



A Project Management and Data Analysis Solution for a Competence Center in the Construction Sector

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Abstract

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The construction sector, much like the society it operates in, is undergoing revolutionary digital transformation that affects everyone who interacts with the built environment. For decades, a major subject for advancements in construction has been Virtual Design and Construction (VDC).

VDC is a multidisciplinary construction management approach that leverages technology and related methodologies to optimize the design and delivery of building projects. By simulating projects before they are built, VDC allows stakeholders to analyze and optimize design and construction processes, improving collaboration, accuracy, and efficiency, leading to better-quality buildings and improved project outcomes.

The VDC competence center at the commissioning company of this thesis project had for long faced challenges in their daily operations. The solution for managing digital support in construction projects was outdated, and a state of complacency was setting in. Thus, this project was initiated with the purpose of improving project management and data analysis capabilities of the VDC-team by developing supporting tools around its processes.

Additionally, the project aimed to set a precedent for the development of similar benefiting business intelligence solutions in other business functions, and to elevate the author's expertise in the use of applied software tools and the management of IT-projects as an employee in the commissioning company.

Supporting background for the project was provided by the author through research into relevant subjects, including challenges in digital transformation in the construction sector, selected software tools, and Virtual Design and Construction itself.

Development comprised of iterative development cycles, concluding with the implementation of a final solution that consisted of integrated data tables in Microsoft SharePoint, a Microsoft Power BI report, and supporting automated workflows with Microsoft Power Automate.

Measurement of success was conducted by comparing the development process and outcomes to pre-defined objectives, and qualitatively through an end-user survey about the final solution.

This product-based thesis was completed between October 2022 and February 2023, with all key stakeholders determining the solution to fulfill set objectives, and the author ultimately obtaining a comprehensive understanding of related topics, tools, and methods.

Keywords

business intelligence, virtual design and construction, project management, data analysis, process automation, microsoft office 365

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1 Introduction

Innovations in technology have introduced the biggest drivers for change during the 21st century. Incorporating digital technologies in an organization improves employee productivity, customer engagement, and creates opportunities for optimizing products and operations. The companies that embrace this digital transformation (DX) have a competitive advantage over those that do not, yet only a minority of companies have successfully done so, especially in the construction industry. (Pratt & Sparapani 2021)

Despite challenges and inaction, most actors in the industry acknowledge the importance of digitalization. A key step to the right direction is to assess and recognize the state of digital maturity within a company. One of such companies is the commissioning company of this thesis project, NCC Suomi Oy, which is on a path to become a data-informed organization. To reach this goal, decisive investment into new technologies and a new generation of talent with determination and expertise are required.

With new resources, internal competence centers and individual experts can start developing simple, yet effective solutions that utilize data to support their own and other actors' daily operations. This thesis project, done as a product-based thesis at Haaga-Helia University of Applied Sciences, is a direct result of putting these new resources to a test at NCC Suomi Oy.

The objective of this thesis project is to improve the daily operations of NCC Suomi Oy's Virtual Design and Construction (VDC) team, by developing a project and data management and analysis solution around its processes. The VDC team is a natural fit for DX-initiatives, since it has the best grasp and expertise on modern digital hardware and software related to supporting construction projects. Upon a successful project, the VDC team sees quantifiable improvement in their project management and oversight. Additionally, the results can be used as precedent to invest in similar projects that support other teams and competence centers at NCC.

1.1 Project Initiative and Objectives

The initiative for this project came from the Virtual Design and Construction team at NCC Suomi Oy. The VDC-team is an internal competence center that manages and coordinates digital support for construction projects. A competence center is a unit within an organization that is dedicated to developing and sharing specialized knowledge, skills, and resources in a specific area of expertise.

The process of reviewing and updating information related to the VDC-team's work has been done via partially overlapping Microsoft Excel spreadsheets. This method is outdated, slow, and prone to errors. From a management perspective, it has been hard to get a comprehensive picture of the team's current situation and provide timely help to construction projects during sales and production phases. Thus, a business requirement for a new management solution arose, with the aim of improving project oversight, status review, planning and scheduling, and information management.

The primary objective is to improve management and oversight of the end-to-end VDC-process with a data-driven solution according to the commissioning party's requirements, along with documentation of the development process, tools, implemented features, and relevant theoretical background. As set deliverables; SharePoint lists, automated workflows, a Power BI report, and a thesis paper are to be created and published.

This project is the first of its kind conducted by both the author and the VDC-team. This fact creates the basis for the secondary objective, which is to set a precedent of such solutions and their benefits, so that similar results can be replicated and applied in the VDC-team, as well as other areas of the company.

Measuring success is done by reviewing whether the objectives and scope were fulfilled. This includes the author's discussion and a review survey filled by each VDC-member.

Finally, as learning objectives the author is to acquire knowledge in using the selected tools and understand their value and use cases for future projects, as well as how to plan, design, and implement an IT-solution to support competence center work at NCC Building Finland.

1.2 Demarcation and Risks

This project includes the development of a solution that fulfils the objectives and deliverables stated in the previous subchapter. Requirements gathering and planning meetings define the content and features to be included, and any additional features that come up during development will be scheduled for after the thesis project's completion as separate work. Design changes to existing features will be implemented, except towards the end of schedule, where they will be reviewed and implemented on a case-to-case basis.

Known out of scope features include a mobile interface, end-user training, and maintenance. Training and guidance for end-users will be provided separately from this project, and maintenance will be part of the author's activities after the thesis project as an employee at NCC Suomi Oy.

In this project, scope creep, insufficient change management, overengineering, insufficient skills, and schedule restrictions are recognized as potential risks. Measures to combat these risks are detailed below.

- Scope creep: In meetings, topics in the scope and outside the scope need to be clearly stated. Development tasks should be listed clearly, so that timely progress is made without steering into features out of scope.
- Change management: If a tool, method, or other component of the project is found to not meet the requirements or flexibility needed to fulfil the objectives, an alternative tool, method, or component must be established in advance. Same precautions must be considered for a case in which end-user feedback drives changes during development. In such scenarios, decisions will be discussed with key stakeholders on a case-to-case basis.
- Overengineering: During design meetings and end-user feedback, features that are not required for the minimum viable product (MVP) should be added into a development backlog or discarded for the time being.
- Skills: The commissioning company must ensure that support is available throughout the project. The author and the commissioning party's representative will agree on specific terms in the commissioning agreement.
- Scheduling: Thesis work and other work are to be scheduled bi-weekly with the author's manager. The author and their manager must ensure that thesis work time is respected.

1.3 Project Structure and Applied Methods

The author of this thesis has started their internship period as a data analyst in the Virtual Design and Construction team at NCC Suomi Oy in May 2022. The author acts as the project manager for this project, and is also an end-user of the created solution, with other

primary stakeholders being the VDC-team's manager as a project owner, a business development manager as a company representative, and three VDC-experts as the core end-user group. Additionally, a lecturer at Haaga-Helia University of Applied Sciences has been requested by the author and appointed as a thesis advisor providing guidance for the thesis process and administering its evaluation.

The goal of ideating and creating specifications for this project has been assigned for the internship period during the summer of 2022. The final project schedule is flexible, with the goal of completing the development project between October and December of 2022 and finishing the thesis report before the end of February 2023.

The VDC-team utilizes an applied scrum method for its development tasks. This project's development is conducted as an iterative process which includes planning, design, build, and implement phases, which are aligned with the VDC-team's scrum sprints.

In the theoretical part, secondary qualitative research through literature review is used as a research method. In the empirical part, the applied methods include quantitative observations, experiments, and statistical analysis. In the discussion part, a survey is used as support for conclusions. (Scribbr s.a.)

1.4 Key concepts

BI – Business Intelligence

BUNFI – NCC Building Finland

DX – Digital Transformation

VDC – Virtual Design and Construction

BIM – Building Information Modelling

SQL – Structured Query Language

2 Theoretical Framework

The theoretical framework of this thesis includes research around three topics to support the understanding of core subjects: digital transformation in the construction sector, key tools used in the project, and the definition of VDC. The first one seeks to provide background for the state of digitalization in the construction industry, and why projects such as this are few and not easy to initiate and implement. The second one details the selection and features of software tools, while supporting the author's learning about the purpose and usage of said tools. The third subject defines Virtual Design and Construction, which is at the core of the whole project through the target group and its competence center work, which includes this project as a development initiative. A deep understanding of VDC is essential for the author and provides important context for external readers of this thesis report.

2.1 Digital Transformation in the Construction Sector

Digital transformation (DX) efforts at NCC affected the initiation of this very project. From a management standpoint, understanding the ins and outs of DX can be the difference maker for which efforts to invest in, and ultimately whether a development project is successful. This section is primarily aimed at internal decision makers at NCC, or at any other construction organization that seeks to understand the challenges of their digitalization efforts. Subsequently, the findings help the project owner to identify which challenges to take into account during development. Lastly, this research supports the secondary objective of setting a precedent for future DX initiatives by raising awareness and understanding of challenges in digitalization.

2.1.1 Digitization, Digitalization, and Digital Transformation

Like many other construction organizations, NCC aims to be as data-informed as possible. It began its digital journey by designing and planning the path and structures that laid the foundation for successful digitalization efforts across the organization. This has led NCC to become the industry leader in Virtual Design and Construction. On NCC's public website, its Chief Information Officer states the following quote:

NCC, like the society we operate in, is undergoing a revolutionary digital transformation that affects everything we do and the relationship with those we interact with. For NCC, digitalization is about the ability to use and create value from the information we generate and have access to.
(Kulotie s.a.)

As can be seen, digitalization, digital transformation, and often digitization, are used in similar context which can create conflation. While they are related terms, they all have different meanings. Digitization refers to the process of converting analog information into digital format, which creates the connection from physical world to software. This can include scanning physical documents or images into digital form or converting analog audio or video recordings into digital files, all together providing the foundation for digitalization efforts. (Gupta 2020)

Digitalization refers to the broader use of digital technologies and tools to improve and enhance business processes, products, and services. This can include using digital tools to automate manual tasks, improve communication and collaboration, or create new digital products and services.

Digitalization enables digital transformation, which refers to the overall process of using digital technologies and strategies to fundamentally change how a business operates and creates value. This can involve a wide range of activities, such as adopting new business models, using data analytics to inform decision-making, or leveraging artificial intelligence and machine learning to create new products or services.

To put the aforementioned into perspective, digitization laid the foundation for digitalization efforts that created the tools and processes leveraged in this project, which as a whole is a digital transformation initiative.

2.1.2 Difficulties in Digital Transformation

The McKinsey Global Institute's industry digitization index shows, that in 2015 the construction sector was second to last in digitization out of 22 sectors, only beating agriculture and hunting. During the last two decades, the construction industry had an annual productivity growth of only 1 % (Ribeirinho & al. 2020, 2). Changes in this sector are slow due to a conservative mentality (Menon 2022), and DX initiatives are hard to implement into work culture and its processes. The latter is due to lack of awareness and skills, and fragmented organizational structure of construction projects. Most projects have several contractors and sub-contractors, often with very niche expertise and backgrounds, making it hard to communicate and align new strategies.

In the European Union (EU), the European Construction Sector Observatory (ESCO) was founded in 2015 to continuously assess the state of the industry and provide feedback to regulators and stakeholders. In April 2021, it published an analytical report, Digitalization

in the Construction Sector, which provides topical insights for actors in the industry, especially EU's member states. Of countries where NCC operates in, Norway was not included in the report, since it's not an EU member state.

As seen in figure 1, the biggest challenges in Finland were considered to be lack of awareness and understanding (62 %), technological readiness (31 %), and lack of skilled human resources (27 %). Lack of awareness and understanding was also considered high in Denmark and Sweden, with 42 % and 55 % respectively. The major difference between the three presented countries was the difficulty of adapting work processes and culture, in which Swedish respondents combined to 80 %, compared to 16 % in Denmark and 15 % in Finland.

Larger cultural differences in Sweden can partly be related to a higher variation in ethnicities. 20 % of the Swedish population has an ethnicity other than Swedish, compared to 14 % in Denmark (Indexmundi 2020), and only 9 % in Finland (PopulationU 2020). Larger and varied ethnicity groups increase language barriers and cultural differences at construction sites. However, since the most impactful decisions happen at the managerial level, these difficulties cannot be attached and blamed on the construction sites, where an individual employee often has no say in which technologies they have in use, or which mandated processes to follow. Increasing and improving awareness, standards, and technological readiness are introduced at the managerial level through investment, learning, and development work.

	Cost of equipment and software	Lack of skilled human resource	Unclear legal framework	Lack of awareness and understanding	Lack of standards	Difficult to adapt work processes and culture	Technological readiness	Low expected return	Unavailability of equipment and software	Lack of synergies and consistency between technologies
Finland	0%	27%	0%	62%	12%	15%	31%	4%	4%	15%
Denmark	23%	26%	16%	42%	26%	16%	29%	19%	3%	23%
Sweden	20%	24%	39%	55%	39%	80%	29%	20%	14%	20%
EU weighted total	28%	43%	25%	45%	32%	31%	22%	16%	8%	21%

Figure 1. Survey results on challenges in digitalization in the construction sector (adapted from ECSO 2021)

The survey results should be taken as guidance rather than certainties, since they may include bias if a respondent is not well versed with certain topics or if there is considerable fluctuation in the number of respondents between member states. Such bias is suggested

by the fact that in Finland, 0 % held cost of equipment and software, and unclear legal framework as important challenges, as opposed to 20 % and 39 % respectively in Sweden. If the respondent doesn't understand software or legal frameworks, their answer might differ from what is the reality in those areas. The survey also doesn't reveal the number of respondents per member state, which can also be a cause for statistical bias when comparing results between member states.

2.2 Software Tools

When researching the software tools, around which the solution of this project would be developed, the existing ecosystem at NCC had to be taken into account. Several adequate candidates can be found on the internet, but having existing premium subscriptions, guides, branded templates, etc. eases workload and provides more integration possibilities. However, before jumping into development, selected tools had to be carefully considered. This was to ensure they include enough features to fulfil technical and end-user requirements, and to avoid issues later in development when changing tools would be cumbersome and cause extra costs in time and money. For the author, this also meant learning to use those tools and being able to describe their pros and cons.

2.2.1 Office Suites

In a digitized world, every workspace is likely to take advantage of various software and applications to ease their workload, analyze it, or improve it. In fact, in western countries, trying to operate without such tools will put you in a major disadvantage, or possibly cripple your work entirely. Gone are the days of fax machines, physical folders, cabinets, and storage rooms. All paperwork, materials, and communication can be handled, stored, and shared digitally, and without pertaining to an ecosystem of digital tools it is close to impossible to interact with stakeholders. There are of course exceptions such as contracts, which can be signed digitally, but often remain in physical form due to their importance and tradition.

Several major software providers package their office applications in so called office suites. At first, these collections commonly included at least a word processor, spreadsheet, and presentation applications. Over the years they grew into all-encompassing ecosystems, which integrate everything needed for knowledge work and routine office tasks. (Giaquinto 2022)

Some of the most popular office suites include Google Workspace, Apple's iWork, LibreOffice, and the most popular one, Microsoft 365. Globally, Microsoft 365 held the majority of market share with 48 % as of February 2022 (Vailshery 2022). Key reasons for their success include an extensive catalogue, ease of use and comprehensive guides, but mainly the fact that Microsoft's operating system, Windows, is used in more than 70 % of all personal computers and often comes with several Microsoft 365 applications pre-installed. (Singla 2022)

Interestingly, according to data platform company Enlyft, the construction sector is the largest Microsoft 365 customer by industry. This is also the case at NCC, which uses it almost exclusively. The cause for this is likely to be the out-of-the-box simplicity of 365 and flexible subscription models for a large number of employees in a variety of positions. Since NCC is able to provide premium access to most Microsoft 365 applications, that was the natural point to search for fitting solutions for this project. In the end, all tools used for development and supporting work were developed by Microsoft.

2.2.2 Key Tools

All the software tools used in this project are developed by Microsoft, with all but one being included under the Microsoft 365 office suite. The main tools are Microsoft SharePoint, Power BI, Power Automate, and Azure Data Studio, on which core development is done. SharePoint and Power BI are also the end-user interfaces. Supporting tools are Microsoft Excel, Visio, PowerPoint, Teams, and Outlook, which are used for communication, collaboration, presentation, and creating supporting material and diagrams.

SharePoint is a web-based collaboration and document management platform used for creating and managing websites and content, organizing documents and files, and for communication within organizations. It enables users to store, organize, and share information with others, and provides features such as document libraries, lists, and wikis to facilitate teamwork. The list feature is a great substitute for shared Excel Spreadsheets and serves a key role in the solution of this project. (Microsoft SharePoint s.a.)

Power BI is a business analytics service used for data analysis, data visualization, and for creating custom and interactive reports and dashboards to help organizations make informed business decisions. It integrates with a variety of data sources, especially all the other selected tools. This combined with the fact that Power BI is already widely used at NCC, and the author's existing expertise, it's the perfect candidate for the business intelli-

gence features of the solution. Power BI also includes Power Query, which is a data connection and transformation tool, and will be used to manage data that is imported to Power BI. (Microsoft Power BI s.a.)

The VDC-team at NCC handles several repetitive tasks that could be automated. Some of them require separate development projects, but through this project at least the flow of existing data and scheduled updates can be automated. Power Automate, Microsoft's cloud-based automation service with a visual, low-code interface, can be used to build and manage workflows and tasks such as sending emails, creating and updating records in databases, and copying files between services, especially those within Microsoft's ecosystem.

SQL (Structured Query Language) is a standard programming language used for managing and manipulating relational databases. It is used to perform various operations such as inserting, updating, and retrieving data stored in databases (Loshin s.a.). In this project, Azure Data Studio is used as the database management tool. It's a modern and user-friendly tool that will be used to manage and pull data from NCC's databases.

As for the supporting tools, Microsoft Teams and Outlook will be used for communication such as emails and online meetings. Excel contains most of the VDC-team's existing data and will be used for minor data management tasks. Visio is an application used for creating diagrams, flowcharts, organizational charts, etc. PowerPoint also supports the creation of diagrams but is mainly used for slideshow presentations.

2.3 Virtual Design and Construction

In the Nordics, NCC is the leading research and development organization towards digital construction methods. This includes heavy investment into Virtual Design and Construction (VDC), and the opportunities that surround it. So, what is VDC? In the industry it's often mistaken to mean an applied version of Building Information Modelling (BIM), but that's only a part of it. Where and when did VDC begin, and how do its roots differ from NCC's own definition? (NCC 2022)

2.3.1 Origins and Definition of VDC

The use of technology in the construction industry can be traced back to the 1960s, when computer-aided design (CAD) was first popularized (Cohn 2010). However, VDC as it is known today, has only been around since the 1990s. At the forefront of development

around VDC was the Center for Integrated Facility Engineering (CIFE) at Stanford University in California, USA. Since 1988, CIFE has shaped the Architecture, Engineering, Construction, and Operation (AECO) industry through their efforts on open research and new methodologies “in the planning, design, operation, and management of the built environment”. (Buncio 2020; Stanford University s.a.)

Over time, new technologies and innovations have improved VDC, but at its core it has stayed the same. VDC is a multidisciplinary construction management approach that leverages technology, digital tools, and related methodologies to optimize the design and delivery of building projects. By simulating and modelling a construction project before it is built, VDC allows stakeholders to visualize, analyze, and optimize design and construction processes. Overall, the use of VDC leads to improved collaboration, increased accuracy, reduced waste, and improved efficiency in the construction process, leading to better-quality buildings and improved project outcomes. Let’s go into more detail through the lens of NCC. (Jones 2022)

2.3.2 VDC at NCC

In October 2016 in Stockholm, Sweden, NCC published its own definition of VDC. This ensured that all stakeholders knew the methodology in the same way, and that it was applied in line with NCC’s existing processes.

VDC encompasses a holistic approach to digital support across the entire lifetime of a construction project, and while the list of its key features, processes, and technologies is long, at NCC they have been grouped under four cornerstones: collaboration, processes, BIM, and metrics. (NCC 2022)

Building Information Modeling is the first and most recognized cornerstone of VDC. BIM is used to simulate and model a construction project before it is built. Architectural, structural, and MEP (Mechanical, Electrical, Plumbing) models visualize the building design and spatial relationships between different building components.

BIM can be further divided into 3D, 4D, and 5D models, each representing a different level of detail and complexity. 3D BIM provides a three-dimensional representation of the building design, 4D BIM adds a fourth dimension of time to the model, representing the construction schedule, and 5D BIM extends 4D by adding a fifth dimension of cost information. An example of a 3D model can be seen in figure 2.

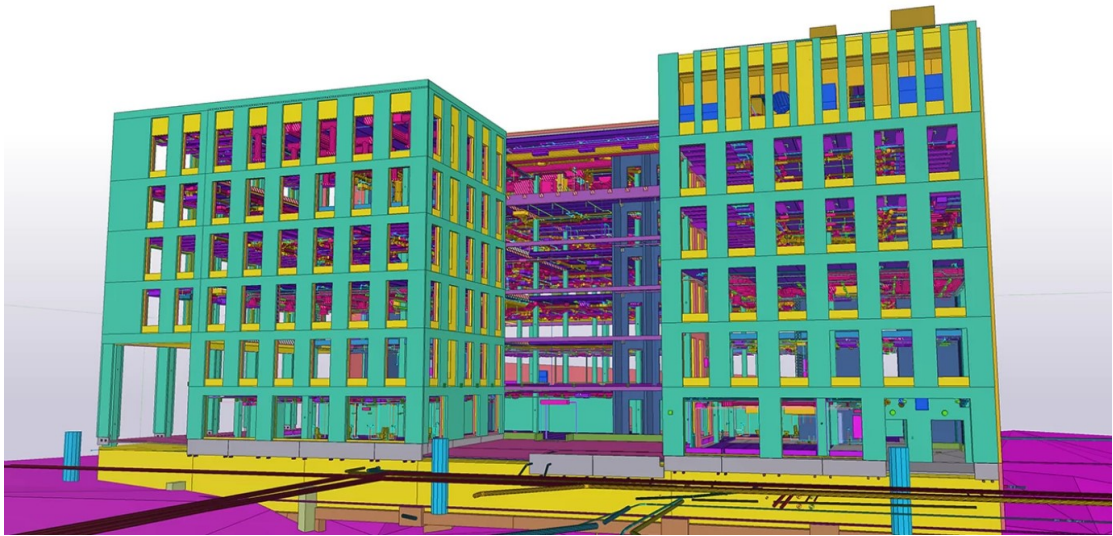


Figure 2. 3D BIM model of NCC's office project, Fredriksberg D (Tekla 2022)

Important to note is that each asset doesn't simply present a visual building block, but also holds quantifiable values, such as name, ID, dimensions, volume, mass, etc., enabling the second cornerstone, metrics, along with calculations and estimations throughout the construction process. This and other real-time data provided by VDC can be used to track and measure the progress and performance of the construction project, improving project efficiency, minimizing waste and costs, and ensuring timely delivery.

Collaboration is the third cornerstone of VDC. Construction projects involve many stakeholders, including architects, engineers, contractors, and owners, each with their own specific requirements and interests. VDC facilitates collaboration between these stakeholders, helping to ensure that everyone is working towards the same goals and that communication is seamless. This helps to minimize the risk of misunderstandings, reduce the likelihood of construction errors, and improve project efficiency.

VDC uses technology to streamline the construction processes from pre-construction planning to post-construction maintenance. This final cornerstone enables construction professionals to visualize, analyze and simulate the construction process in real-time, making it easier to identify and resolve issues before they occur on the construction site.

3 Empirical Framework

This chapter contains the background, processes, development, and outcomes of the project, split into two subchapters. First, the target group and its operations and processes are presented, providing the starting point for creating the solution. Second subchapter details the development process, the development itself, and the outcomes of the solution, which are separated by the four core development components: SharePoint lists, Power Automate workflows, Power BI report, and implementation of the final solution.

The business problem this project responds to, as well as objectives, deliverables, and how to measure success, are detailed in subchapter 1.1 Project Initiative and Objectives. Assessment of the final solution and its development process are discussed in the concluding chapter.

3.1 Target Group Organization, Operations, and Processes

This subchapter lays background for the project by detailing the target group's organization, its operations, and by assessing its processes. The operations and processes contain the subjects that this project seeks to respond to by improving the VDC-team's project management and data analysis capabilities.

3.1.1 The Commissioning Company: NCC Building Finland

NCC AB is a major Nordic construction group operating in Sweden, Norway, Denmark, and Finland. In 2021, it had an average of 13002 employees and total net sales of 53,41 billion SEK, or 5,21 billion EUR (NCC Annual Report 2021). NCC AB divides into five business areas, which are NCC Building Sweden, NCC Building Nordics, NCC Infrastructure, NCC Industry, and NCC Property Development.

NCC Building Nordics is further divided into three operative divisions; NCC Building Norway, NCC Building Denmark, and NCC Building Finland (BUNFI), which is registered in Finland as NCC Suomi Oy. The annual net sales of NCC Suomi Oy in 2021 were 480 million EUR (Taloussanomat 2022).

BUNFI builds residential and non-residential buildings ranging mainly from apartment buildings and offices to public buildings such as schools and special projects such as hospitals. It has strong expertise in sustainability, digitalization, and customer cooperation methods. In addition to building, BUNFI has a steady footing in the refurbishing market,

which has increased due to a large repair debt in Finland and hesitant investing into new buildings in the uncertain post-covid economy. (NCC 2022)

3.1.2 The VDC-Team and Its Operations

The target group of this project is the VDC-team of NCC Building Finland. Its role is to support all staff members and construction projects that deal with VDC-related activities. It operates under the support function Strategy & Business Support (highlighted in the organizational charts in figures 3 and 4), and reports to the head of said support function.

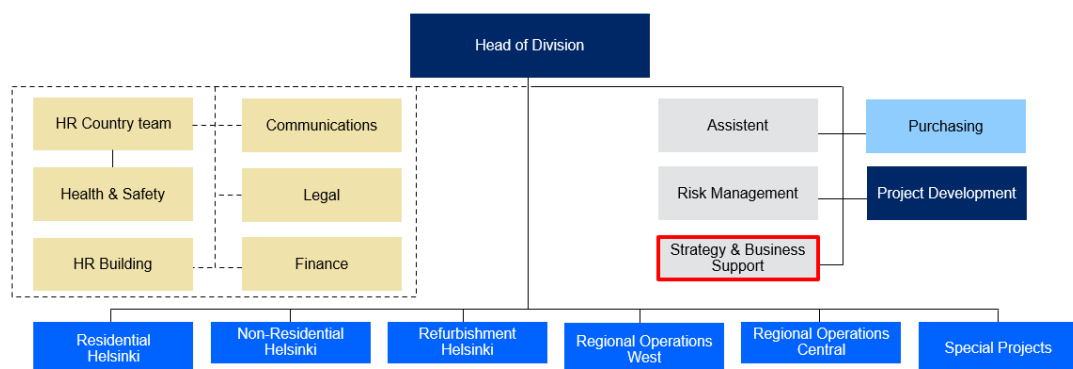


Figure 3. NCC Suomi Oy's organizational structure on department level (adapted from NCC 2022)

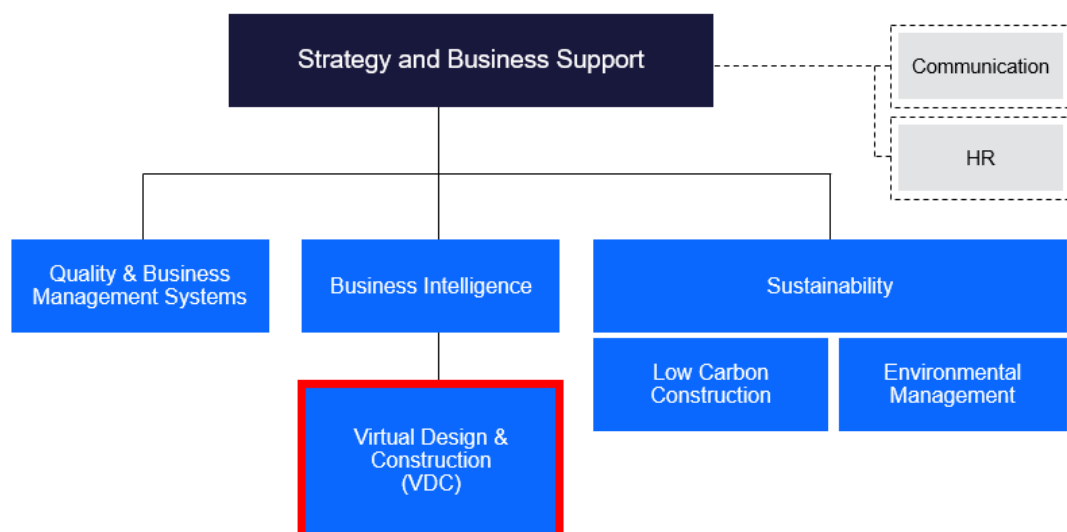


Figure 4. VDC-team's position in the organization (adapted from NCC 2022)

In 2022, a new business management system was implemented, and core processes and their tasks are better defined for everyone to see. File management was also included so that all important meeting notes, plans, contracts, and other documents are accessible in a shared, central location. This is not just useful, but also necessary due to regulations for

construction companies and projects, set on both national and EU level (Ministry of the Environment s.a.). With this company project management overhaul, VDC decision points were also aligned so that relevant parties know when to complete tasks and what documentation to uphold.

BUNFI's departments take on tender and/or sales projects depending on where the construction site is located and what type of construction is in question; residential, non-residential, refurbishment, or special projects. As demonstrated in figure 5, each department can have several projects. The VDC-team supports projects that are certain size, and/or have agreed upon VDC-methods in use (represented in dark blue color). Smaller projects, seen especially in the refurbishment sector, do not always require VDC for successful production. Management of the aforementioned project support is the subject this solution aims to improve, by enabling better project management and analytical insight into the operational situation.

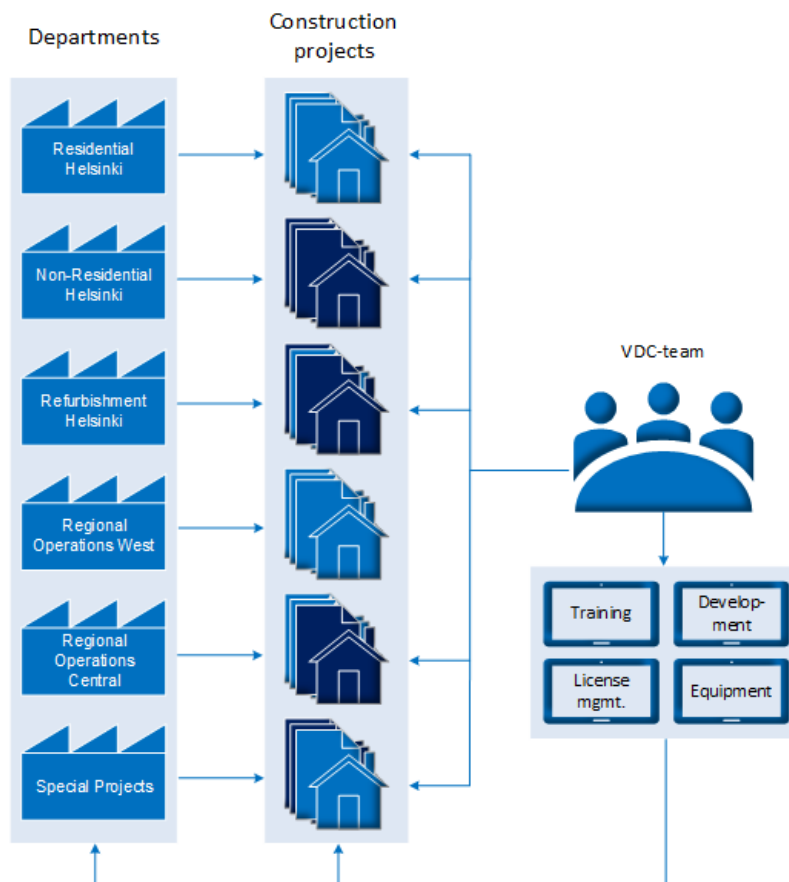


Figure 5. A diagram illustrating how the VDC-team operates alongside construction projects

The VDC-team does not only help construction projects in their design and production, but also oversees several other important tasks. Staff members need to be trained to use new

software and hardware, as well as provided sufficient licenses to those tools. Software can include new scheduling or BIM tools, and hardware can include Virtual Reality (VR) glasses or drones. Drones are used to capture images from the air, providing a new perspective for modelling and marketing. Other image and video capturing, such as laser scanning and 3D-capture, are also conducted by the VDC-team or someone who is given training, which is often necessary in remote projects. Most new digital pilot projects are conducted by the VDC-team since its experts are well versed in modern digital construction tools and are able to create and share results and learning material from said pilots.

3.1.3 Assessing the VDC-Process

BUNFI's VDC-process is constant, with slight differences within contracting and sales projects. To form a clear picture for the VDC-team's project management and the SharePoint list content, the VDC-process steps were drawn out and documented. This work can also serve a purpose for NCC's strategic development for when the process itself is undergoing changes. Changes in the process affect several layers of the solution (SQL, lists, event order, Power Query, DAX), and therefore laying a thorough foundation in this area via process maps and other documentation provides significant help when referring to what has been agreed upon, and where changes would need to be made regarding the solution.

Construction projects at BUNFI begin with a sales process, in which at first a new lead is added into BUNFI's customer relationship management (CRM) tool and project development begins. From there, won projects move into design and production until a finalized project is handed over to a customer. Most projects also have a warranty and maintenance period which is its own process, however that process rarely includes VDC-activities. To provide a visual example, figures 6 and 7 present sales and production processes in a residential construction project, utilizing Business Process Modelling Notation (BPMN). In these collaboration process flowcharts, all the VDC-team's decision points occur and are linked into the sales and production processes. Decision points are activities that are set to happen in pre-designated points along the overall process. At NCC, this term is widely used when referring to mandated process steps, most of which require documentation to be created and uploaded into BUNFI's project management system. Communication between the VDC-team and departments to organize and align these process steps has been difficult. Upon a successful completion of this project, these issues will be greatly reduced.

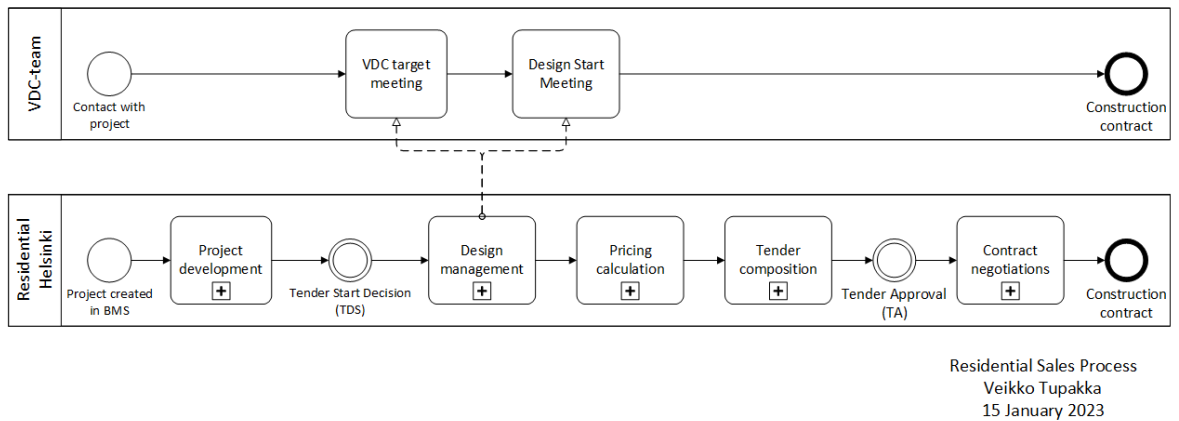


Figure 6. High-level flowchart of a residential sales process at NCC

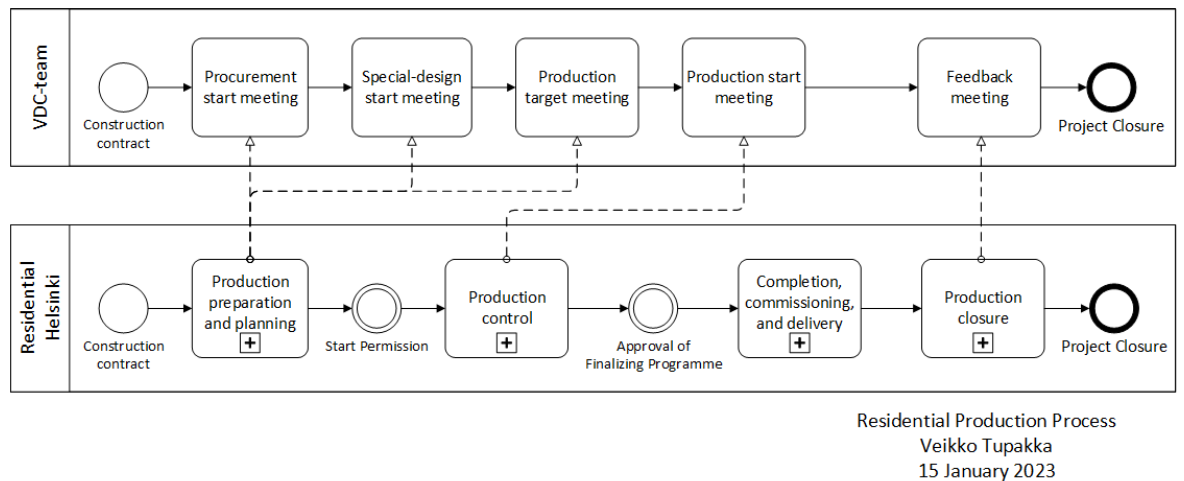


Figure 7. High-level flowchart of a residential production process at NCC

3.2 Production and Outcomes

This project’s development tasks were included in the VDC-team’s development sprints to organize and follow progress. The tasks were constructed collaboratively by the project owner and manager and aligned with the sprint schedule. While a sprint normally consists of one development iteration, in this project, the sprint tasks did not have to complete a full iteration (figure 8). This was due to the fact that the thesis process followed a schedule that was separate from the VDC-team’s sprint schedule. Separate schedules also helped reduce the risk of the author’s work as an NCC employee hindering their thesis work as a student.

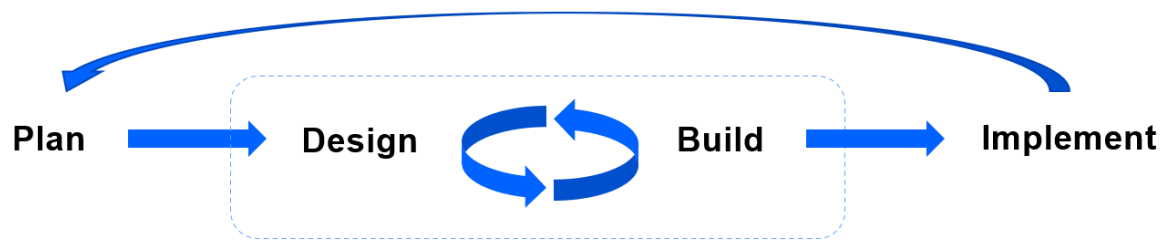


Figure 8. Illustration of the development cycle applied in this project

After planning an iteration, its contents were designed, prototyped, and built, until approved content was ready to be implemented (figure 8). The first iteration included the creation of a minimum viable product (MVP) with the features that enabled basic functionality. After the implemented content was tested and presented, feedback from the end-users was gathered to support the next cycle of development. The main development components created during the iterations were building SharePoint lists, building workflows with Power Automate, creating the Power BI report, and finally data migration and go-live. An additional back-end component that ran throughout development was data management, which included the extract, transform, and load (ETL) process of collecting, compiling, cleaning, and transforming data from NCC's databases and the VDC-team's original Excel files to be used in the lists, Power Automate, and Power BI.

The following subchapters describe the project initiation and aforementioned development components with their respective outcomes.

3.2.1 Initiation and First Designs

Project initiation began with a simple meeting where the VDC-team presented a whiteboard with categorized wish-list of features. An idea of a data structure was drawn out with the help of BUNFI's Business Development Manager, who oversees the VDC-team, BI, and digitalization (figure 9). This draft was a defining kickstarted for the project by formalizing thoughts into a visual map, which ended up being the foundation of the whole solution.

In the following weeks, existing data sources were mapped and researched. Tools to use had already been decided, although not fully tested. The data model follows the star schema, which is a type of data model used in data warehousing and business intelligence. It is named after the star shape created by a fact table at the center surrounded by multiple dimension tables (Microsoft Learn 2023). The final model (appendix 3) had one key change, which was to use the VDC Events list's data as the primary fact table, and VDC Projects as secondary. This was done to ensure unique table relationships.

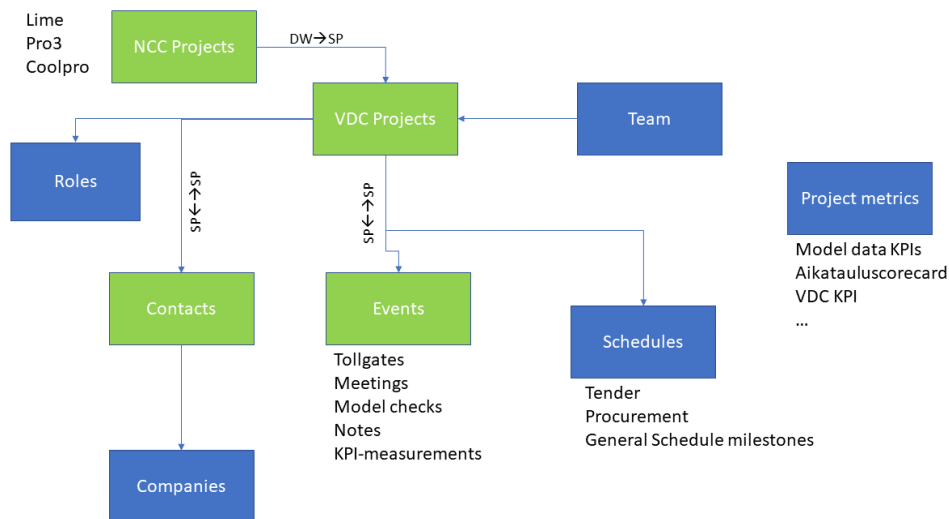


Figure 9. First data model draft

Drafts for the Power BI report and SharePoint lists populated with Power Automate using dummy data were created to show end-users what features could be included, provide them with a basis from which they could create new user-stories, and to test the functionality of all the selected tools.

3.2.2 SharePoint: Building Lists

The VDC-team hosts an intranet site on Microsoft SharePoint with all necessary information and guides around VDC at NCC, for all co-workers to see. They also have an internal site just for the team's own operations, which provides a platform for creating the SharePoint lists planned for this project. Lists allow users to create, manage, and share structured data in the form of a table, and are essentially data tables that can be configured to form their own relational database. They include many of the same functionalities as Excel, with additional features focused on cooperation. They can also be easily integrated with the other Power Platform tools in use.

The process of building and configuring the lists began with a design meeting, where all the necessary data columns in the original Excel file were documented and listed categorically. Then, each column's parameters and settings were added to the document. This process, demonstrated in figure 10, was repeated for all three lists included in the previously defined data structure: VDC Projects, VDC Events, and VDC Contacts.

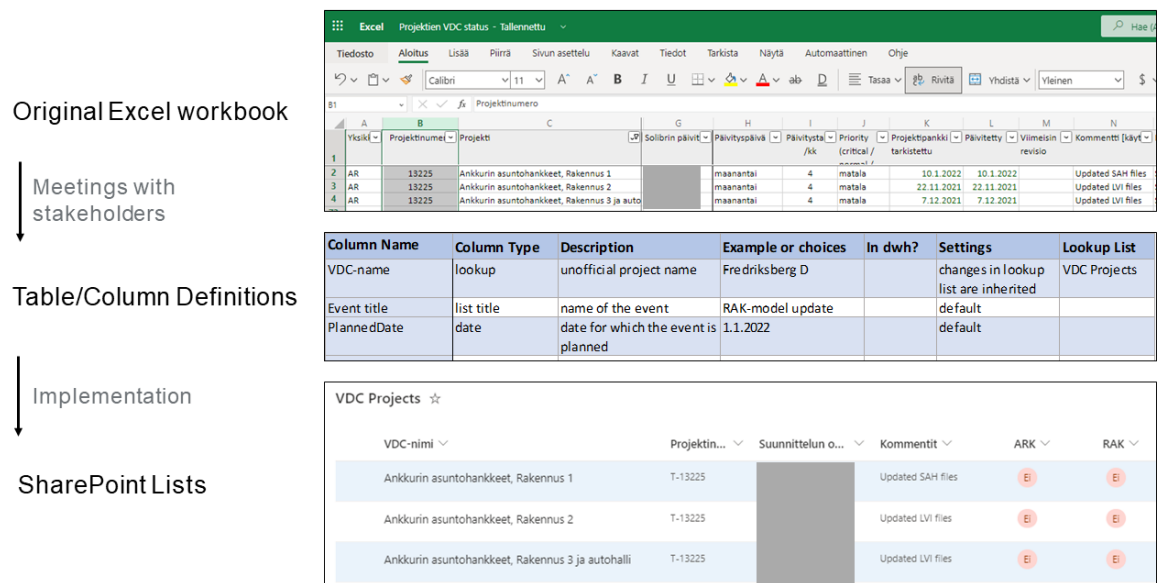


Figure 10. Process of defining list column settings and definitions

The project list holds a unique row, known as an item, for each construction project that has ongoing VDC-activities including key VDC personnel, software tools in use, BIM status, etc. The event list contains 12 items for each project, with each item representing a VDC decision point, such as Production Target Meeting. Planned and realized meeting dates, notes, and attached personnel can be documented within these items. The events are linked to their respective projects in the project list with a project ID in a lookup column. Finally, the contact list is a registry of related persons or entities. Its items can be used as lookup values in person/organization columns in the other two lists. The end-user of the lists is then able to open the contact items from the project and event lists to view more detailed information. Complete tables of all the list column definitions and settings can be viewed in appendix 1.

The “collection, storage, use, transfer and disclosure of personal data” must be conducted according to the European Union’s General Data Protection Regulations (GDPR), as stated on the Office of the Data Protection Ombudsman’s website. This means that over the entire lifecycle of the VDC Contacts list, only details that are current and can be proven to be purposeful for the operations of the user’s organization can be stored.

3.2.3 Power Automate: Developing Automated Processes

The VDC-team’s previous data management solution, which was essentially a simple Excel spreadsheet, did not include existing company data from NCC’s databases. This meant that any information outside their own work had to be repeatedly checked from source systems or requested from co-workers, causing outdated information and delays.

Since all this data already existed, it was only a matter of making it easily available. Thus, providing useful and live data was set as a requirement for this thesis project.

As detailed in section 2.2.2 Key Tools, Power Automate enables automated workflows that integrate seamlessly between SharePoint lists, Excel, and Power BI with a basic license. During the summer of 2022, simple workflows that pull data from Excel and add it to lists were created to practice the use of the tool and verify that its functionalities are as required. After proof of concept, a request for a premium license was sent and approved. A premium license allows the user to establish a data connector to Microsoft's SQL Server, from which data queries could be pulled directly. Before this, a temporary solution was to pull data first into an Excel file, and from there to SharePoint. The SQL data connector cuts off the middle-agent and is faster and more reliable.

Figure 11 lists the workflows which are present in the final solution. A temporary flow for mass-populating the VDC Project list during data migration was also built; but as a supporting one-time-use flow, is not relevant to the final solution. In addition, a few other workflows were created for test purposes, or for features that ended up being removed. The numbers in figure 11 represent the position of the workflow in the overall automated processes described later. The icons represent flow trigger types, which in this case are either scheduled, manual, or SharePoint activity triggers. The manual flows are kept offline and used as backup in cases where the automated ones fail.










		Name
5		Scheduled Update VDCProject from VDC_Mappin...
4		Manual Update VDCProject from VDC_Mapping 
6		Save changes in VDCProjects
1		When project is created, add ProjectMappingTest...
3		Create default events - MANUAL 
2		When project is created, create default events - N...

Figure 11. List of Power Automate flows in the final solution (adapted from Power Automate 2023)

The main plan was two-fold: decrease the amount of manual work as much as possible and ensure up-to-date project data. Without automations, the end-user would have to insert every project and event item by hand, and fill/update column information by reviewing different source systems, as was the case with the original Excel file. After the lists were built and necessary data from NCC's databases was queried with the help of Azure Data Studio, the best initiation point for the automated processes was found; being the unique Project Number (PN).

Figure 12 illustrates two automated processes, along which workflows 1, 2, 5, and 6 are executed. The first process starts when a user adds a new project into the VDC Projects list by inserting only the Project Number. Flow 1 is then triggered and uses the PN to find a matching data row via SQL Server, and fills the Project Name, Department, Sales Status, and Production Status column values. Then, flow 2 triggers and creates all pre-defined event items in the VDC Events list, with the PN being linked to the VDC Projects list.

The second process is scheduled for every workday at five in the morning, right after all databases have updated. Flow 5 is triggered and iterates through every item in the VDC Projects list, updating any value that has changed after the database updates. Every time an item value is updated, flow 6 triggers a new instance. It captures both the old and the new value and creates a new item in an additional list called 'VDC ChangeArchive'. This list requires zero user input, nor is seen by the end-users. It acts a back-end data table that can be directly imported into Power BI. Since flows 3 and 4 are manually triggered, they are not present in either process.

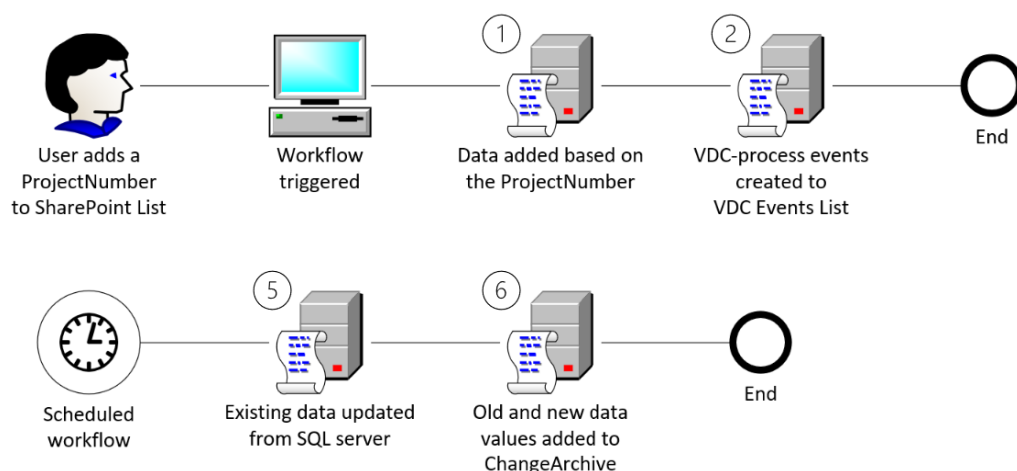


Figure 12. Power Automate process flowcharts

The first process was built early in development and satisfied the first part of the two-fold plan. Subsequently, it increased the author's expertise with Power Automate and enabled the creation of more complicated flows for the second part of the plan.

Flow 6 was found to be an especially tricky one to build. The initial thought process was such that the old value should first be captured, then updated, and finally the new value captured as well. The issue with this logic was that before updating, the flow wouldn't know which values are old, and would capture all values as old and only the updated ones as new. Additional research was required.

SharePoint list metadata contains version history, including version numbers. With this information, two key Power Automate building blocks, known as actions, were discovered. The first of them was a 'Get changes for an item or a file' action, which can be set to compare two item versions, outputting a Boolean value for each column; 'true' meaning a change has occurred, and 'false' meaning no change. The second action was 'Send an HTTP request to SharePoint', which pulls an item or items with a provided parameter.

With these actions, flow 6 could be built separately from flow 5, and works as follows:

- Step 1: When an item is modified by flow 5, flow 6 triggers and temporarily stores the modified item.
- Step 2: The 'Get changes for an item or a file' action stores the current and previous item version numbers and returns a Boolean value for each column's change status.
- Step 3: An HTTP request pulls the previous item version, using the previous version number from step 2 as its parameter and temporarily stores the item.
- Step 4: The flow divides into parallel control actions, known as switches. Each switch checks one column's Boolean value stored in step 2, and if the value is 'true', executes step 5.a, or 5.b if the value is 'false'. Data that can be updated from NCC's databases are in columns Project Name, Project Number, Department, Sales Status, and Production Status. Therefore, switches for just these five columns are included.
- Step 5.a: If the switch input equals 'true', an item is created in the VDC ChangeArchive list. The old value comes from step 3, and the new from step 1.
- Step 5.b: If the switch input equals 'false', the flow path ends.

3.2.4 Power Automate: Data Management

The project numbers used in the beginning are constant, but for this project, were not simple to implement. On NCC's servers, data is imported from multiple source systems. Necessary sources in this project were BUNFI's project management system, CRM, and financial management system. At first, combining and querying these tables with SQL was complex, but later on became simpler. This was due to the fact that such a combined data table had demand in several other data analysis projects, and an ongoing project to source and create the table, called ProjectMapping, ran alongside this thesis project. Collaboration between both projects transpired, decreasing the complexity of the query applied in workflows and Power BI (appendix 2).

Yet an issue remained. The identification number (ID) for a record in each source system is unique for only that system, and when combined, there was overlap causing duplicate values. In the ProjectMapping table, this was solved with an additional ID column. However, use of the source system IDs is required for the VDC-team. The solution for this went through a couple of iterations, because the project number had to be easily identified by the end users. Figure 13 contains an adapted excerpt from the SQL query in appendix 2, showcasing the conditional logic used to create a unique combined PN column, while being easily understood by the end-users.

```
,case
  when source_T_ID is not null then 'T-' + source_T_ID
  when source_L_ID is not null then 'L-' + source_L_ID
  else 'P-' + source_P_ID
end as project_number
```

Figure 13. An adapted excerpt from SQL query showing the logic of project numbers (adapted from appendix 2)

If the primary 'source_T_ID' for a project exists, it is used as the 'project_number' value with the prefix "T-" (e.g. T-13640). If it doesn't exist, but the secondary 'source_L_ID' does, then it is used instead with the prefix "L-" (e.g. L-10225). Otherwise, the third 'source_P_ID' and prefix "P-" are used (e.g. P-88). In the database, two equal IDs in a source table are not possible, but when different sources are appended, such cases are bound to happen. The prefixes solve this issue by re-introducing uniqueness, while also providing context for the end-user about which source the ID is from.

3.2.5 Power BI Report: VDC-Dashboard Setup

Developing a Power BI report begins by selecting, transforming, and loading data into the desktop application. Simple reports can also be created online, but the browser environment lacks several key features. For this report, the core data model was comprised of the three SharePoint lists and the ProjectMapping data table from NCC's server. Power BI internal data connection and transformation tool, Power Query (PQ), was used to connect to SQL Server and import the ProjectMapping table with a pre-defined query. By transforming and cleaning data in the back-end server side instead of in PQ, report performance can be improved. While this benefit is not as noticeable with small data amounts such as in this project, it's still good practice, and improves longevity and eases editing data in the future.

The SharePoint lists required more transformations to be done in Power Query. Power BI includes a connector that connects straight into a SharePoint site's list library, from where a desired list can be navigated into and selected. From settings to choose whether to include only the default list view or all columns including metadata, the setting "all" was selected so that item IDs, creation dates, and column type info could be accessed. After this was done for each list, they were transformed into a usable form to enable the creation of the data model and usable visuals. Basic transformations included renaming columns, changing data types, replacing values, sorting, and deleting unnecessary columns.

Some more complex transformations were required as well. New custom and conditional columns were created, and queries merged to include new columns or to create new dimension tables. An external calendar table was created with DAX (Data Analysis Expressions), which is a formula language used to create measures and calculated columns in the data model; and to manipulate and aggregate data. The final data model can be viewed in appendix 3.

Not every transformation happened without issues. All lookup columns are loaded as nested records, from which the required data have to be extracted, and/or expanded. In the case of SharePoint lists, the type of record and its contents can vary greatly depending on the column settings on SharePoint's side. For instance, if a person/group column type allows multiple values, and the first-row value is blank, expanding them can only be done by creating duplicate rows for those items which include more than one value. This is not allowed since it removes required uniqueness. No solution for this issue was found during development, and a temporary solution was to disallow multiple values in those columns.

3.2.6 Power BI Report: VDC-Dashboard Pages

The Power BI report had two major versions: a draft version and the more complete live-data version. The level of detail required for the report in the final solution was to have a thematically organized page layout, a data model that combines list data with NCC's internal sources, and visuals that provide basic insight into the current and historical situation of NCC's projects and the VDC-process. This can be summarized as "make data available", which can be seen in the solution as more simplistic data tables instead of graphs and KPIs. More detailed report versions were planned for after the project, when end-users had had time to get familiar and utilize the report, so that they can start ideating new user-stories and requirements for KPIs, tables, and visuals that they know would create additional business value.

The first version included five report pages: Dashboard, Project List, Event List, BIM info, and Project Search. In addition to those, the final solution included Date Matrix, Project Details, Change Archive, and Project Pipeline pages. Screenshots of all pages can be viewed in appendix 4, excluding the Project List, BIM info, and Change Archive pages, which were agreed to be left for later development. Basic details about won construction projects are public information, but names and monetary values of those in development are hidden from all report screenshots due to confidentiality.

The Dashboard page (figure 14) layout stayed the same since the draft version. Its purpose was to present the current situation and important upcoming project phase transitions. The top row KPIs and left side alerts with conditional coloring provide minor value, with the plan to be completed after the project. The tables, however, were already being used in weekly meetings before the project had closed. The left side tables provide quick insight into which project are going into calculation or design phase in the next one or two months, and which contracts were won in the last month. This enables the VDC-team to be proactive and plan ahead which projects to contact or what meetings to organize, which was severely lacking before the report. The right-side tables show scheduled meetings, and the pie chart details the workload split, improving resource management.

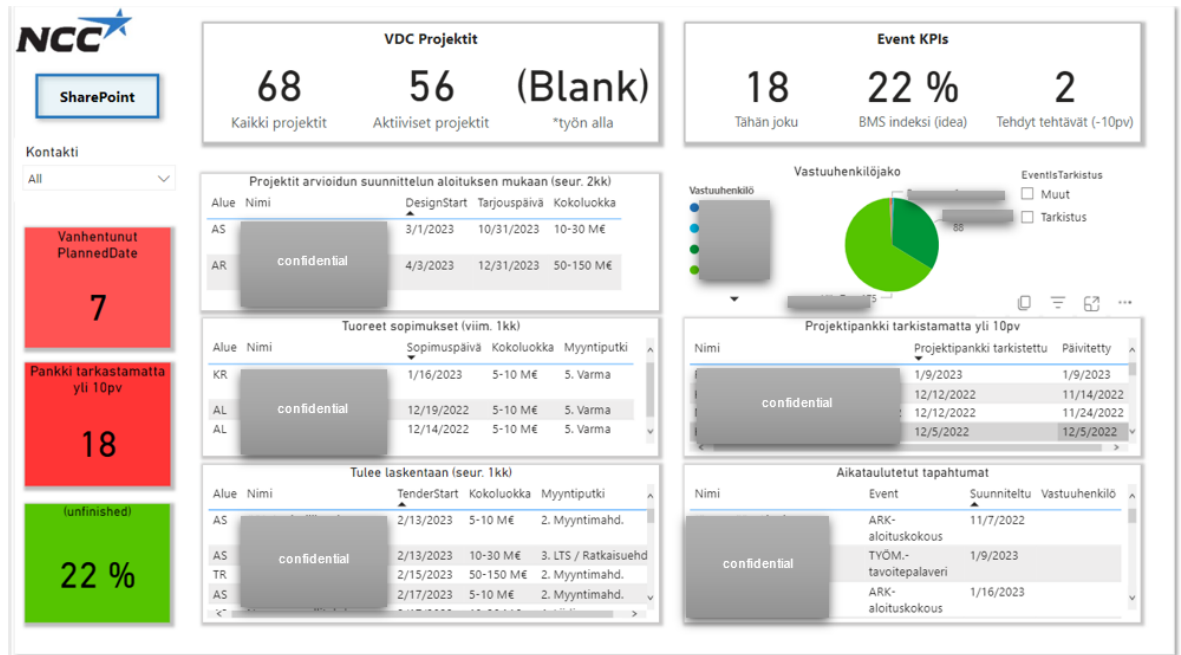


Figure 14. A screenshot of the Dashboard report page

The Project List and Event List pages are meant to show list content to the user without them needing to open the lists separately. The Event List page is finished with tables to view all events, recent completed events, workload split, and a KPI gauge to show the number of events completed within schedule vs not in schedule. Slicers enable users to filter event types, departments, or events assigned to specific VDC-members. The Project List presents just the list contents and is planned to be finished later on in similar fashion to the Event List page.

The Date Matrix page was specifically requested by the VDC-team manager, so that they can get an overview of planned and completed events per project. Planned event dates show in yellow, completed in green, and late in red. The table includes a tooltip that shows the Project Details page of the project upon which the cursor is hovered over.

The BIM info page was planned to detail which BIM model disciplines were in use for each project but requires more specifications from the end-users before completion. The Project Search page presents all requested information about NCC's projects in the database. This previously unavailable data brings a lot of value compared to the required effort to implement it.

The Project Details page let's the user to select a project that is on the VDC Projects list and shows all relevant data from the previous page's table combined with the list data on

one organized view for that single project. This page is used as a drill down page and a tooltip in tables on other pages that list VDC projects.

The requirement for the Change Archive page came late in development. When the process of updating data in the VDC Projects list happens automatically, the end-users noticed being unable to find projects that had their name changed. This doesn't happen often, but when it does it is an annoyance and a hinderance, and in the worst case could lead to data being inserted for a wrong project. The previous chapter mentions the creation of a VDC ChangeArchive list, which is managed by automated workflows. When new items are added to the list, they show up in a table on the Change Archive page as presented in figure 15. This way the users can check what changes are made and when. This level of information was considered sufficient for the time being, with plans to improve the page later, or if changes are made to the automated process.

VDC Project Change Archive (old vs new values)

Project Name	#	Old Value	New Value	Created	Version
Herttuankulma 1 A, B, C ja autohalli	L-9546	4. Tarjottu / YTS	5. Varma	29.1.2023	53.0
Kaskilaaksontie 7 (Hankekeh)	T-13545	3. Viimeistely ja käyttöönotto	4. Käyttö ja ylläpito	29.1.2023	26.0
Maljalahti 2 A ja 3 A	T-13613	2. Rakentaminen	3. Viimeistely ja käyttöönotto	29.1.2023	48.0

Figure 15. Screenshot of a table presenting old vs new values on the Change Archive page

Project Pipeline is the last report page (figure 16). It has a lot of potential through its external Gantt chart plugin from Power BI's Visual Store, but the best application and contents of the visual remain unclear until further use of the overall report. After learning and implementing this visual, it was recognized to potentially provide significant value for other teams and managers at NCC. Unfortunately, key functionalities such as milestones are locked behind a paywall. Evaluation of benefits is required to justify costs and will be done after the completion of this project.

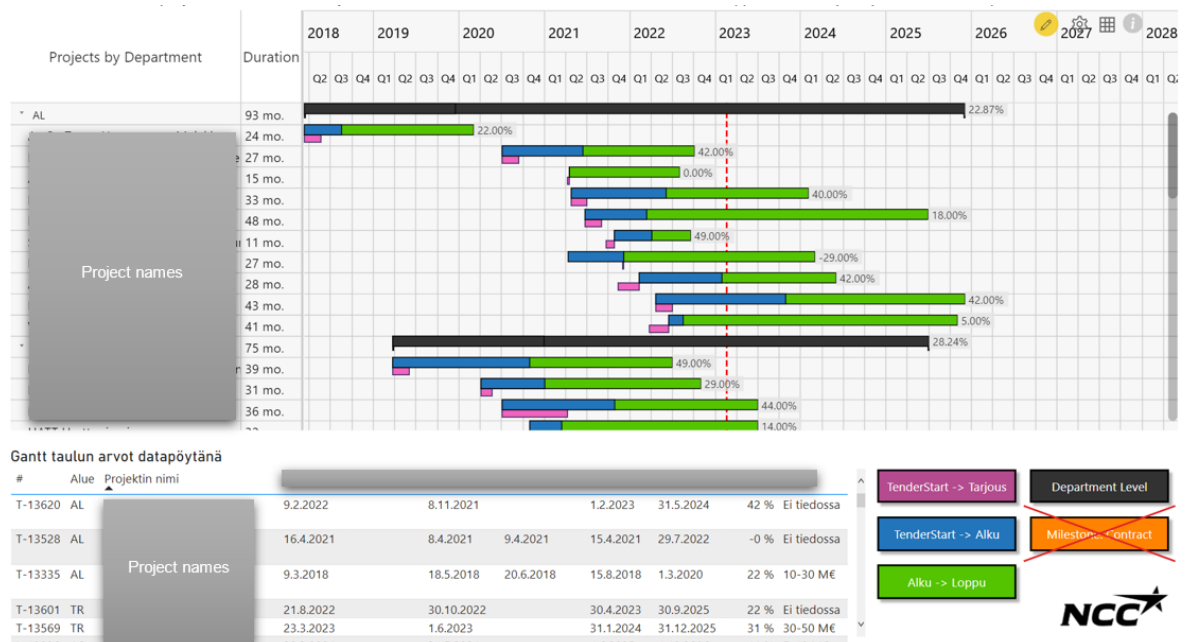


Figure 16. A screenshot of the Project Pipeline report page

The report is refreshed three times a day, which in itself does not guarantee data accuracy, which heavily relies on the source systems. For instance, if a business controller at NCC forgets or ignores their duties to update project information in the CRM, the data in the report end up being inaccurate as well. Additional precautions towards having the latest data without errors are done by alerts from Power BI Service if a scheduled refresh fails, or by Power Automate if an automated workflow fails. Permission management for the report allows all Power BI workspace owners and VDC-team members to view and share the report. Editing is only allowed for the report owner.

3.2.7 Data Migration and Go-Live

Leaving the original Excel spreadsheet behind and implementing the new solution into daily use was planned to happen before the 2022 winter holiday season. The main requirement was that it must, at minimum, allow the VDC-team's daily operations to be executed on a level that matches the old solution. This requirement was met in late November, and migration to the new system was scheduled for early December.

As preparation, Power Automate workflows had been tested, and the SharePoint lists and Power BI report had been approved by key stakeholders. Time for migration was reserved for one full working day at the end of a week, when the old Excel did not need to be used.

Data migration began by downloading the original Excel file and splitting and transforming its contents to match the list structures. When done, an ad-hoc, manual Power Automate

flow was used to populate the lists. The lists would have allowed data to be copy-pasted all at once. However, this feature did not match the data into destination formatting (e.g. a name to be linked to a lookup list), which could be with Power Automate since it is able to read column types and their settings.

After the lists were populated, end-users were informed and instructed. At first, the goal was to use minimal features and learn more later. When the lists contained live operational data, the VDC-Dashboard was updated. Throughout development iterations, some columns had been deleted, added, or modified, and the Power Query formulas required changes to be made. This was expected, and after done the new report version was published for users to see.

4 Discussion

In this chapter, the created solution and the thesis process are assessed from the perspective of the author/project manager, as well as through a survey collecting thoughts from the end-users.

4.1 Assessment of the Final Solution and the Development Process

The final solution consists of the created SharePoint lists, the VDC-Dashboard Power BI report, and the automated workflows. Together, they successfully improve project management capabilities, provide up-to-date data, and enable insight into the current, historic, and upcoming operations of the VDC-team.

Measures to combat risks during development were detailed in subchapter 1.2 Demarcation and Risks. Risks in scope creep and skills were avoided successfully. Change management risks were not done according to stated plan, but instead, thorough research into tools was done beforehand, so that situations where one would need to be replaced would not happen in the first place. Overengineering saw minor errors, and some features that were not useful leaked into the implementation and had to be removed from the final solution.

Scheduling had major issues. While thesis work time was respected, the overall schedule ended up expanding by two months from the initial plan. The contract between the author and the commissioning party allowed for flexibility until the end of February 2023, which enabled successful completion of the project. The author also failed to communicate these changes sufficiently to the thesis advisor. Establishing proper deadlines in additional meetings with the project owner and the thesis advisor could have potentially decreased the effects of this issue.

The author also recognized prevalent issues in the VDC-process in relation to the collaboration with construction project stakeholders. The issues that initiated the project itself affect the utility of the lists and the report. Before the VDC-team had up-to-date data about production phases, VDC decision points (detailed in figures 8 and 9 in subchapter 3.1.3 Assessing the VDC-Process) experienced lacking organizing on a regular basis. With approximately fifty simultaneously ongoing construction projects, recognizing and communicating all meetings according to the process was close to impossible. This has led to decision points such as design start meetings to be conducted well after design has already begun, causing redundant work and frustration.

Before meetings are mandated or audited and reporting is required by upper management, the author believes that the VDC Events list content will not be sufficiently filled. This subsequently causes report pages such as the Date Matrix to be inaccurate. Moreover, without set requirements the motivation to review the VDC-Dashboard for the VDC-team's status is estimated to be low.

During spring 2023, the VDC-process will undergo refinement and the results will be updated into BUNFI's project management system. Additionally, the VDC-Dashboard is believed to greatly increase the VDC-team's ability to anticipate, communicate, and organize meetings with the construction project stakeholders. Over time, the utility and usage amount of the report are estimated to exponentially increase due to the aforementioned process improvements and the increased discovery of data insights for the end-users, who are then able to request further improvements of the report through new features, KPIs, graphs, and measures.

Known development features for the solution and surrounding work have been planned for after the completion of this thesis project, including but not limited to the following:

- Continuous development of the VDC-Dashboard Power BI report
- Additional automations with Power Automate
- SharePoint list archives
- Internal presentation and marketing of the project and its results
- Mapping the needs of other competence centers at NCC
- Integration of NCC's reference repository into the solution

4.2 Review Survey

Two weeks after the final solution had been implemented into daily use, a review survey was sent out to four end-users. It included six statements, four of which were to be answered on a scale of 1 to 5, with 1 meaning the respondent doesn't agree, and 5 meaning they do. Two of the statements were answered by selecting one of five pre-selected answers. For the project to be determined as a success, the overall answers were expected to be positive. The summary of average answers can be reviewed in figure 17.

When reviewing IT-projects, feedback is commonly collected much later than two weeks, after the users have had time to familiarize and use the implemented product. Ideally, a review would be conducted after six months from the initial review. Since the nature of a thesis project does not allow for such time frames, the review questions were formed to

not expect total greatness. For example, instead of asking if the solution is great, asking whether it is seen as having a lot of potential in the future was chosen for the review.

The first statement was that the SharePoint lists are easier to use than the shared Excel workbook. The average answer was 3.8, with all answers being 3 or above. This meant that the majority agrees, and the new solution provides an answer to a tangible issue. This answer is expected to go up as the solution has been in use for longer.

The second statement was that the user often ran into issues with the Excel workbook (unsaved work, data loss, sync errors, locked file due to someone else using it, etc.). The answers had a lot of spread with an average of 2.5, meaning that there were some issues, but they were not the main reason a new solution was needed.

The third one stated that the user sees a lot of potential with the new solution. This statement had five pre-defined answers: I do not (1), it needs more work before I'm fully on board (2); yes, but right now it's a bit confusing (3); yes, a good foundation (4), it's already great (5). Two respondents answered number 3, and two answered number 4. This means that after a short while of use, the solution was seen as slightly confusing, but had a good foundation with a lot of potential. These answers were seen as particularly good for the situation and expected to increase as time went on.

The fourth statement was about the technical comprehension of the implementation and went as follows: I understand how the new solution works and why (list relations, adding and updating data, integration of Power BI and NCC's database, etc.). The average answer was 4.3, proving that the users had been provided sufficient information of how the solution was developed and how it works.

The fifth question asked if the user has used Power BI, mapping the needs for training in the future. Pre-defined answers were provided: I have not (1), I've been shown reports (2), I've checked some reports myself and know what Power BI can be used for (3), I often check reports to support my work (4), I check reports and have tried to build some myself (5). Three answers were number 3, and one was number 5. This means that all the users know the potential and application of data analytics with Power BI, but all except one might need additional support with how to best consume reports.

The sixth and final statement stated that the development process went well (timeline, meetings, communication, etc.). The average was 3.5 with three times number 4 and once number 2. This was expected to have a lower score due to the author noticing schedule

overruns and slight issues with organization. However, the majority thought the process went completely fine.

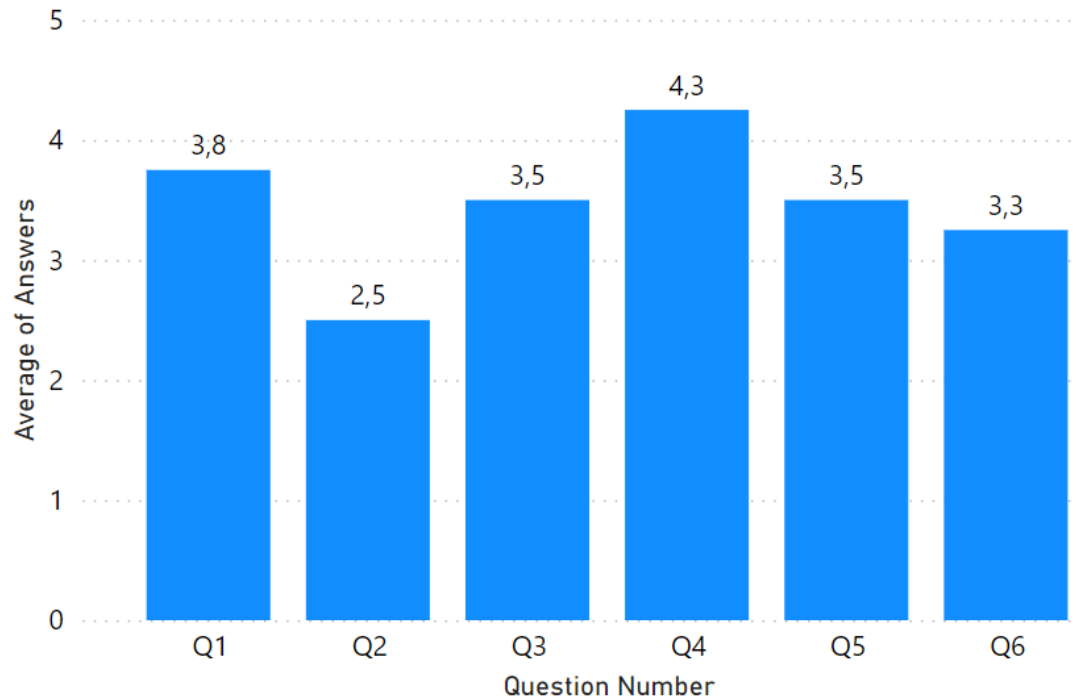


Figure 17. A bar chart presenting the average answer value for each question

Last but not least, a free form question to provide feedback and constructive criticism was included in the review. There were two answers, with one saying thanks, and one providing a good summarization of this whole project from the perspective of an end-user:

The SharePoint-list solution is what was expected and already useful for the team. On the report side we need to still do some development work to make best of it. In general the development process went well being one of the first projects you have led - you organized the meetings you needed and collected the input. It is not easy task to create a tool for the needs of others. Perhaps some software development methods to collect, explain and prioritize wishes into features would be helpful in the next project to create structure and understanding.
(Unknown user 2023)

4.3 Conclusion

Although not perfect, the project was concluded to be a success, fulfilling the primary, secondary, and learning objectives, as well as measuring positive in the review survey with a total average of 3.5 (scale of 1 to 5). The primary objective was to improve management and oversight of the end-to-end VDC-process with a data-driven solution according to the commissioning party's requirements. All key stakeholders stated this objective to have been fulfilled by the deliverables, which were the SharePoint lists, automated workflows, a Power BI report, and a thesis paper. The secondary objective was to set a precedent of

such solutions and their benefits, so that results can be replicated and applied in other areas of the company. By the end of the project, possibilities about discovering the needs of BUNFI's legal team for similar applications had already been discussed. Measuring success was done by conducting the review survey and establishing that the objectives and scope were fulfilled.

Over the entire duration of the project, the author gained considerable knowledge and expertise in the practice and possibilities of the used software tools, as well as conducting an IT-project in a professional environment, subsequently fulfilling the learning objectives. Furthermore, coming from an IT-field into a company operating in the construction sector, the author gained notable competence in the subjects of Virtual Design and Construction, construction practices and terminology, and the revolving business operations.

After the completion of this thesis project, the author continues as an employee at NCC Building Finland, further developing the created solution and other business intelligence development projects.

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Appendices

Appendix 1. SharePoint list column definitions and settings

a. VDC Projects

Column Name	Column Type	Description	Example or choices	In dwh?	Settings	Lookup List
Project name	text, one line	official project name	Fredriksberg Koy, talo D.	x	default	
Department	text, one line	NCC department code	TR	x	updates automatically	
ProjectNumber	text, one line	unique ID in to track project data	T-13577	x	updates automatically, enforce unique values	
Design Manager	person/group	name of design manager in NCC's Office network	Smith John	in future	allow multiple, show picture	
BIM Coordinator	lookup	name of BIM coordinator	John Smith		default	VDC Contacts
Site VDC contact	lookup	name of site VDC contact	John Smith		default	VDC Contacts
Additional contacts	text, one line	name of additional contact	John Smith, Mary Jones		default	
UpdateDay	choice	name of a weekday	Monday/Tuesday/...		default	
Comments	text, multiple lines	general notes for the project	No need to update ARK models - John, 12.6.		default	
Model repository	choice	name of the repository used	SokoPro 2.0/Hahtela/...		default	
Dalux	choice	is Dalux in use for the project	No/Ordered/In use/NCCcfc		default	
Dalux responsibility	choice	Entity responsible of TC	VDC/Production		default	
Trimble Connect	choice	is Trimble in use for the project	No/Ordered/In use		default	
Trimble responsibility	choice	Entity responsible of Dalux	VDC/Production		default	
Solibri	yes/no	is combined model in use	yes		default	
Solibri responsibility	lookup	Person responsible of Solibri	John Smith		default	VDC Contacts
NCCcfc status	choice	NCCcfc status	No/Ordered/In use/On hold			
ARK	choice	ARK model status	No/Native/NCCcfc		No as default	
RAK	choice	RAK model status	No/Native/NCCcfc		No as default	
LJ	choice	LJ model status	No/Native/NCCcfc		No as default	
VV	choice	VV model status	No/Native/NCCcfc		No as default	
IV	choice	IV model status	No/Native/NCCcfc		No as default	
SAH	choice	SAH model status	No/Native/NCCcfc		No as default	
SPR	choice	SPR model status	No/Native/NCCcfc		No as default	
Buildots	choice	Buildots status	No/Suggested/In use		No as default	
ActiveProject	yes/no	project activity status	yes	in future	Yes as default	
VDC Ambition	choice	VDC target level for the construction project	NO VDC/Foundation/Digital/ Data Informed	in future	NO VDC as default	
Project status	choice	Sales pipeline status	1. Lead/... /8. Lost	x	updates automatically	
Production status	choice	Construction phase	0. Not started/1. Preparations/...	x	updates automatically	
Repository checked	date	last date the repository was checked	44562		default	
Repository updated	date	last date the repository was updated	44562		default	
Modified	metadata	automatic modification date and time	Yesterday 10.17am		updates automatically	
Modified By	metadata	automatic name of modifier	Smith John		updates automatically	
ID	metadata	unique system ID for the list row	103		enforce unique values	

b. VDC Events

Column Name	Column Type	Description	Example or choices	In dwh?	Settings	Lookup List
Project name	lookup	unofficial project name	Fredriksberg D		changes in lookup list are inherited	VDC Projects
Event title	list title	name of the event	RAK-model update		default	
PlannedDate	date	date for which the event is planned	44562		default	
ActualDate	date	date when the event is conducted	1.1.2022		default	
Comments	text, multiple lines	important notes for the event	This event was moved to 1.1.23, JS		default	
Person responsible	person/group	name from NCC's Office network who is assigned for the event	Smith John		default	
Event tag	choice	Event tag for list filtering	ARK-model update/Design start meeting/...		default	
Attachment	attachment	field for attaching related files	Meeting_Minutes.pptx		default	
Department	lookup	NCC department code for list filtering	AR	x	automatically inherited based on VDC-name selection	VDC Projects
Modified	metadata	automatic modification date and time	Yesterday 10.17am		updates automatically	
Modified By	metadata	automatic name of modifier	Smith John		updates automatically	
ID	metadata	unique system ID for the list row	103		enforce unique values	

c. VDC Contacts

Column Name	Column Type	Description	Example or choices	In dwh?	Settings	Lookup List
Company	choice	company of the contact	NCC/Other		allow manual values	
Contact name	list title	name of the contact	John Smith		default	
Office Profile	person/group	profile of the contact if exists in NCC's Office network	Smith John		show picture	
Phone	text, one line	phone number for external contacts	+358 10 1234567		default	
Email	text, one line	email address for external contacts	john.smith@ext.com		default	
VDC-member	yes/no	is the contact part of VDC-team	Yes		default	
Info	text, multi line	additional information	don't call before 1pm		default	
Modified	metadata	automatic modification date and time	Yesterday 10.17am		updates automatically	
Modified By	metadata	automatic name of modifier	Smith John		updates automatically	
ID	metadata	unique system ID for the list row	103		enforce unique values	

Appendix 2. SQL query for ProjectMapping table

```

SELECT
  [id]
  , case
    when p.tyonumero is not null and p.tyonumero > 1 then p.tyonumero + 1e7
    when limeid is not null then limeid + 2e7
    else proid + 3e7
  end as idproject
  , case
    when p.tyonumero is not null and p.tyonumero > 1 then 'T-' + cast(p.tyonumero as nvarchar)
    when limeid is not null then 'L-' + cast(p.limeid as nvarchar)
    else 'P-' + cast(p.proid as nvarchar)
  end as Projektinumero
  ,p.[name] as Projektinimi
  ,p.[tyonumero] as Tyonumero
  ,p.[sisainenprojekti]
  ,[proid] as Pro3ID
  ,[proliiketoiminta]
  ,[laskentanumero]
  ,[projectservicenumber]
  ,p.[sisainenyritys]
  ,[limeid] as LimeID
  ,[hankenumero]
  ,p.toimiala as toimialaBlank
  , rtrim(case
    when n.aluenimi is null and pienaluekoodi = 945 then 'AL'
    when n.aluenimi is null and pienaluekoodi in (940,941,942) then 'AR'
    when n.aluenimi is null and pienaluekoodi in (953,946,954,916) then 'AS'
    when n.aluenimi is null and pienaluekoodi in (915,952,925,911) then 'ER'
    when n.aluenimi is null and pienaluekoodi in (902,901,900) then 'KR'
    when n.aluenimi is null and pienaluekoodi in (914,912,918) then 'TR'
    else n.aluenimi
  end) as toimialaMapping
  ,n.aluenimi as toimialaNormirap
  , rtrim(left(n.pienaluenimi,4)) as yksikköNormirap
  , rtrim(left(s2.fi,4)) as yksikköLime
  ,p.[alku]
  ,p.[loppu]
  ,[perustettu_pro3]
  ,[perustettu_coolpro]
  ,[Process1_approved]
  ,[Process2_approved]
  ,[Process3_approved]
  ,[perustettu_lime]
  ,s1.fi as projektivaihe
  , case
    when l.company = 4501 then 'NCC PD'
    else s3.fi
  end as project_type_NCC
  , case
    when l.korjauskohde = 1 then 'Refurbishment'
    when l.construction_category = 243401 then 'Residential'
    else 'Non-Residential'
  end as segmenttiNCC
  ,l.probability
  , iif(l.korjauskohde=1, 'Korjaus', 'Uudis') as korjauskohde
  , [Process1_status]
  , [Process2_status]
  , [Process3_status]

```

```

,[tarjouspäivä]
,[sopimuspäivä]
,p.[tulot]
,[active]
,[lahde]
,[pro3version]
,[pienaluekoodi]
,[coolproliiketoiminta]
,p.[tyopaallikko]
,[vastaavamestari]
,[Process1_prepared]
,[Process1_inspected]
,[Process2_prepared]
,[Process2_inspected]
,[Process2_prepared]
,[Process3_inspected]
,[Process1_created]
,[Process2_created]
,[Process3_created]
,[Process1_form]
,[Process2_form]
,[Process3_form]
,[tulee_laskentaan]
,case
  when Process1 is not null then Process1
  when Process2 is not null then Process2
  when Process3 is not null then Process3
  else DATEADD(WEEK,-10,offerdate)
end as tenderstartLime
,case
  when Process1 is not null then Process1
  when Process2 is not null then Process2
  when Process3 is not null then Process3
  else DATEADD(WEEK,-10,tarjouspäivä)
end as tenderstartMapping
,case
  when GETDATE() > p.loppu then '4. Käyttö ja ylläpito'
  when p.alku > getdate() then '0. Ei aloitettu'
  when dateadd(MONTH,2,p.alku) >= getdate() then '1. Rakentamisen valmistelu'
  when dateadd(month,-4,p.loppu) < GETDATE() then '3. Viimeistely ja käyttöönotto'
  else '2. Rakentaminen'
end as ProjectPhase
,case
  when GETDATE() > p.loppu then '4. Käyttö'
  when p.alku > getdate() then '0. Ei aloitettu'
  when dateadd(MONTH,2,p.alku) >= getdate() then '1. Rak.Valm'
  when dateadd(month,-4,p.loppu) < GETDATE() then '3. Viimeistely'
  else '2. Rakentaminen'
end as ProjectPhase_Short
,case
  when GETDATE()<p.alku then 0
  when GETDATE()<=p.loppu then cast(DATEDIFF(day,p.alku,getdate()) as decimal) / cast(DATE-
DIFF(day,p.alku,p.loppu) as decimal)
  else 1
end as ConstructionTime
,case
  when varmuuskoodi = 'VARMA' and n.uudet <= GETDATE() and n.Tulot < 5e6 then '0-5 M€'
  when varmuuskoodi = 'VARMA' and n.uudet <= GETDATE() and n.Tulot < 10e6 then '5-10 M€'

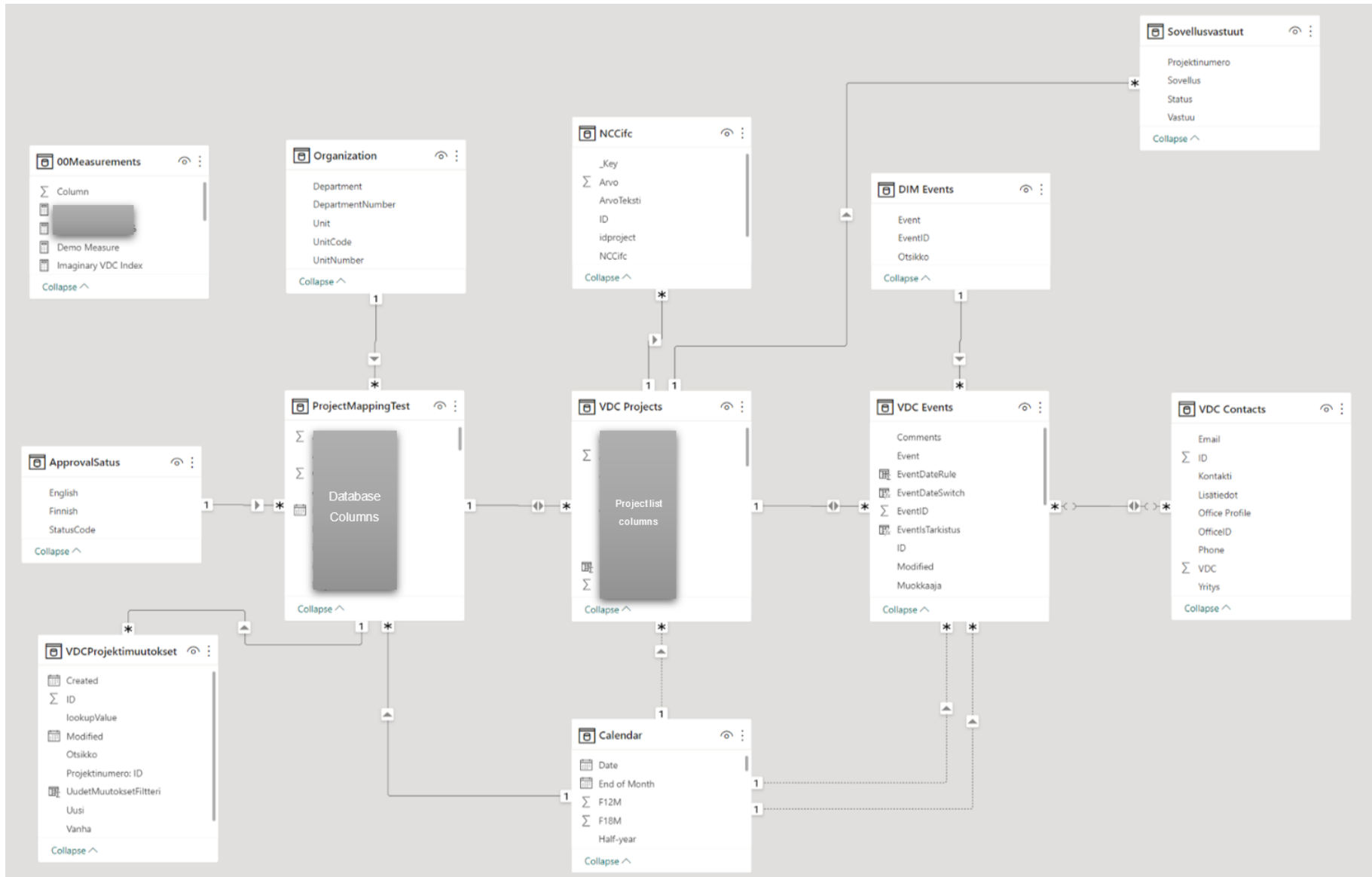
```

```

when varmuuskoodi = 'VARMA' and n.uudet <= GETDATE() and n.Tulot < 30e6 then '10-30 M€'
when varmuuskoodi = 'VARMA' and n.uudet <= GETDATE() and n.Tulot < 50e6 then '30-50 M€'
when varmuuskoodi = 'VARMA' and n.uudet <= GETDATE() and n.Tulot < 150e6 then '50-150 M€'
when varmuuskoodi = 'VARMA' and n.uudet <= GETDATE() and n.Tulot > 150e6 then '>150 M€'
else null
end as sizecategory_N
,case
when projectstatus = 241601 and arvoliidi <> 411201 and isnull(l.[value],0) = 0 then s4.fi
when projectstatus = 241601 and arvoliidi = 411201 and isnull(l.[value],0) = 0 then 'Ei tiedossa'
when isnull(l.[value],0) = 0 then 'Ei tiedossa'
when l.[value] < 5e6 then '0-5 M€'
when l.[value] < 10e6 then '5-10 M€'
when l.[value] < 30e6 then '10-30 M€'
when l.[value] < 50e6 then '30-50 M€'
when l.[value] < 150e6 then '50-150 M€'
when l.[value] > 150e6 then '>150 M€'
end as sizecategory_L
,l.DesignStartDate
FROM [Database].[dbo].[ProjectMappingTest] p
left join Database.dbo.Table1 n on p.sisainenprojekti = n.sisainenprojekti
left join Database.dbo.Table2 l on p.limeid = l.idproject
left join Database.dbo.Table3 s1 on l.projectstatus = s1.idstring
left join Database.dbo.Table3 s2 on l.implementation_unit = s2.idstring
left join Database.dbo.Table3 s3 on l.type = s3.idstring
left join Database.dbo.Table3 s4 on l.arvoliidi = s4.idstring
where year(p.alku) >= year(GETDATE())-5
and active = 1
order by id asc

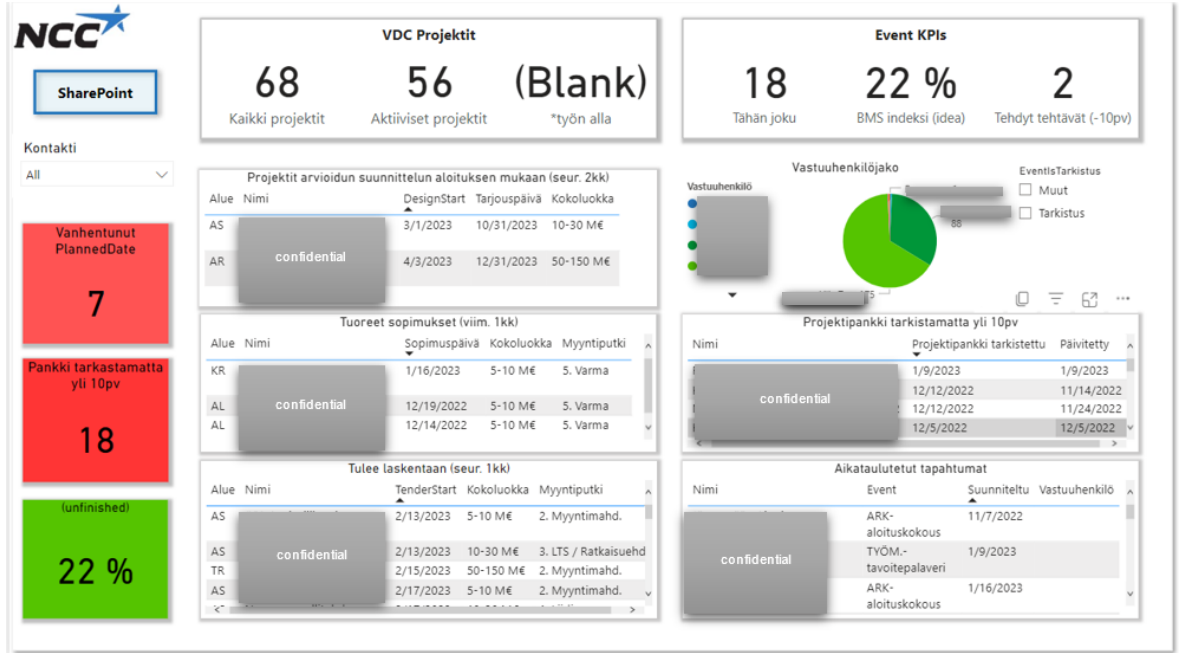
```

Appendix 3. Power BI Data Model

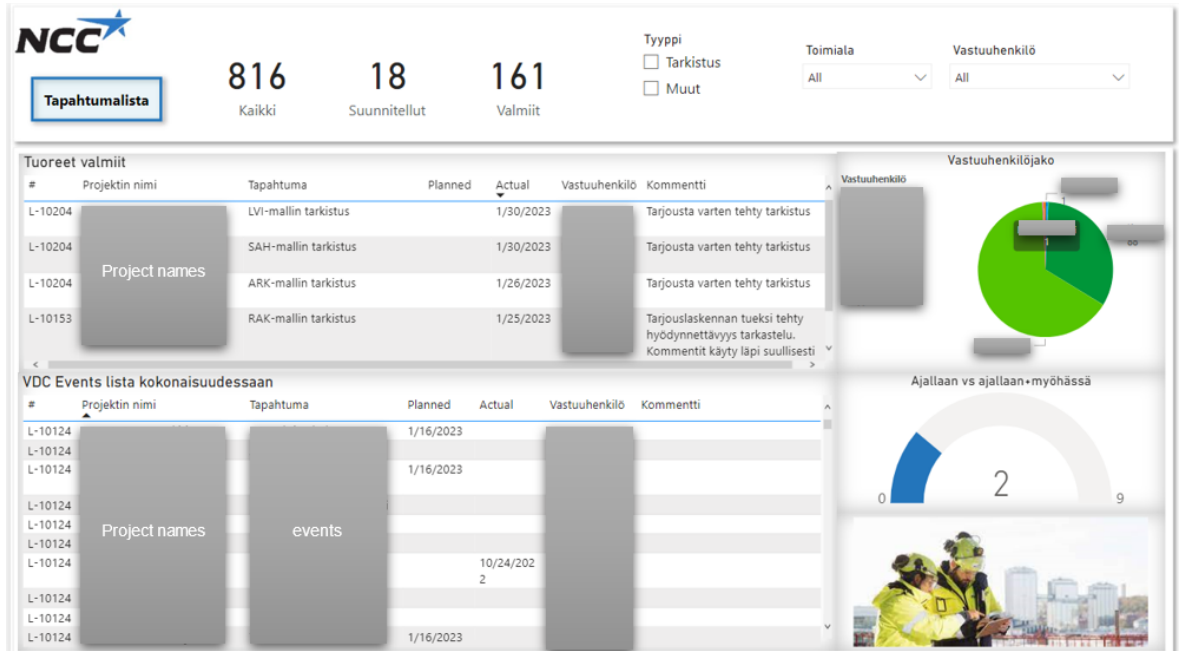


Appendix 4. Power BI Report Pages

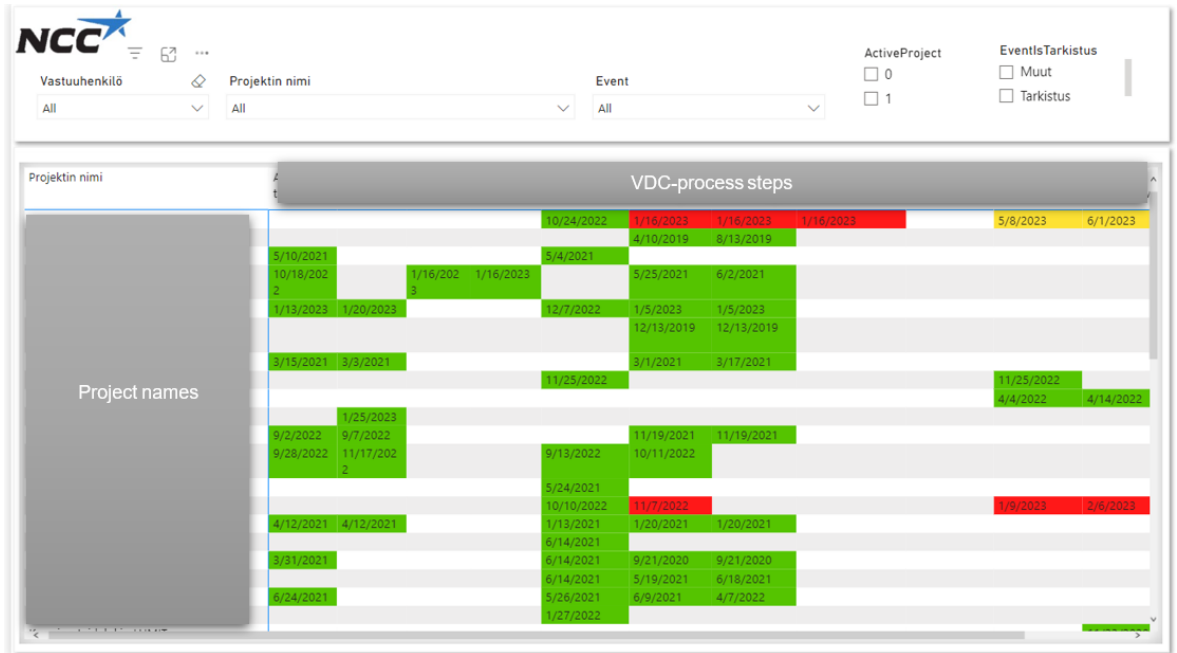
a. Dashboard



c. Event list



d. Date Matrix



f. Project Search

The screenshot shows the NCC Project Search interface. At the top, there are filters for 'Myyntiputki' (5. Varma), 'Lähde' (All), 'Projektinumero' (All), and 'LimelD' (All). On the right, there are dropdown menus for 'Department, Unit' and 'Työnumero'. The main area is a table with the following columns: ID#, Alue, Yksikkö, Projektinimi, Työ#, LimelD, Pro3ID, PSN, Lähde, laskenta-numero, Myyntiputki, Kokoluokka, Todennäköisyys, and segra. The table contains 18 rows of project data. A large grey box labeled 'Project names' is overlaid on the left side of the table. On the right side, there are search boxes for 'Työnumero' and 'Projektinimi', and a large grey box labeled 'Project names' is overlaid on the bottom right.

ID#	Alue	Yksikkö	Projektinimi	Työ#	LimelD	Pro3ID	PSN	Lähde	laskenta-numero	Myyntiputki	Kokoluokka	Todennäköisyys	segra
T-12345				12345	2225	152		pro3		5. Varma		100 %	Non
T-13315	AS	ATKS		13315	1911			coolpro		5. Varma		100 %	Non
T-13458	KR	KRE		13458	8630	1491	100005472	pro3		5. Varma		100 %	Refu
T-13630	KR	KRE		13630	9535	1522	100006753	coolpro		0 5. Varma		100 %	Refu
T-13390	AS	ATA		13390	6541	2305	100002360	coolpro		5. Varma		20 %	Non
T-13621	AS	ATA		13621	9370	122	100005607	pro3		5. Varma		100 %	Non
T-13225	AR	ART		13225	5978	7	100002234	coolpro		5. Varma		100 %	Resi
T-13387	AL	ATU		13387	8057	2116	100002357	coolpro		0 5. Varma		100 %	Resi
T-13522	AL	ATU		13522	8234	1351	100004937	coolpro		5. Varma		100 %	Resi
T-13454	AL	ATU		13454	1705	2259	100002399	coolpro	30922	5. Varma		100 %	Resi
T-13335	AL	ATU		13335	1703	2147	100002321	coolpro	30885	5. Varma		100 %	Resi
T-13309	AL	ATU		13309	8771	2218	100002303	coolpro		0 5. Varma		100 %	Resi
T-13439	KR	KRE		13439	8401		100002390	coolpro		5. Varma		100 %	Refu
T-13533	KR	KRE		13533	8848			coolpro		5. Varma		100 %	Refu
T-13628	TR	TRU		13628	10452	199	100006722	coolpro		5. Varma		100 %	Non
T-13526	KR	KRE		13526	8070			coolpro		5. Varma		100 %	Refu

g. Project Details

KR
Toimiala

13558
Työnumero

9019
LimelD

110
Pro3ID

100004915
Project Service Number

Suunnittelun ohjaus

K21

Myyntivaihe 5. Varma
 Tuotantovaihe 2. Rakentaminen
 VDC Ambition Better
 Päivityspäivä maanantai
 Projektipankki Sokopro 2.0

Sovellus	Status	Vastuu
Buildots	Ei	
Dalux	Käytössä	
Solibri		<input type="text"/>
Trimble Connect	Ei	

Tietomallikoordinaattori

Työmaakontakti

(Blank)

alku	loppu	Tarjouslupa	Tarjouslaskentalupa	Tarjouspäivä	Sopimuspäivä	Tuotannonaloituslupa	Tulee laskentaan	DesignStart
4/12/2021	4/12/2021			1/13/2021	1/20/2021	1/20/2021		

NCCifc Status	ARK	RAK	LJ	VV	IV	SAH	SPR
Ei	Käytössä	Käytössä	Käytössä	Käytössä	Käytössä	Käytössä	Käytössä

Kommentit

h. Project Pipeline

