?

BIM can take over the traditional process as soon as all teams have good level of knowledge in BIM and are willing to work in a BIM environment. In the case of Schiphol, the general BIM knowledge of the individual teams is good enough to work in a BIM environment. Some teams clearly show that they are unwilling to participate in this innovation. This unwillingness is a bigger danger than the actual BIM knowledge, mainly because where teams are willing to learn, and not afraid to innovate, knowledge will follow. With teams being unwilling to work together according to BIM, no level of knowledge can change this.

7. What will the BIM process look like when it is completely integrated in Schiphol?

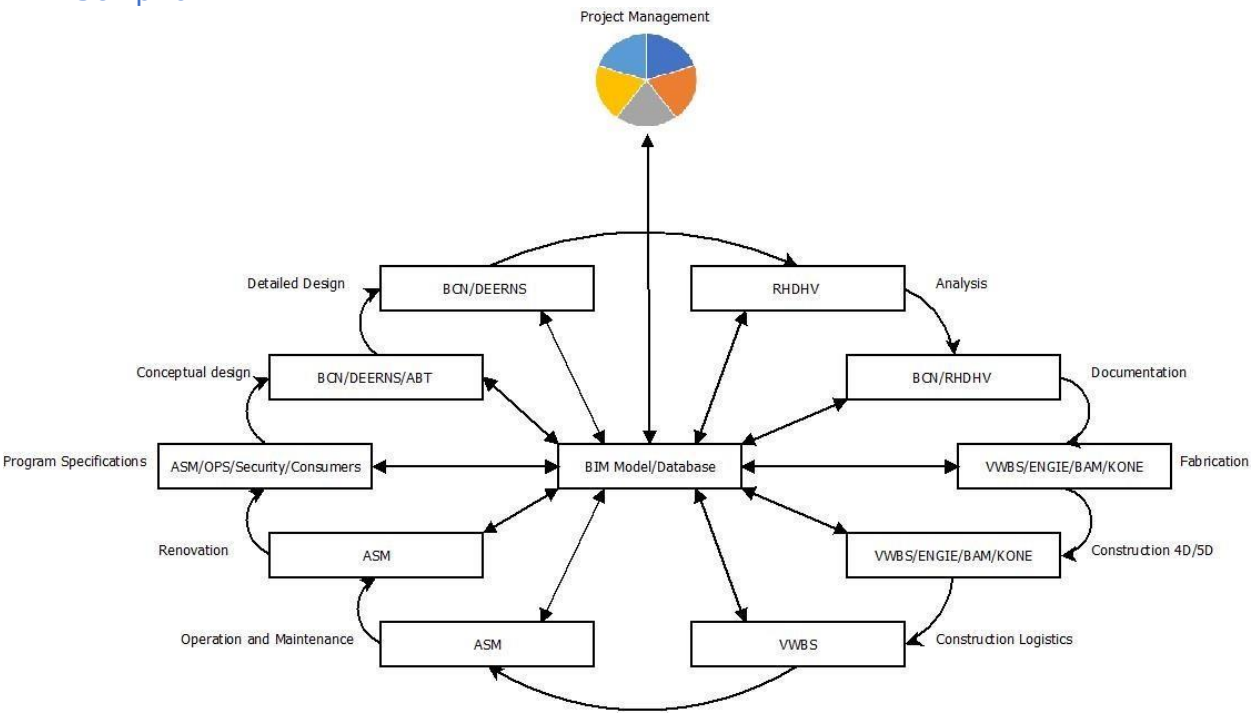

Figure 48: BIM process at Schiphol

The above figure shows what the BIM process at Schiphol should look like. The project is split up into different stages. For every stage a team or multiple teams are in charge. While a team is in charge all other teams have an advising role. They monitor the BIM model/database for mistakes and give advice were needed. As the project advances through the stages the BIM model and database keeps growing, adding more specific data to it. If at a certain step a change influencing previous steps is needed, the project goes back to that step. The team in charge of that step takes back control and the process is repeated. In the meantime, the project is under close supervision by the project management team which consists of BIM experts from every quadrant of the BIM circle who again are led by a project manager. This team makes sure

deadlines are kept and the data in the BIM model is what is expected by all teams at all stages.

Figure 49: Project managemt with BIM experts

8. What are the benefits of a fully integrated BIM process?

The benefits of a fully integrated BIM process are that projects can be carried out with greater precision because of the participation of all teams during the entire project. In the interviews it is clearly visible that with the current method of working together there is a lot of rivalry between teams. Teams feel as if they are continuously being opposed. There is a lot of unwillingness in working together. The benefit of an integrated BIM process is that an object will be continuously monitored as it progresses through the steps of the BIM process. This way when the construction phase is reached, all issues have already been solved, making the production and installation of the object straightforward. This is beneficial to the object because alterations are not needed during the installation, which often cost extra time and money.

9. What are the potential risks of integrating BIM?

The biggest risk of integrating BIM currently is the position of BIM in general. In the Netherlands BIM is still an upcoming method doing projects. For BIM to be the best method of working, involved teams much have a certain level of knowledge. This limits the selection of teams. This could even mean in the case of Schiphol, where the teams have 5year contracts, that some teams are unable to commit to this level of expectancy. Another big risk, which is in line with the unwillingness of companies to convert to BIM is the loss of intellectual property. BIM allows all involved teams to see all data. In some cases where for example two different elevator companies are contracted to do elevators, there is a risk that these companies will steal each other's intellectual properties through the coordination model. This risk is very real for Schiphol. Being the 3rd biggest airport in Europe, Schiphol has a lot of intellectual property in their asset management models. With BIM these models would become available during upgrade projects, making it that teams with bad intentions can steal these

intellectual properties and implement it in other projects which are not Schiphol related.

10. Which process is the most realistic for Schiphol?

With the goal of Schiphol being to do asset management from a BIM environment, it is important that all projects are also done in BIM. This way ASM can secure this goal by being part of the project management team. Apart from that, having main contractors under contract for 5 years, makes the choice for BIM easier because essentially all teams required for the BIM circle are already available. With Schiphol being so big and having so many projects, it would be a smart choice, because BIM is more predictable than other project methods. BIM works to create co-operation between teams, making working together more pleasant. If this is achieved, better results can be booked faster making projects less costly. For all the above-mentioned reasons BIM would be the perfect organization method for projects at Schiphol

Answering the main question

Having answered all the sub questions, the next step is to answer the main research question: "How can BIM be optimally used as a building process when considering a building which already exists and is constantly being transformed?"

The research period at VWBS showed that whilst BIM has been around for quite some time and a lot of companies claim they work according to a BIM organization, the teams tasked with the upgrade Wortel g-pier project are not quite there yet. The goal to find out how to optimally use BIM for existing buildings, changed during the research to how BIM can be integrated as a process at Schiphol in general. It became clear that the teams involved with the upgrade Wortel g-pier project were not even close to understanding what BIM is and how BIM works. This problem had a lot to do with the fact that some of these teams are part of Schiphol since the 60's. There was such a level of hierarchy established that this would become very difficult to change. With ASM clearly wanting to innovate and head in the right direction with BIM, other teams would be forced to either join this trend, or risk losing their position in the Schiphol project chain.

BIM is a process based on working together and helping others to achieve their goals during their steps in the BIM circle as good and as efficient as possible. The way projects are currently carried out at Schiphol, with ASM clearly wanting to head in the BIM direction, but the project manager PLuS not knowing how to meet this goal, handing out the wrong kind of contracts and expecting the wrong kind of teamwork, there is a lot of rivalry between teams working on the same result, namely, the realization of the upgrade Wortel g-pier.

So, to answer the research question, the first step would be for Schiphol to create a project management team consisting of BIM experts of every quadrant of the BIM circle, in lead of a Project manager with ample experience in BIM. With this team in place, projects can be setup correctly according to BIM standards.

With a strong basis, the teams tasked with realizing the project, need to make sure they are knowledged in BIM and are willing to work according to the BIM system. This means, making sure there are people available as soon as a project starts, to consult the team in charge of each step of the BIM process. This way issues during the progression of the project can be prevented and the quality of the design prior to the building and construction phase is much higher, preventing issues during this phase.

Next to that this also ensures that the quality of the coordination model and BIM database is of a high enough quality that ASM can use this data to perform asset manage through the BIM environment, which was the goal of ASM to begin with.

Finally, if this system is implemented correctly, data on projects will be available to all teams in real time. Every team taking part in any upgrade and/or renovation project at Schiphol becomes responsible for also adding data of the as-built situation of Schiphol. The longer the BIM process is and stays the method of choice, the better the as-built data becomes, the less data of the prior as-built situation needs to be added.

It is important to realize that the wish of ASM to do asset management through a digital BIM environment, Schiphol must make funding available for project teams to enter as-built data into the project. It is only this way that the wish of ASM can be realized. The creation of this data will this way be integrated step by step, and in time, as all areas of Schiphol are upgraded and/or renovated, will become more complete.

Generalizing the results

In all previous chapters, the results were based on a specific case. The goal of this research is to provide a general conclusion create an answer to the research question which can be used for any project where there is already an existing structure in place. One of the ways to generalize the results is to create a roadmap showing how to integrate BIM as a building process considering a building which already exists and is constantly being transformed.

The roadmap

The BIM roadmap consists of the steps that need to be taken to make sure a good integration of BIM is possible. With these steps a basic project setup is possible.

Step 1: Find teams for every step of the BIM circle. For every step of the BIM circle below there should be at least one, or more companies which oversee each step. These companies should have a good amount of knowledge in working in BIM and should also be willing to work in a BIM organization.

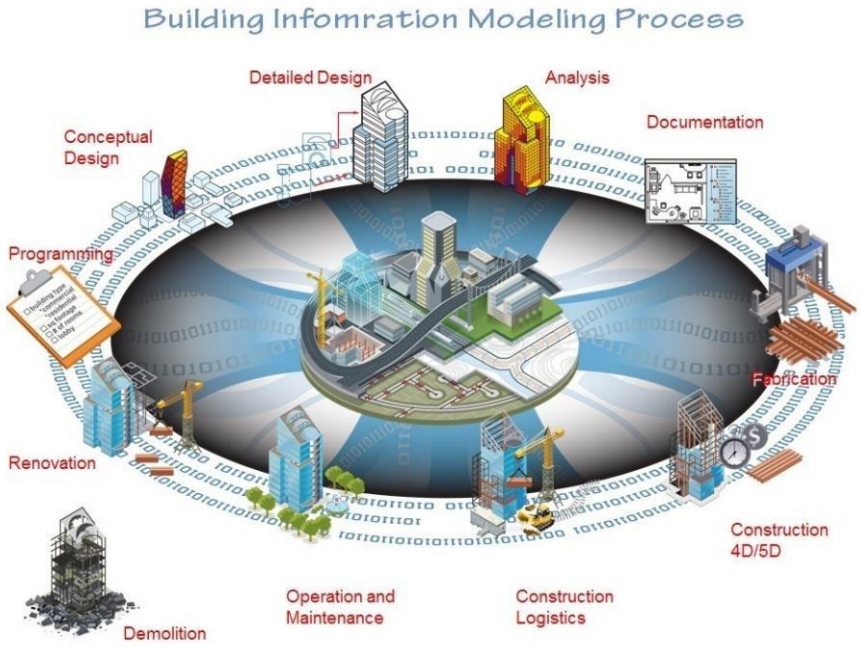

Figure 50: The BIM circle (http://aecdsl.com/the-key-bim-terms-you-need-to-know/)

Step 2: Assign a BIM expert from every quadrant of the BIM circle led by a project manager with ample BIM experience. These BIM experts can be part of the companies which are part of the teams of the BIM circle. It is important to have an expert of each quadrant, because this way the conditions of every quadrant and the complete process can be guaranteed.

Figure 51: Project management collaboration

Step 3: Write contracts which are in line with the BIM process. All companies in every quadrant should get contracts with the same conditions in them. This step is also the first step where the existing building is mentioned. It is important that the contracts include clauses for modelling the current state of the building. This can be set up in a way that every team models the current situation based on its expertise.

Step 4: Make sure that every team understands their responsibility as an advisor when the project is at another step. This is very important because this advice makes the overall design stronger. Making sure costly mistakes during the building and construction phase are prevented.

Step 5: Create a BIM coordination model and database which is updated in real-time and includes communication possibilities. This way all data can be viewed real time, preventing teams working for extended periods of time on objects or parts of the design which then prove to be impossible due to clashes. The including of the communication possibilities make sure that everything is available in one environment. This way no team can fall back on "other" methods of communication which possibly cannot be retraced. The more dimensions are integrated in the BIM environment the better the results will be.

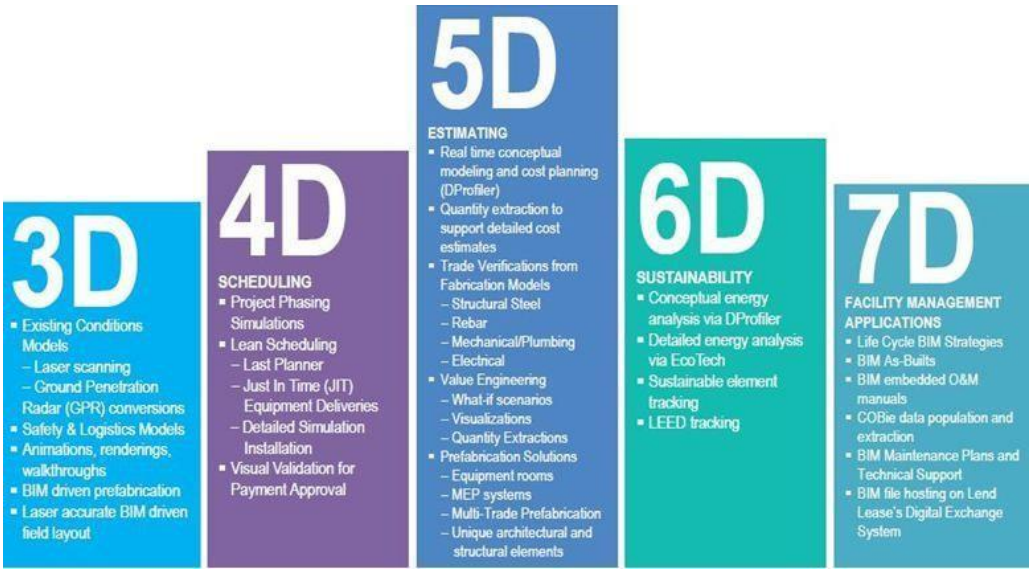

Figure 52: 7D BIM. (http://www.bimpanzee.com/bim-3d-4d--5d--6d---7d.html)

Step 6: The project manager (collaboration) continuously monitors progress and makes sure deadlines are kept and the quality of the coordination model is up to spec during the BIM process. The quality of the coordination model can be monitored according to the expected level of detail (LOD). This LOD is also part of the contracts and the IDM.

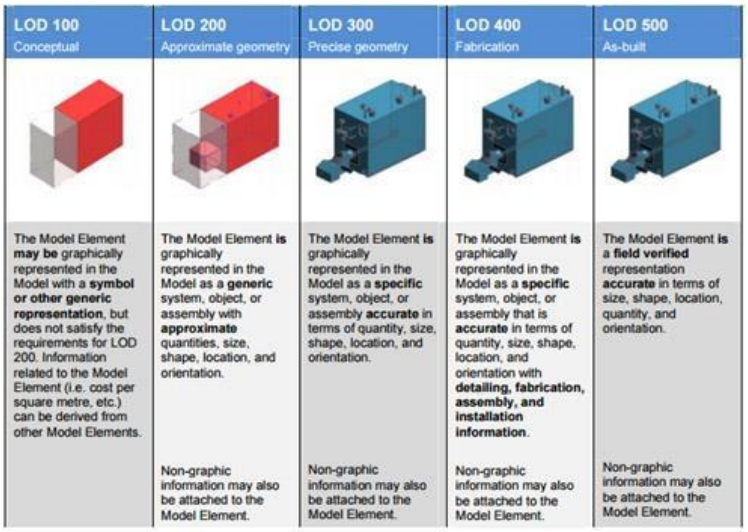

Figure 53: BIM LOD (https://www.bimandco.com/Content/images/screenshots/fr/lod-types.jpg)

Step 7: Build the project according to the coordination model and BIM database making sure all aspects of the model and the database are produced as intended by the documentation

Step 8: Update the coordination model with as-built information. As-Built data is added to the coordination model to document discrepancies between the

execution model and the actual placed object. This way when handing over the model and database to asset management.

Step 9: Operate and manage the building with the coordination model including the BIM database and as-built information updating the model continuously if any changes are made.

Step 10: Start a new renovation and/or upgrade projects with the coordination model and BIM database intact eliminating the need to first document the current situation as that has continuously been done.

If these steps are taken into consideration BIM can optimally be used as a building process considering a building already exists and is continually being upgraded.

Recap

Essentially the idea behind BIM is to create a circular process in which all companies involved with a project are either leading a certain step in the BIM circle or advising that step.

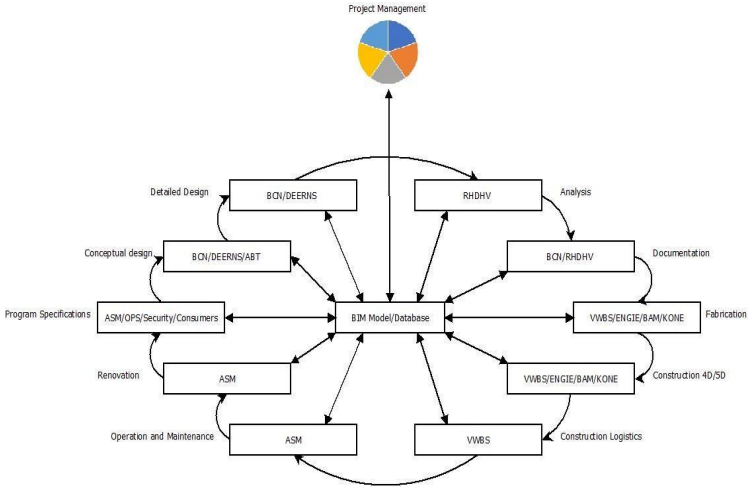

Figure 54: BIM circle

This process will always be led by a collaboration of an expert of every quadrant of the BIM circle combined with a project manager. In doing so the requirements of every quadrant can be defended.

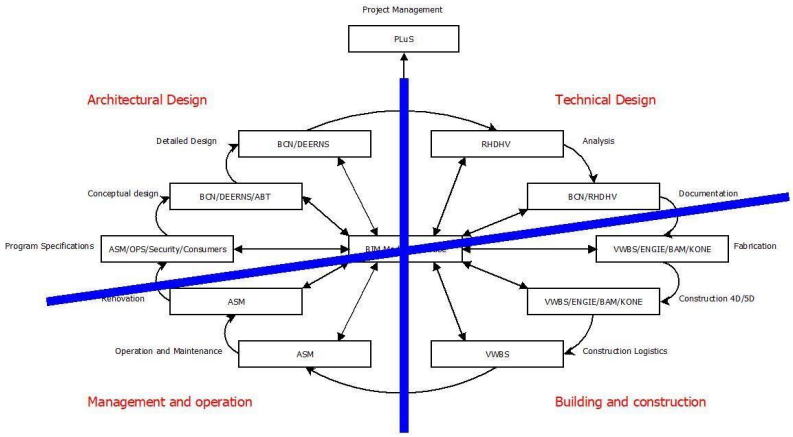

Figure 55: Quadrants

It is important to understand that not every quadrant expects the same from BIM. Where the Architectural Design quadrant expects much more visual data, the Management and operation quadrants relies much more on acquiring the correct data behind the visual representation.

This is the reason the quadrants are introduced to the BIM process. When the experts of each quadrant come together with a project manager they can make sure that the IDM and BIM protocol are written correctly and include all data needed for every company involved.

Looking back at the situation at Schiphol, there were multiple IDM's and BIM protocols. All these documents did not include a complete overview of what was expected from every company and what benefited every company. This is very in line with the way the project at Schiphol was set up. As can be seen in the chapter about the actual situation.

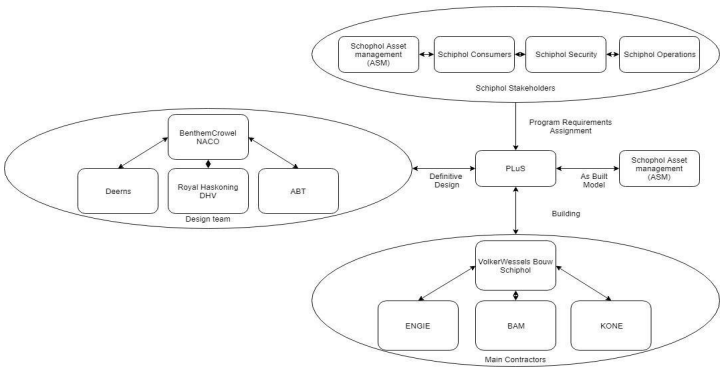

Figure 56: actual project hierarchy

It is clearly visible in the figure above that there is no resemblance between figure 54 and 56. Figure 56 shows a very traditional way of executing projects. While in the interviews it does become apparent that within every bubble of figure 56 there are some traces of the BIM circle, BIM can only succeed if the whole principle of working together is implemented.

Figure 57: Project management collaboration

In figure 57 the project management step of the BIM circle in image 54 is zoomed in on. Now as stated before this team consists of 4 experts together with a project manager. The idea behind this team is to make sure that the BIM process is always guaranteed. BIM can be a difficult process if companies are not exactly aware of or continuously helped with the goals. These four quadrants ensure that all different expertise's are treated. It is important that all companies understand that this team is leading the BIM process at all times.

Finally, the companies should understand their role of advising others. BIM relies on a social aspect. Without this social aspect BIM is reduced to nothing more than a traditional process carried out in 3D. The social aspect of advising each other to better the design prior to execution is what makes BIM strong. Issues can be resolved way before the actual building stage because contractors, engineers, clients and architect work together and help each other achieving the best possible solutions to a design.

So, for BIM to work, companies should change their attitude of being competitors and trying to earn money from mistakes and extra work during a project to becoming companions, working together to save and make money because of the success of a project, in eliminating over budget and over time situations.

It is this exact attitude change that will make it possible for Schiphol to execute projects in BIM. The companies at Schiphol are still too involved with generating profit from issues during a project and trying to blame others instead of working together to execute projects as efficiently as possible and with a minimum amount of issues during the building phase. For this companies should let go of classical building process and embrace the BIM process.

Innovation factor

As can be seen in the generalization of the results, the idea of this research was to find a conclusion that could be applicable on different levels. In this case the idea was that this research could be used on three different levels, namely VWBS, Delft University of Technology and Myself as author. The idea is to write a report which is innovative and contains beneficial information.

VWBS

VWBS form the beginning stated that it wanted to know the answer to the main research question. This came forward from the idea that the fact that Schiphol was continuously being transformed. VWBS felt that the real issue at Schiphol came mostly from this factor. As the research progressed it became more and more apparent that the real issue was not solely the availability of correct data.

The issue had a lot more to do with the socio-technical cooperation between different companies that were involved with this project. If Schiphol really wishes to innovate around BIM, a change in the way projects are executed is necessary. The traditional way of setting up and executing projects at Schiphol and the close mindedness of some companies who work for Schiphol creates a roadblock for BIM.

For VWBS it is important to realize that no amount of technology can change the social aspect of BIM. Almost all companies who play a medium to large role in any Schiphol upgrade project have the technology and software available to be able to correctly execute anything in BIM. The major problem is that certain companies are not willing to let go of the very traditional way of execution. This has mostly to do with the fact that these companies will lose a lot of power.

TUDelft

For the TUDelft, which is an institution for the future of architecture and engineering this document shows what the current issues are that companies face. The goal is to prepare students to not make the mistakes that are currently being made. Even though Delft is clearly a university of "Technology", in the field of project management, architecture and engineering, especially when considering BIM, the social aspect is very important.

It is important to teach students what the philosophy of BIM is. The idea of BIM is to create a situation where companies work together through the entirety of a project sharing knowledge and information to benefit the quality and result of a project. Instead of benefiting form mistakes of the previous step.

Personally

For the author personally, this document taught a lot about the social aspects of BIM. As author I initially perceived BIM to have more influence on a technological level, through modern software. However, in doing this research I realized more and more that BIM has much more to do with social aspects. The idea of working

together and bringing forward solutions instead of benefitting from other's mistakes, is the real idea behind BIM.

This idea of BIM personally made me grow and understand that it is usually better to work together and try to solve problems together instead of remaining silent on issues that are known from a financial standpoint.

Reflection

Graduation process

- how is your graduation topic positioned in the studio? The graduation topic is positioned very in the studio in design informatics. Furthermore, it has influence on all different segments of the studio. It is about how different expertise communicate in the world of BIM.
- how did the research approach work out (and why or why not)? And did it lead to the results you aimed for? (SWOT of the method) The approach seems to be working fine. The idea to present a critical analysis before debating with the companies has resulted in very strong opinions.
- if applicable: what is the relationship between the methodical line of approach of the graduation studio (related research program of the department) and your chosen method
  First one needs to have a hypothesis and design a structure (new BIM approach) and that can then be discussed.
- how are research and design related
  The research approaches the topic as to find out what the problems are, and the design proposes an array and visualization of solutions
- did you encounter moral/ethical issues or dilemmas during the process? How did you deal with these?
  There are indeed some issues which arose in which I wondered if it would be smart to document. I have chosen to leave any sensitive information which has no impact on the report out of the report.

Societal impact

- too what extent are the results applicable in practice? The whole idea of this research is to be able to implement it into practice as soon as possible.
- too what extent has the projected innovation been achieved?
  Companies need to realize that technology has moved on and they need to keep up with innovations to achieve good methods of executing projects.
- does the project contribute to sustainable development? It very well does; the better companies work together in BIM the more waste is prevented during the execution phase of a project
- what is the impact of your project on sustainability (people, planet, profit/prosperity)?
  BIM is a more sustainable way of building, as problems and solutions are created before a building is built.
- what is the socio cultural and ethical impact?
  People need to learn to work together when executing difficult projects like in Schiphol.
- what is the relation between the project and the wider social context?

This all has to do with the way companies work together, contracts are formed, and new laws are set up. This research assist in better understanding how companies need to work in BIM

- how does the project affect architecture / the built environment?
  The project forces a change in mindset, architect and engineers should not be afraid to consult each other's expertise and work together.

Appendix 1: Literature List

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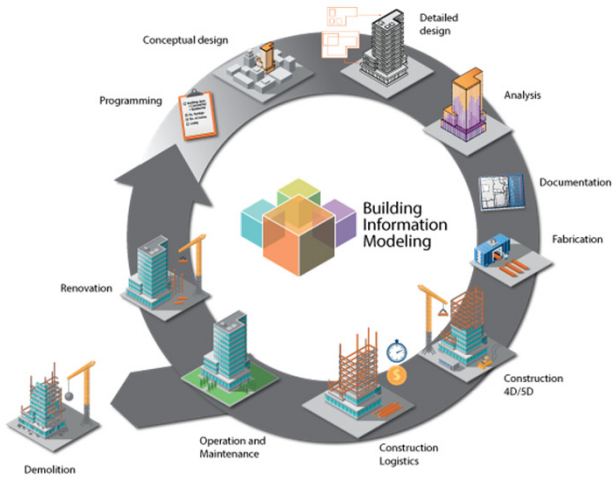
Appendix 2: Powerpoint presentation used for interviews



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BIMplimentation - BIMtergration

A proposal to research the integration of BIM for dynamic existing buildings.

Case study: VolkerWessels Bouw Schiphol, Upgrade Wortel G-pier.

TU Delft

Delft University of Technology

VolkerWessels

Bouw Schiphol

Table of contents

Personal Interest

- Project Manager/Planner
- Airports (Schiphol Airport)
- Airports (Curacao International Airport)
- Airports (Antillean Flight Services)
- Hands-on approach to building
- Complex projects

History

- What is the historical approach on Building Processes?
- How does integral thinking work?
- What does BIM mean for Airport Design?
- How does BIM work for existing buildings?
- Why has BIM become so relevant in recent years?

Objectives

- Find out the current planning & building process at Schiphol
- Describe the theoretical integrated BIM process at VWBS & Schiphol
- Compare the results of the real world situation and the theoretical optimum
- Explain the realistic adoption & integration of BIM into the process

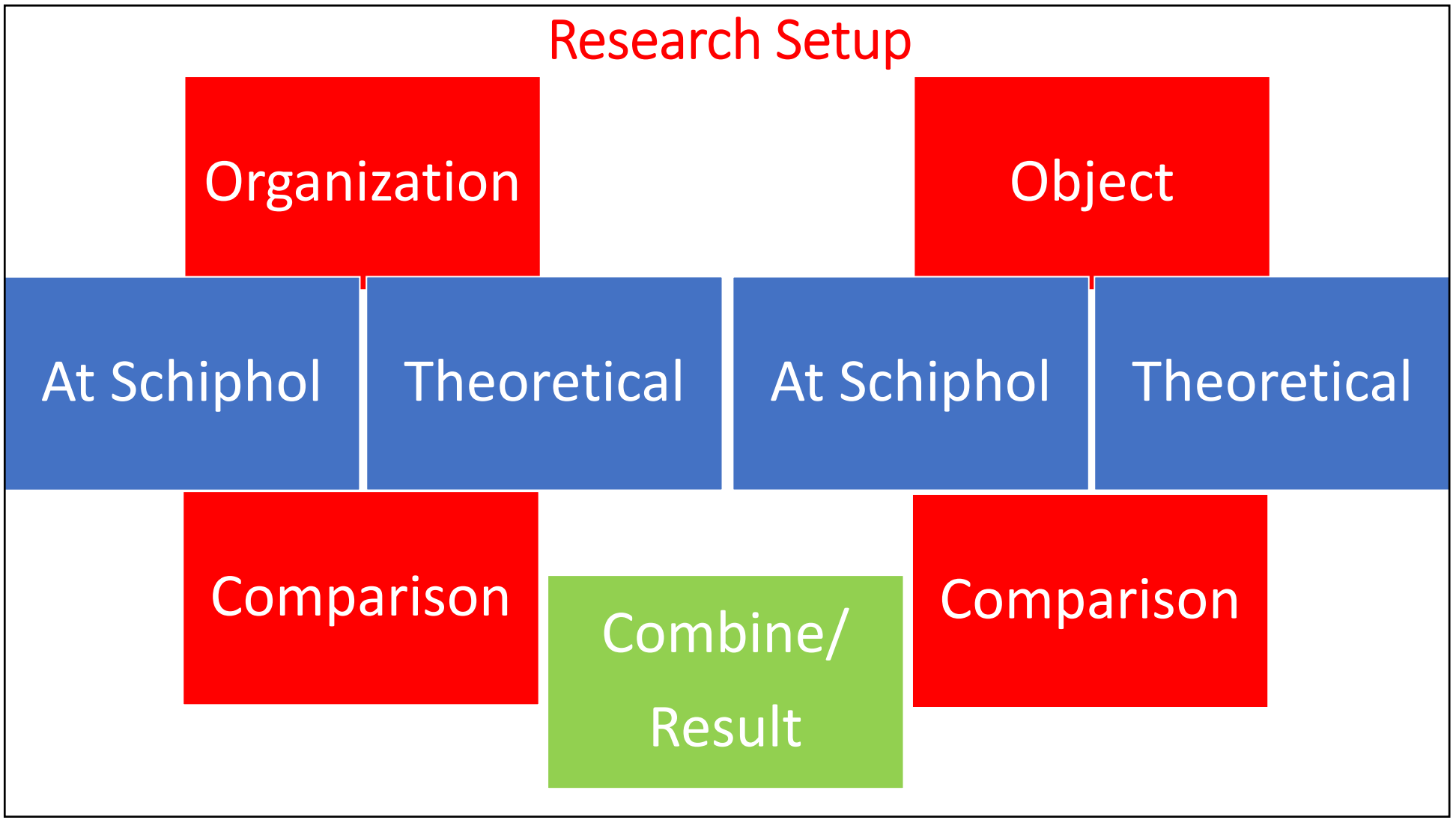
Main Research Question

- *"How can BIM be optimally used as a building process when considering a building which already exists and is constantly being transformed?"*

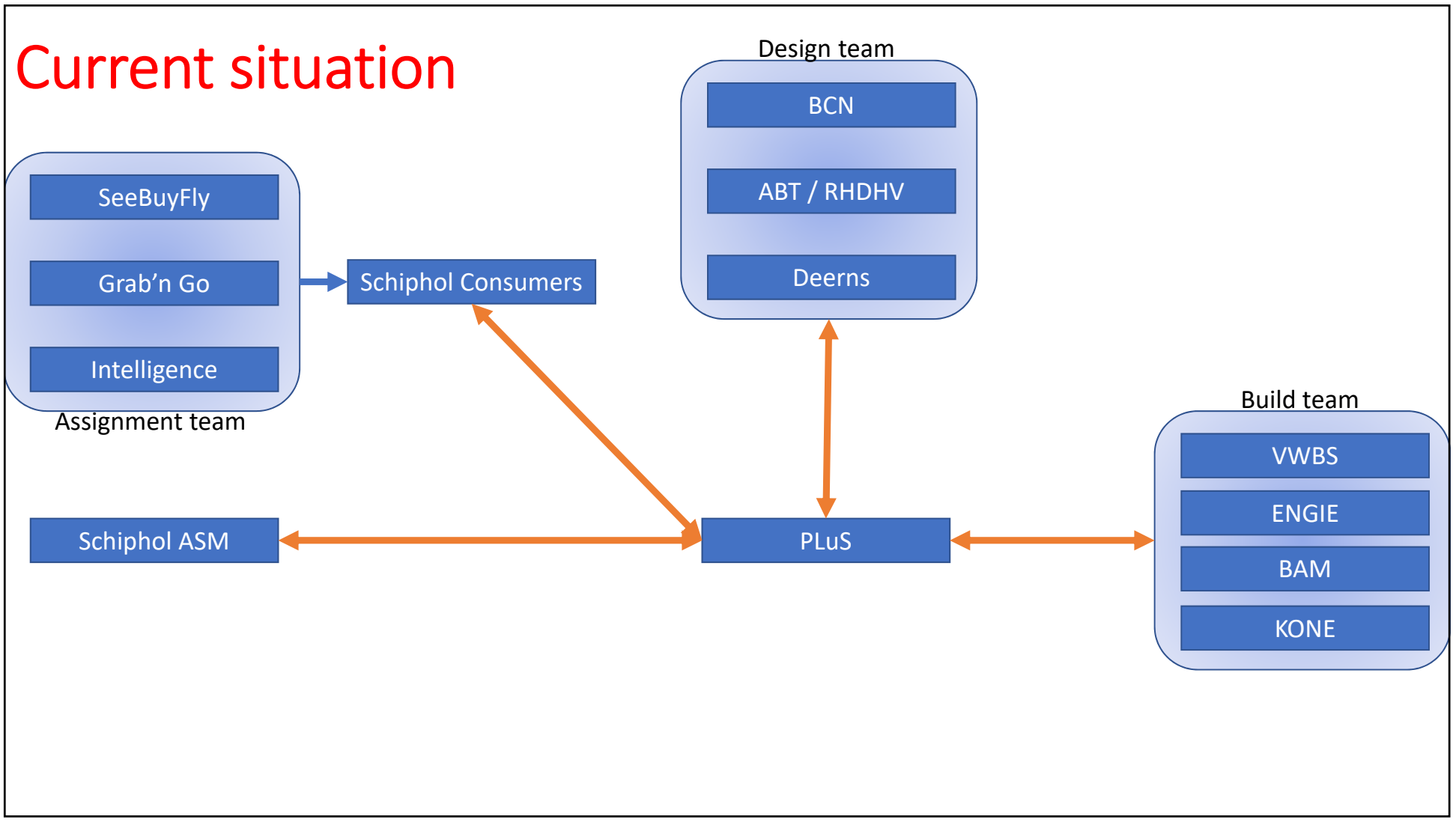
Approach

1. General knowledge on the BIM building process.
2. Research to the Building process currently used at Schiphol
3. Research the differences between the theoretical framework and the situation at Schiphol
4. Combine the Organizational track with the Object track and find the issues.
5. Write scientific report based on findings. Make movie(animation) about the results.

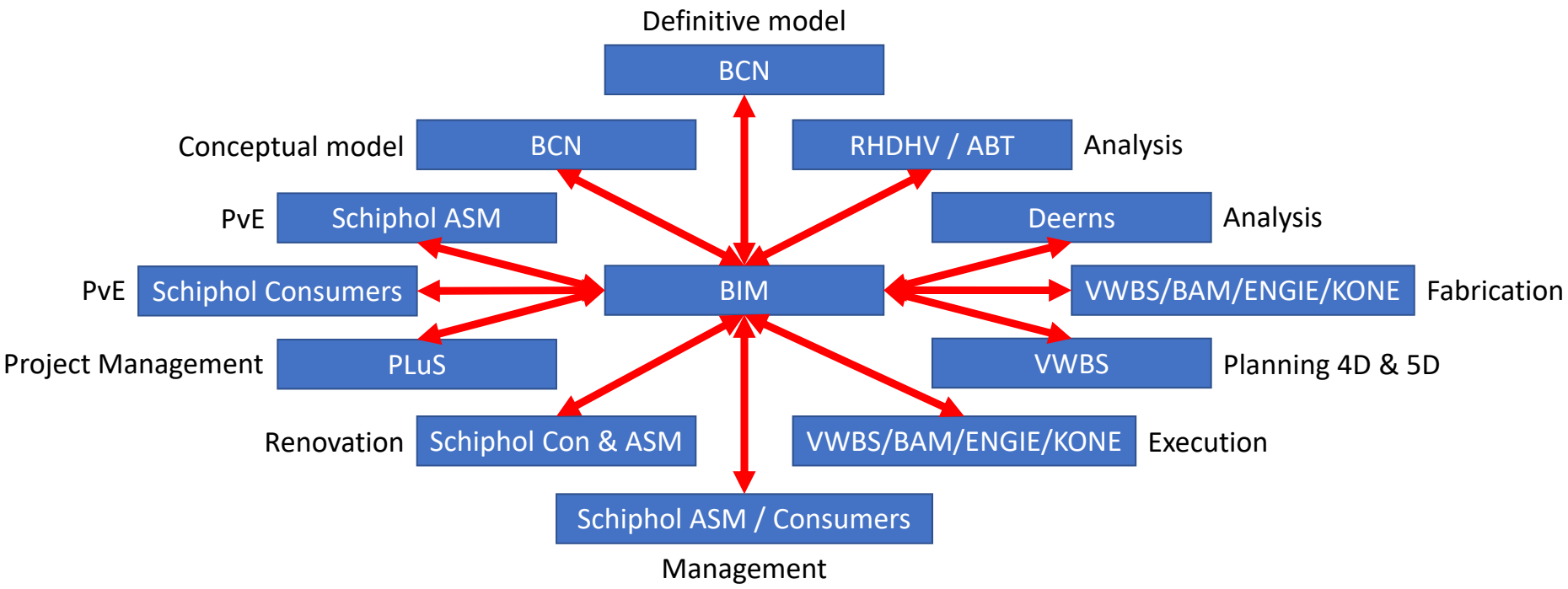
Research Setup



Current situation



Theoretical BIM



Goal1: The reality vs. The theory

How do companies work with BIM in the real world?

How should companies work with BIM according to theory?

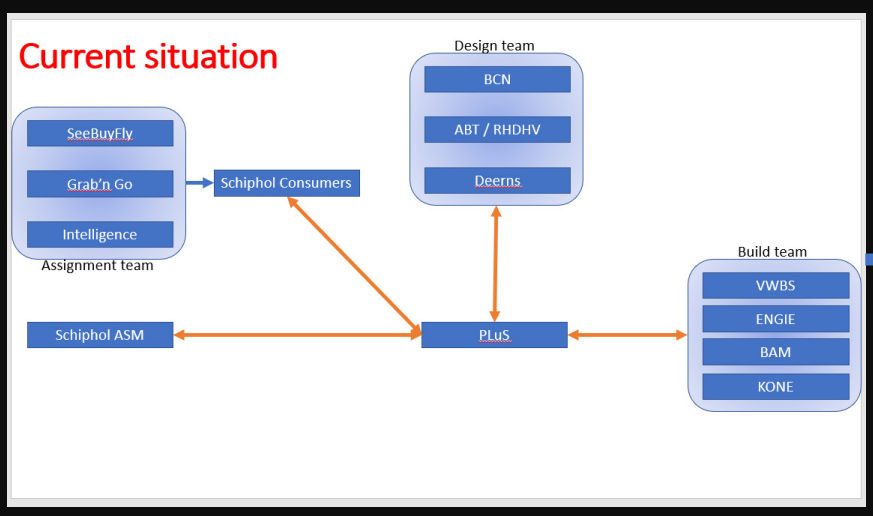
Goal2: Find the differences

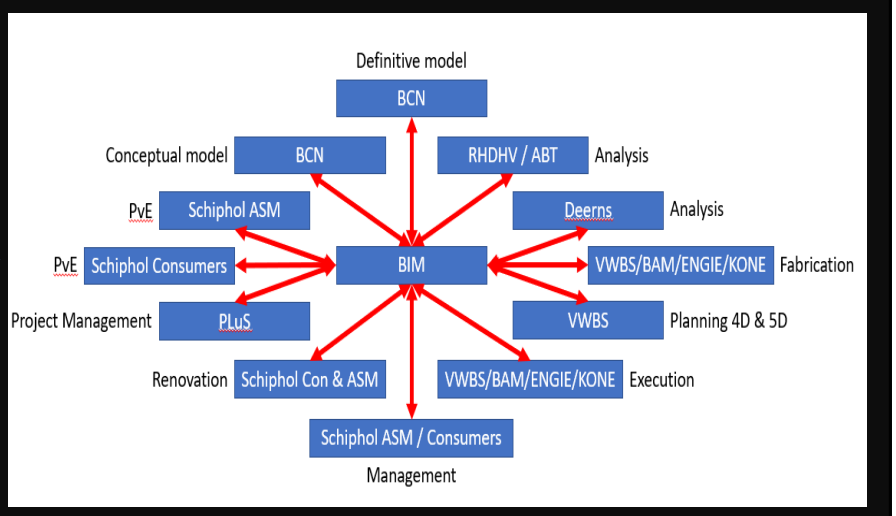
What are the differences between the theory and the reality of BIM when considering upgrade and renovation projects?

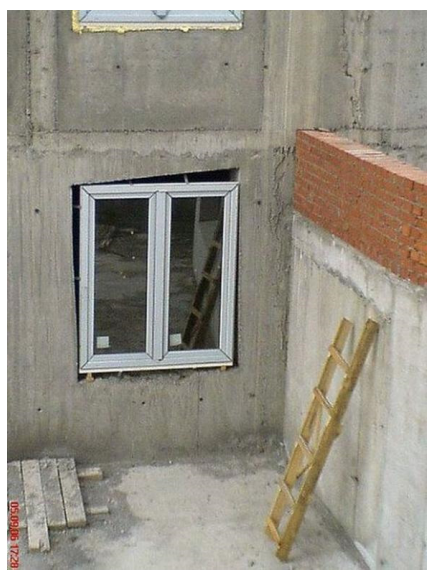
Goal3: The result

What is the best “solution” for the differences between the Theoretical BIM process and the real life situation?

Quick recap



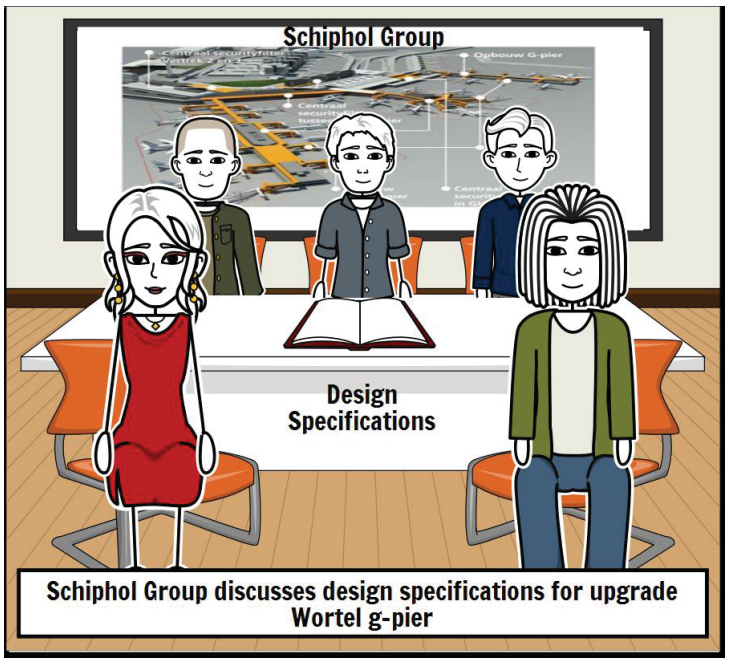




Why BIM?

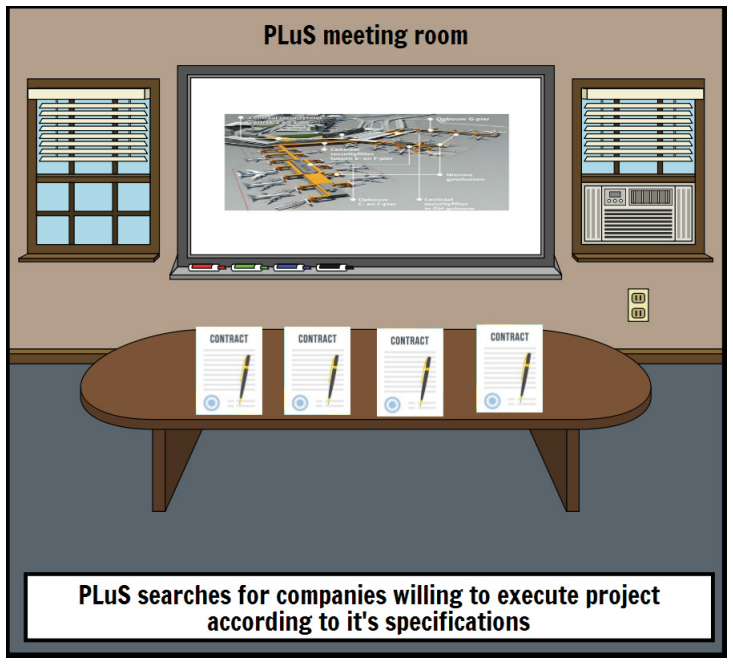

BIM
design
information
business
sector
government
involved
likely
start
approach
modelling
collaboration

Appendix 3: Storyboard

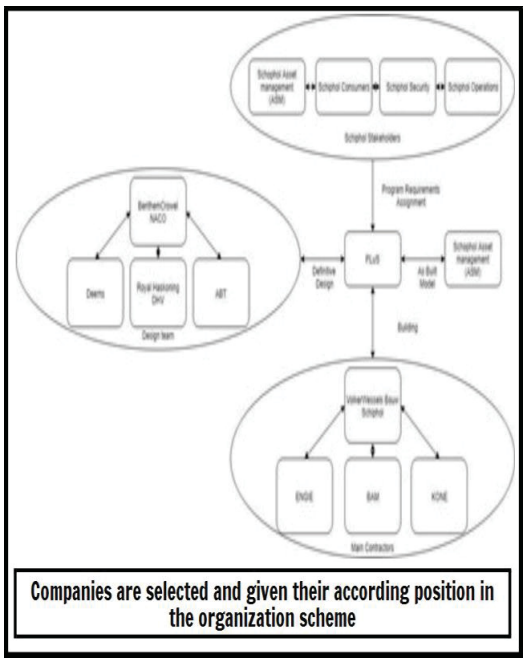


Schiphol Group discusses design specifications for upgrade Wortel g-pier

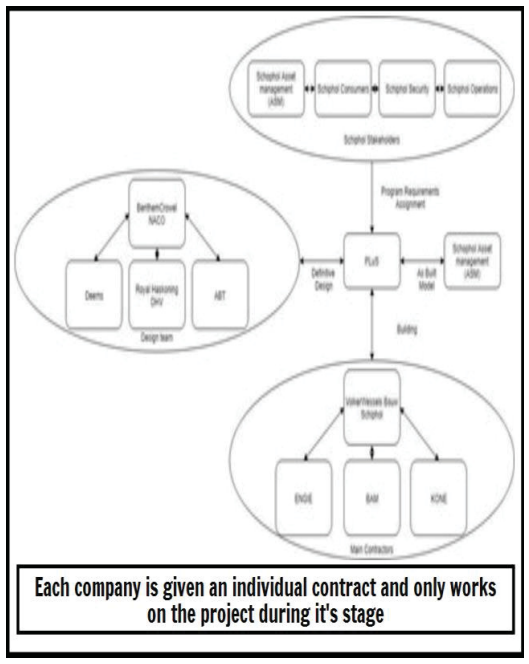
PLuS is assigned with realizing the project upgrade Wortel g-pier and is handed over the project spcifications



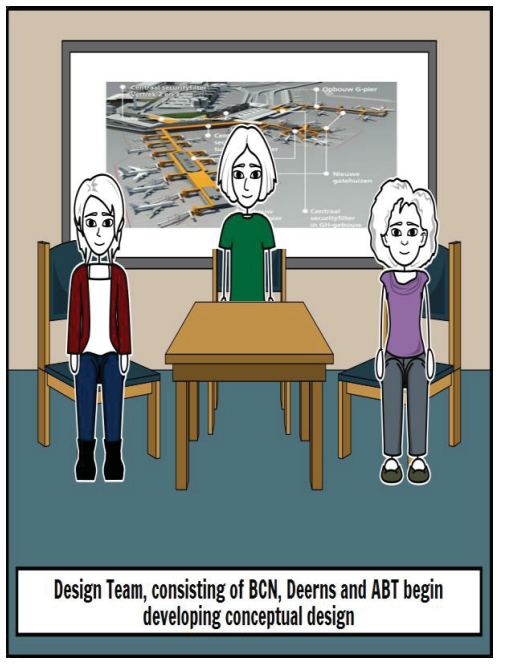
PLuS searches for companies willing to execute project according to it's specifications



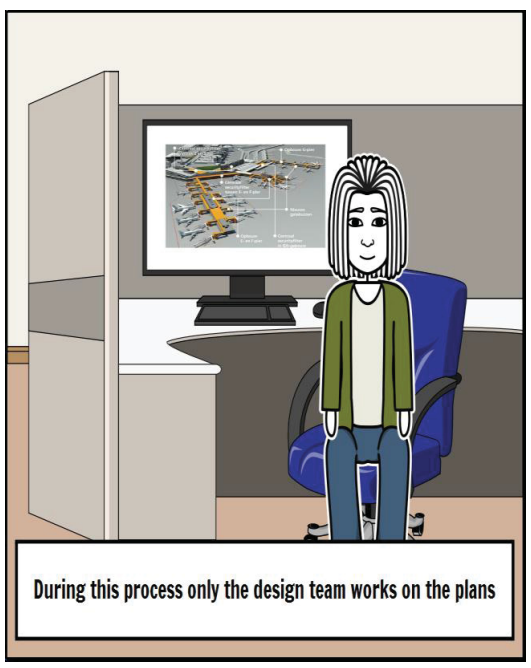
Companies are selected and given their according position in the organization scheme



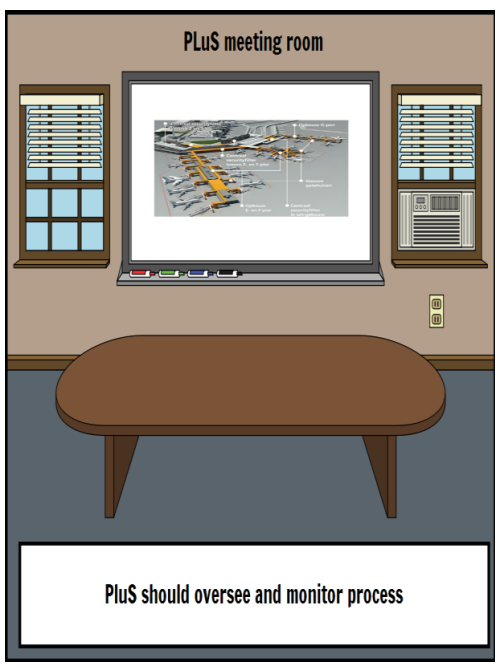
Each company is given an individual contract and only works on the project during it's stage



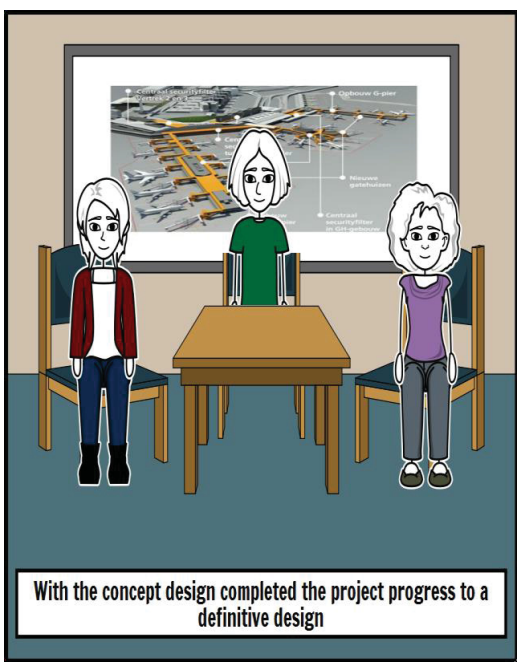
Design Team, consisting of BCN, Deerns and ABT begin developing conceptual design



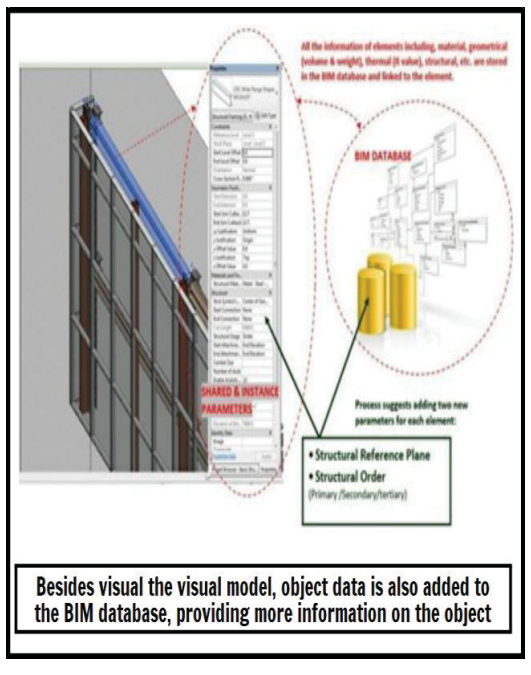
During this process only the design team works on the plans



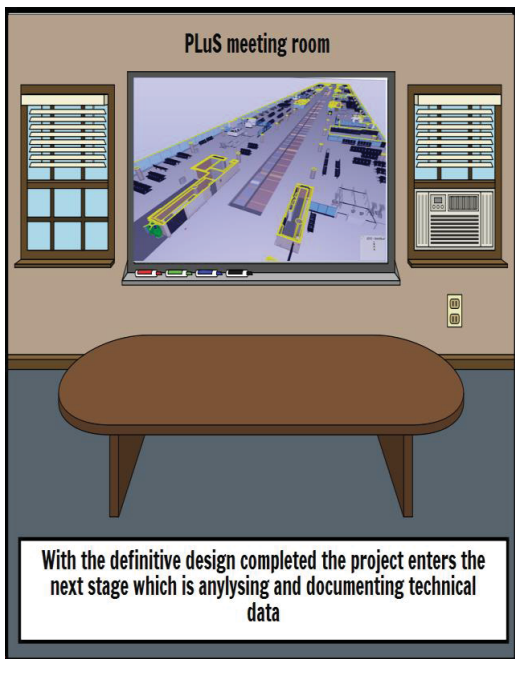
PluS should oversee and monitor process



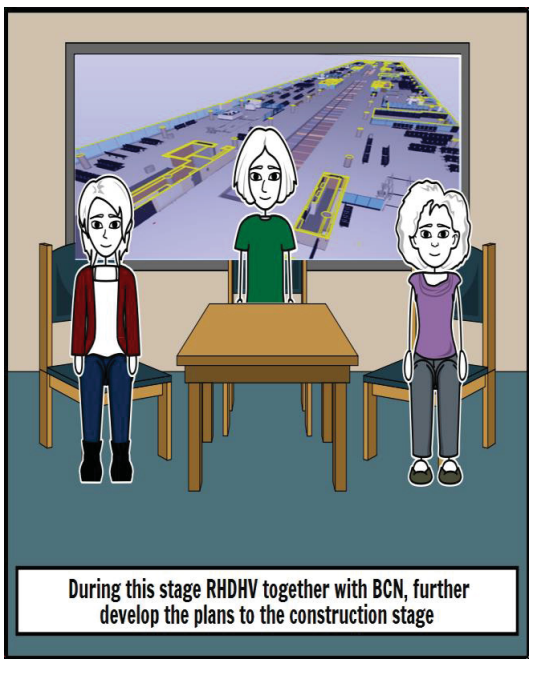
With the concept design completed the project progress to a definitive design



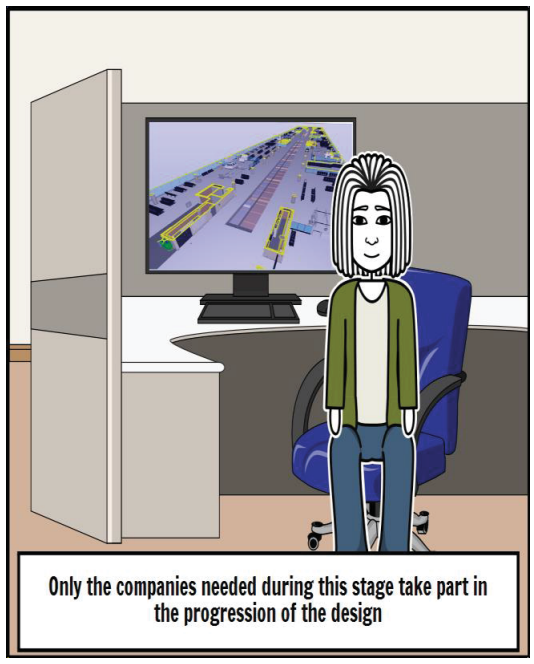
Besides visual the visual model, object data is also added to the BIM database, providing more information on the object



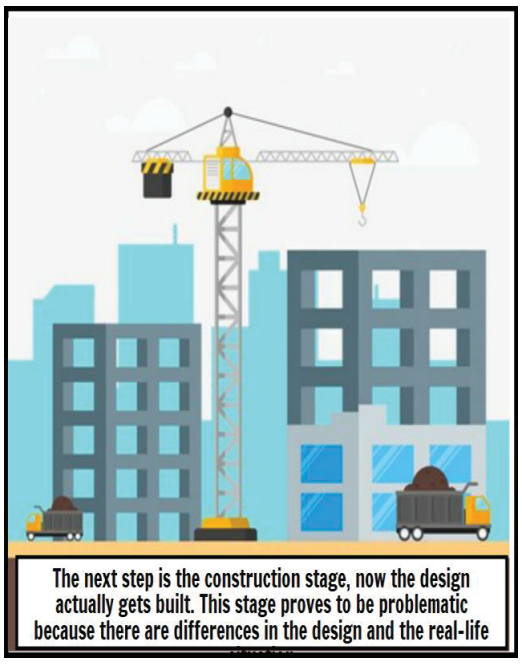
With the definitive design completed the project enters the next stage which is anylysing and documenting technical data



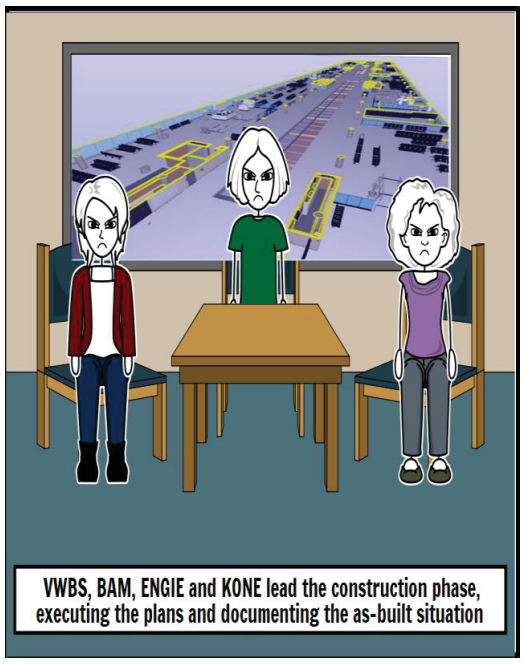
During this stage RHDHV together with BCN, further develop the plans to the construction stage



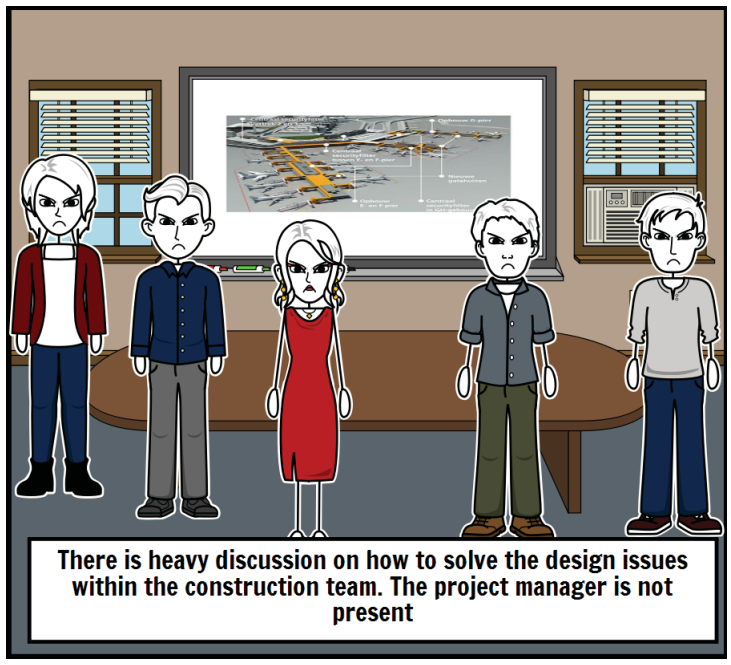
Only the companies needed during this stage take part in the progression of the design



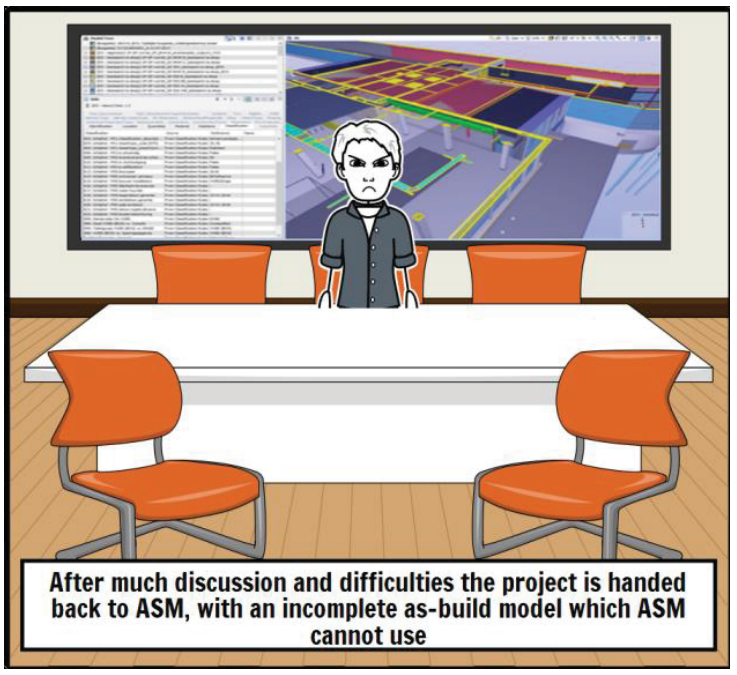
The next step is the construction stage, now the design actually gets built. This stage proves to be problematic because there are differences in the design and the real-life



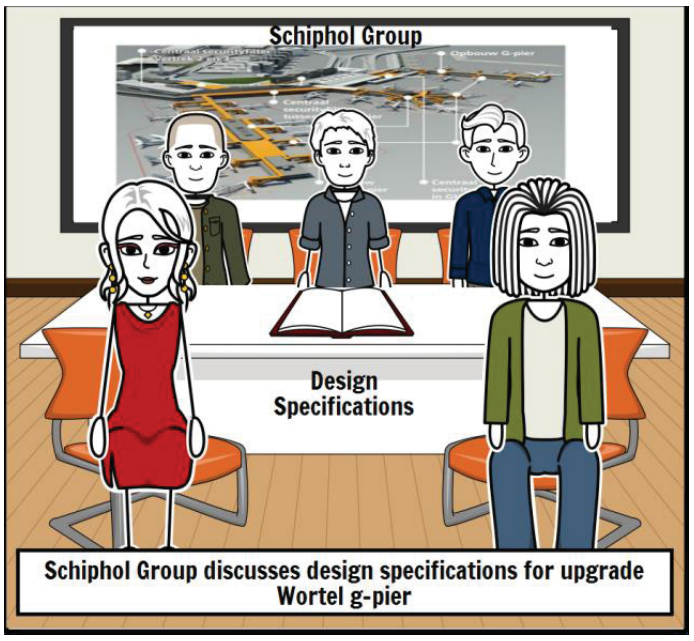
VWBS, BAM, ENGIE and KONE lead the construction phase, executing the plans and documenting the as-built situation



There is heavy discussion on how to solve the design issues within the construction team. The project manager is not present



After much discussion and difficulties the project is handed back to ASM, with an incomplete as-build model which ASM cannot use



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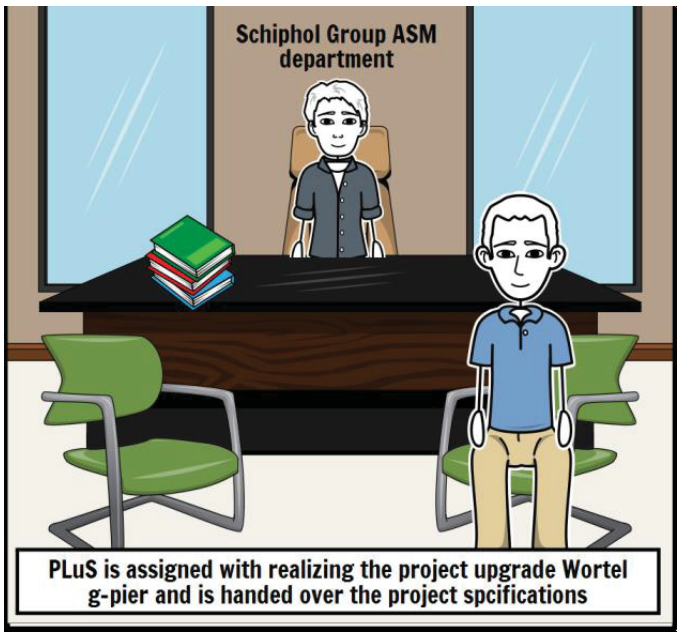

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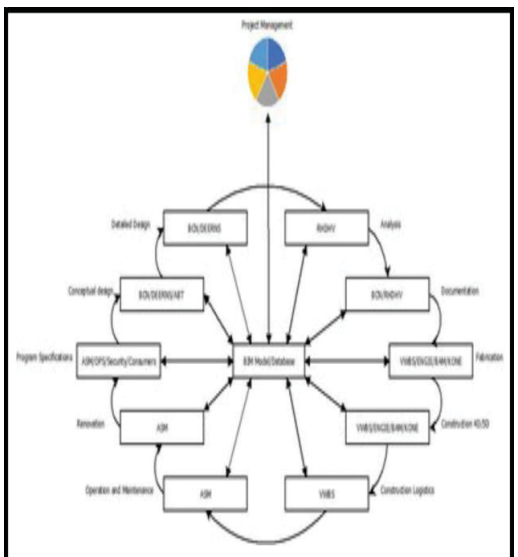
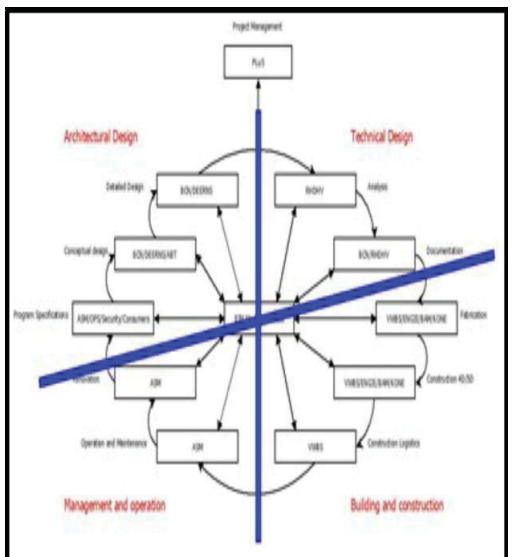
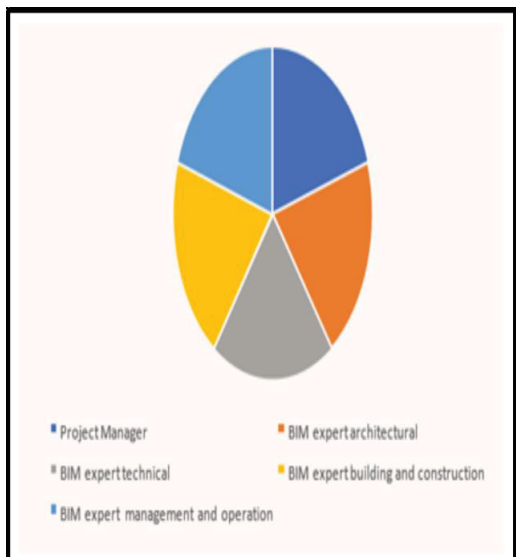
PLuS searches for companies willing to execute project in BIM environment



Companies are selected and given their according position in the BIM circle

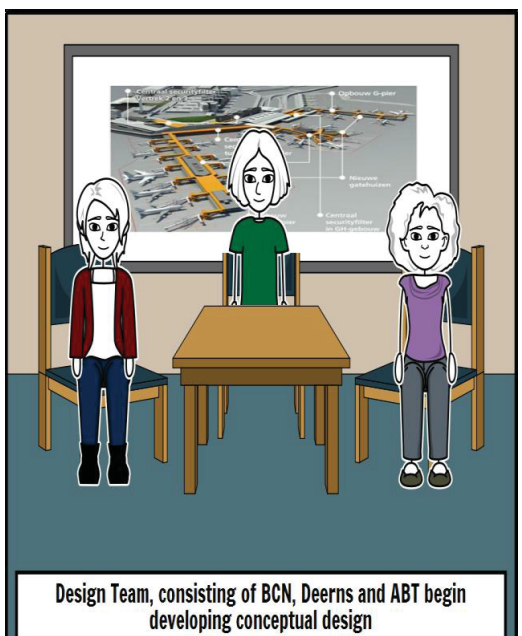


From every quadrant a BIM expert is elected to join the Project management collaboration



These experts work together, led by the project manager from PLuS

A collaboration environment is created in the form of a coordination model and database



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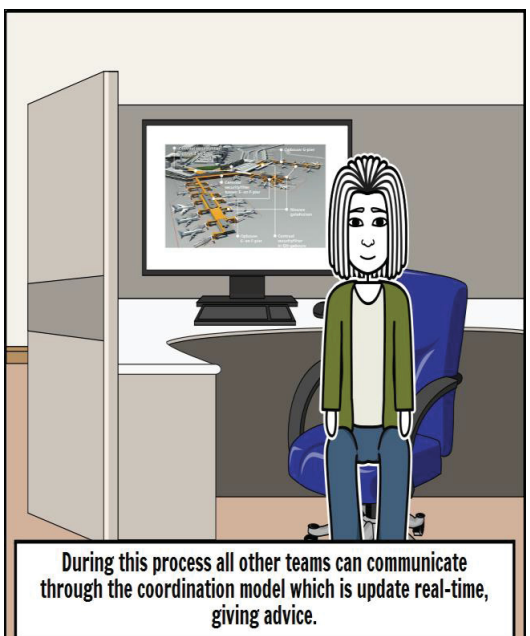
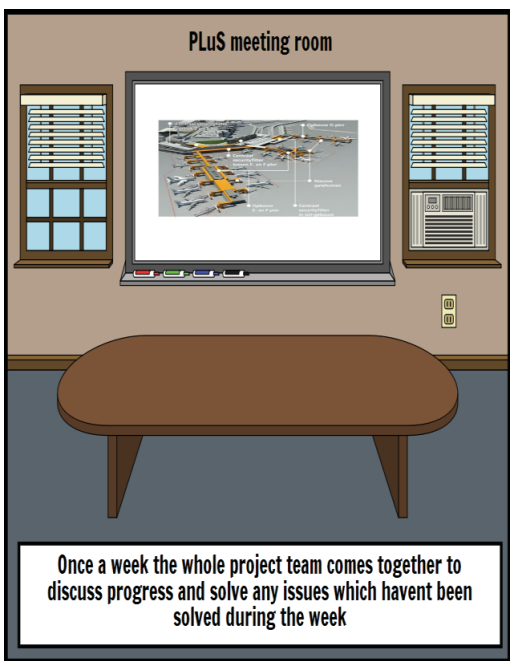
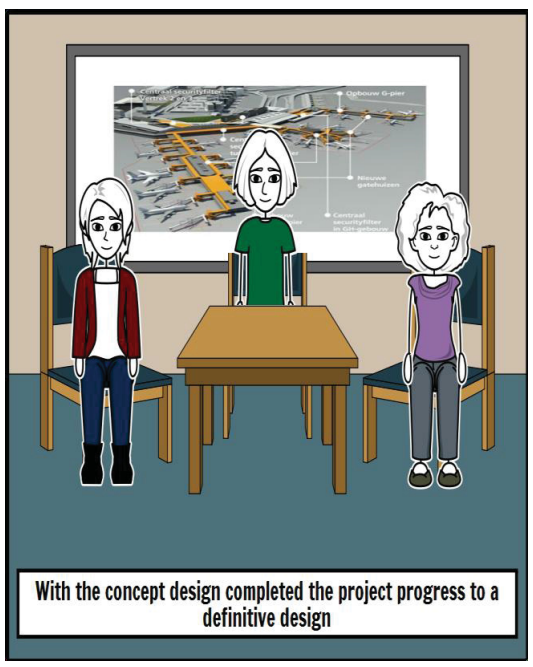


During this process all other teams can communicate through the coordination model which is update real-time, giving advice.



Once a week the whole project team comes together to discuss progress and solve any issues which havent been solved during the week



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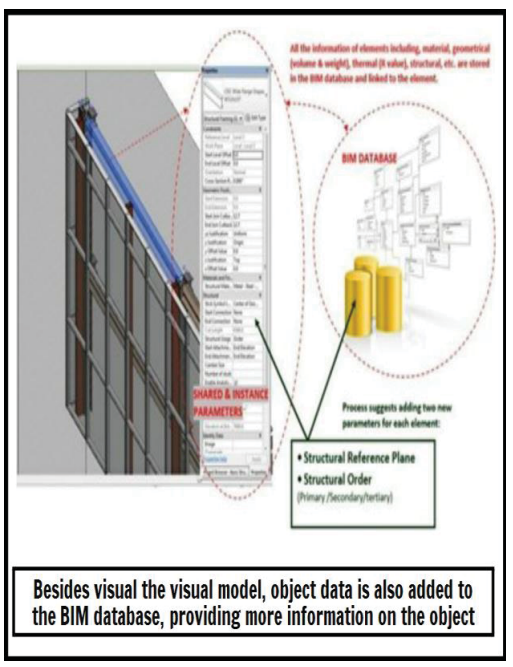

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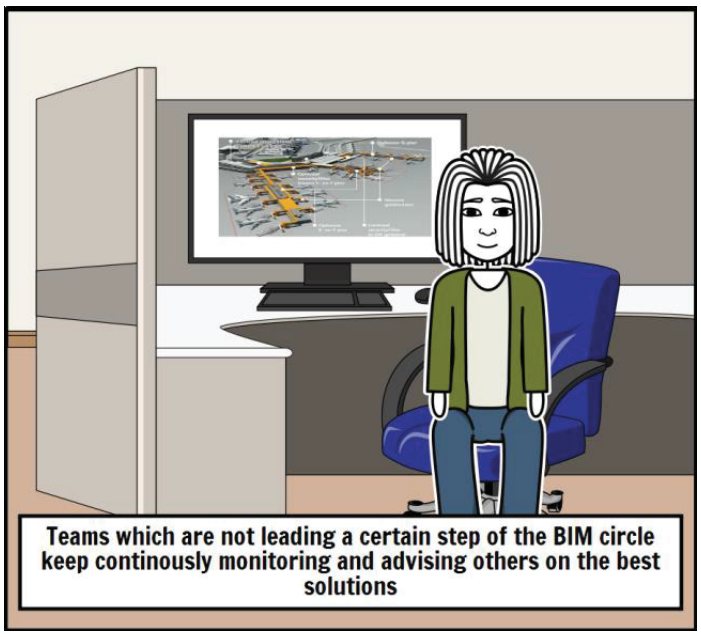
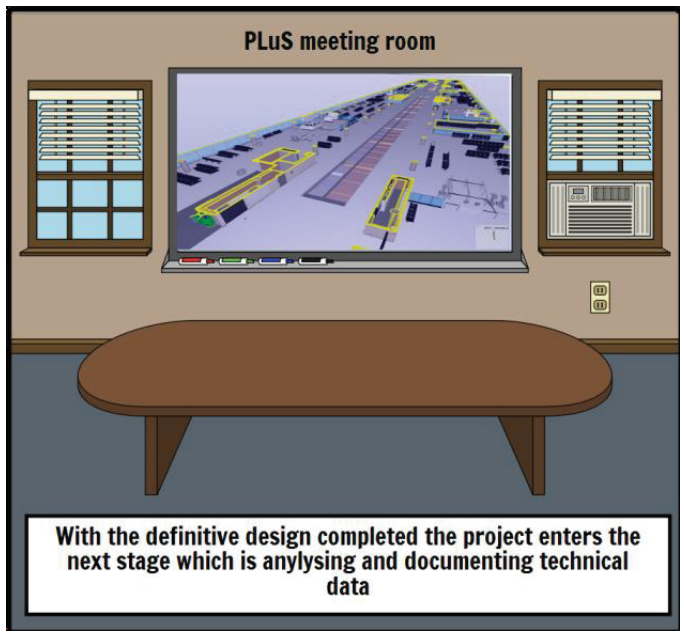


Teams which are not leading a certain step of the BIM circle keep continously monitoring and advising others on the best solutions



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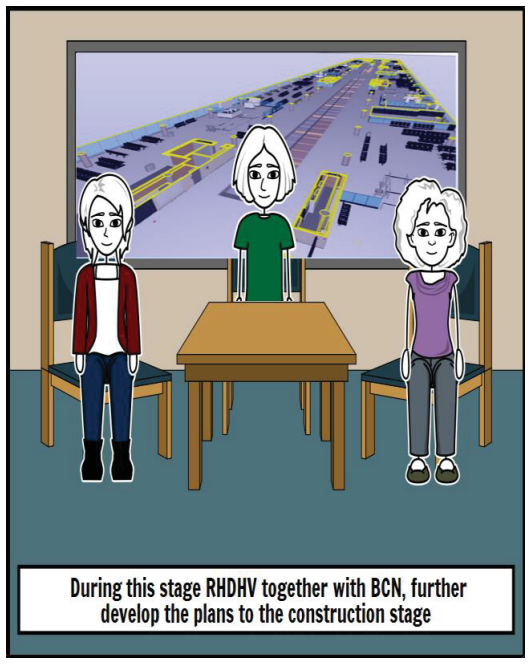
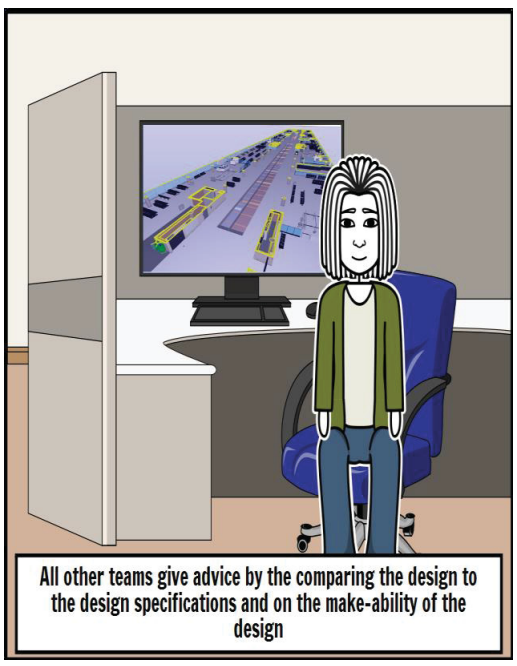
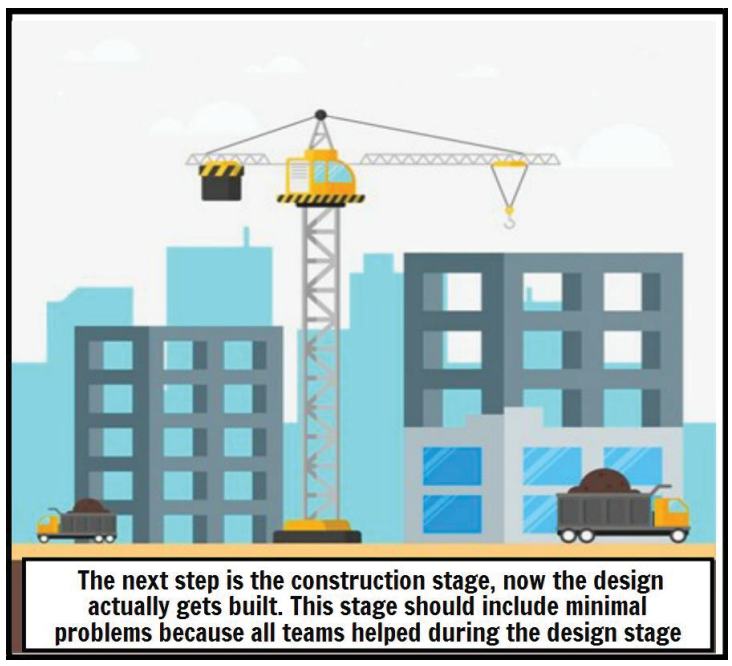


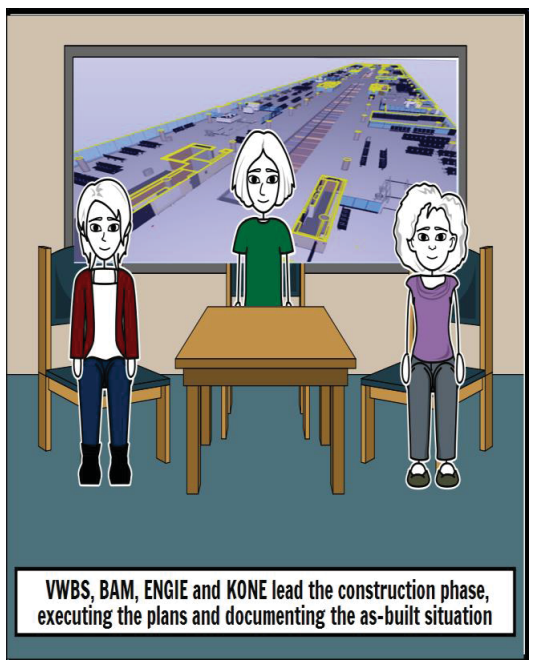
During this stage RHDHV together with BCN, further develop the plans to the construction stage



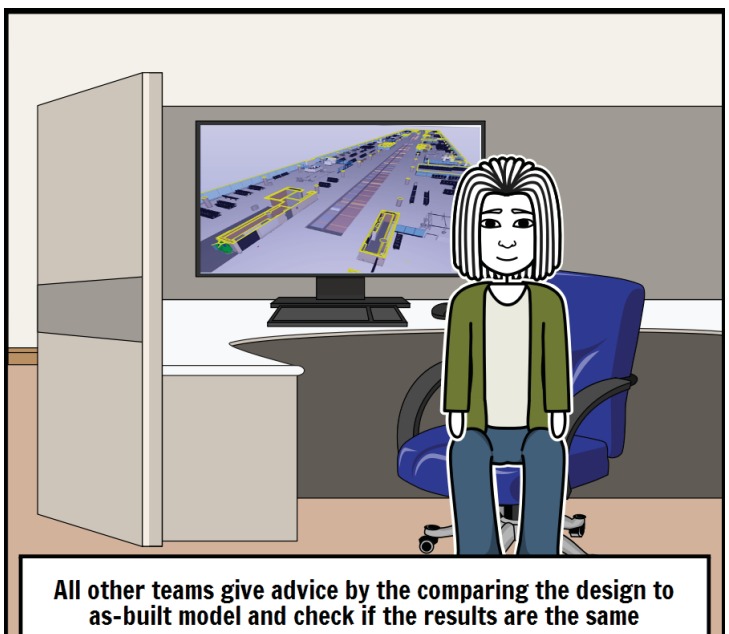
All other teams give advice by the comparing the design to the design specifications and on the make-ability of the design



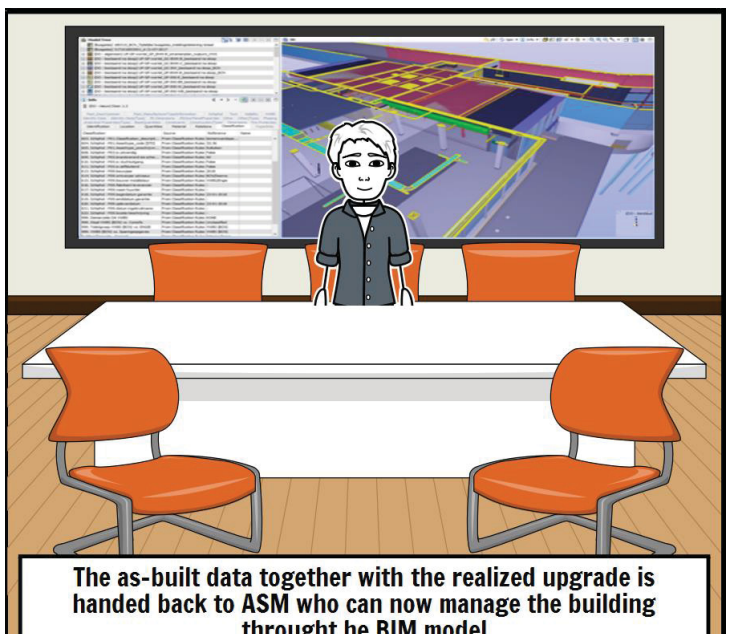
The next step is the construction stage, now the design actually gets built. This stage should include minimal problems because all teams helped during the design stage



VWBS, BAM, ENGIE and KONE lead the construction phase, executing the plans and documenting the as-built situation



All other teams give advice by the comparing the design to as-built model and check if the results are the same



The as-built data together with the realized upgrade is handed back to ASM who can now manage the building throught he BIM model