Academic year 2022-2023

TPK 5100 : Applied Project Management

Evaluation and reflection report

Teacher : Bassam Hussein

Group 38

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Summary

1. Introduction

For the project assignment we choose to do the following approach : Conducting an empirical investigation about the digital/numeric transformation in the construction project. Indeed, the construction projects have greatly evolved with the use of new technologies and they are still in transformation. Digital transformation concerns management tools, which makes it possible to streamline information and have more data. These data are important for decision-making and reactivity.

On the other hand, the building and infrastructure construction sector is particularly affected by employee accidents. So we focus on the following problematic: ***How digital/numeric transformation has affected and is affecting the safety of workers on site and the safety of building operations?***

To produce this empirical study we have drawn on the literature as well as on the valuable testimonies of professionals in the sector. The purpose of this empirical study was to produce a report summarising our research and exploiting these results to answer our problem.

2. Evaluation of Project management effort

In order to carry out this project, it was important to set up a good organisation so that we could all move forward together in the same direction and not fall behind on things to be done.

In our case we had a good organisation by choosing a group leader, Denis, from the beginning. We chose Denis as the group leader because it's him who came up with the idea of doing the project on this subject and because of his experience in a company.
In addition, we managed to organise a weekly meeting where we could share individual progress and establish the tasks to be carried out by each person in the coming week. Regular meetings are a very important element in the organisation of a project, they ensure that everyone is moving in the same direction and that mistakes made are accounted for and corrected as soon as possible.

The only thing that was a problem was that not everyone was available for the meetings, so it was important to communicate what was said during the meeting so that they were not late or lost in the progress of the project.

In terms of project risk management, as we anticipated, the main risk we faced was not being able to find a professional from the construction industry to interview. We got in touch with professionals on linkedin but unfortunately we did not manage to organise an exchange with a Norwegian professional, our objective was to compare the situation between French and Norwegian companies.
However, we managed to have discussions with French professionals thanks to Denis' network.

In terms of communication within the group it was quite good, as said before we managed to organise a weekly meeting and communicated the discussions of these meetings to people who sometimes could not be present.

To conclude, We evaluate our project management effort as successful because we managed to cope with the difficulties we encountered and we respected the different instructions. We managed to deliver the project as we wanted, we respected the deadlines and the planning we had set. The only thing that unfortunately did not go as planned was the interview with the professional.

3. Evaluation of the impact (Project success)

The digitalisation of the construction sector has generated a lot of changes in the whole process of construction. In fact, from the reflection of the building to the building site, the impact of this digitalisation impacts a lot of people.

First of all, before the construction itself begins, all the preliminary studies regarding the safety of the building construction are done digitally, whether it is the digital modeling of the building or the study of the soil. Thus, the first targets concerned by the digitization of the construction sector are the people who will carry out the preliminary studies such as the building engineers for example. Then, once these studies have been carried out and the construction site begins, digitization also impacts the safety of the workers. Indeed, all the machines used have evolved a lot, especially concerning the safety of the workers, such as the GPS chips mentioned above, which allow the workers on the ground not to be injured by the machines. The customers of the buildings to be constructed are also targets of our project as they also benefit from the increased safety generated by the progress that has been made in recent years. This translates in different ways: the cost of the building will be lower because the risk of accidents has been greatly reduced and the number of interventions has been reduced; in addition, the construction time has been reduced.

Throughout this project, we realised that the advances that have led to the digitalisation of the construction sector have greatly improved safety throughout the building construction process, saving time, money and physical damage. It also allows workers on construction sites to feel safer while working, which increases their efficiency. This digitalisation has therefore had a positive impact on all aspects of construction. However, there are some negative aspects that can be drawn from this. Indeed, workers must constantly be trained and adapt to the functioning of the new tools they have at their disposal. Although in the long run it is better to be up to date with the different tools, some may be reluctant to learn if they are asked to change habits they have had all their lives, such as learning to use software where some did everything by hand.

Scale	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
We evaluate the quality of our literature review as outstanding				X	
We evaluate the quality of the communication		X			
We evaluate the quality of our organisation throughout the project as astonishing			X		
We evaluate the redaction of our report as good				X	
We evaluate the team work we demonstrate during the whole duration of the project as satisfying					X

4. Factors that have contributed to failure / success

The success factors that have contributed to the success of our project are:

Project management :

- Effective project risk management prose: We have planned and analysed all the risks we could meet to avoid failing because of them. One of our risks was « Failed to find a person to interview in the period scheduled ». Thanks to this identification, we knew we had to contact people on linkedin as quickly as possible.
- Organisational factors: clear roles and responsibilities : Due to the few times we had to realise our 3 supports, this factor was really important to avoid wasting time. In addition, some tasks depended on other tasks. So we organised meetings every week, to update what has been done since last week, and to decide who to do what for the next meeting.
- An adequate project planning : We had many things to do (2 reports, 1 video) in a short amount of time (1 month), so the planification of the project was important.
- Project follow-up: We weekly met to check what has been done since the last and what will have to be done for the next week. For every meeting, we wrote a resume in a typical document to avoid confusion.
- Team skill: Experiences in other projects : Most of us have ever done group projects during our studies. So there are some reflexes we had, for example, writing a resume for each meeting. It takes time, but it is an essential tool for group coordination.

Project success :

- Involvement and effective communication: This factor is linked to the organisational factor. We used a Messenger group to deal with the project. We used it because we are all responsive with this app. After each weekly meeting, one of us posted on this group a summary of the meeting, and tasks each one had to do for the next week. The purpose of this post was to inform those who were missing, and have a commun and easy access note to avoid confusion.
- Team skills: Knowledge about the subject. Some members of the team were familiar with technologies in building construction. It was very helpful, especially for contacting working people in this sector quickly.
- The clarity of project purpose: This factor is very important for technological projects that require an important precision.

The most important factors were the organisational factor and the involvement and effective communication factor. The organisational factor was very important because we had many supports (2 reports, 1 video) to do during a short time (1 month). A good organisation ensured us to optimise the time we had. It also allowed us to allocate the time needed to complete each task. Communication was also very important to ensure a good organisation. Also, being reactive was necessary because of the time constraint. The project has to be dynamic and for this, we needed effective communication on Messenger.

We compare our identified factors with the factors listed in (Hussein 2018) pp-92 :

- Case-specific factors (non generalizable) :
    - Team skills : some members of the team were familiar with the technical subject of the project.
- Structural Factors (generalizable and correlated with project characteristics) :

  Most of our success factors are structural factors, as you can see in the table below :

Characteristic	**Success Factors identified in our project**
Organisational complexity (The project requires contribution from multiple organisational units)	● Organisational factors ● Involvement and effective communication ● Project follow-up
Transformation (purpose of the project is to introduce substantial changes to existing work process, system or procedure)	● The clarity of the project purpose
Constraints (The project should be completed under one or several constraints, such as time, resources, requirements from authorities or other stakeholders)	● Adequate project planning
Uncertainty (The project has considerable level of uncertainty regarding scope of work, impact, methods or the outcome)	● Effective project risk management prose

- Cultural/soft factors (generalizable and not correlated with project characteristics) : none

5. Most important lessons from your project

Conducting a group project is an opportunity to accumulate skills and gain experience in several areas through contact with other group members but especially through the subject matter.
Through this experience of a few weeks and the lessons learned, we now know more precisely how to conduct such a group project to avoid unnecessary mistakes or waste of time. This feedback allows us to draw up the following list of advice.

Firstly, our experience has taught us the importance of organising the project with rigour and completeness.
Indeed, we started our project by drawing up a Gantt chart and distributing the main tasks among the different members of the group. This planning proved to be of crucial importance. With six different members with different schedules on this project, it was essential that everyone could relate to this document in order to complete the different documents in time.
However, this experience has enabled us to highlight the importance of detail. Indeed, this Gantt chart was good but perhaps lacked precision and it would have been useful to make it evolve according to the progress of the project and the hazards experienced. We realised that some parts of the project were more time-consuming, complicated or technical and would have required more "workers". Our advice is to accompany the Gantt schedule with a resource chart to have a more precise idea of the needs (time, resource use…) of each part.
This lack of precision also led to new sub-parts or sub-tasks being assigned to certain members during the project. This resulted in a slight imbalance in the workload between the members.
We therefore recommend that a very precise Gantt chart be drawn up and accompanied by a resource charter for a project of this kind.
Finally, we found that it was very important that one person was responsible for the overall review of the documents to ensure that the link between the different parts was clear. Indeed, when working with six people on a document, this role is essential. We thought of assigning this responsibility to a member of the group but somewhat underestimated the time needed for this task.

Our second piece of advice concerns communication. After all, organisation is not enough and good communication within the group is essential.
We believe that weekly meetings are the minimum to ensure this. This meeting allows us to make sure that the project is progressing well, to bring up any difficulties that some people may encounter and to change the objectives and the schedule accordingly.
For our part, this meeting enabled us to rebalance the number of people working on this document because we realised its importance and the involvement it required.
To accompany these meetings, we set up an interactive logbook so that we could report from home on a more regular basis the problems encountered or the subjects that we wanted to discuss together during our meeting.

To conclude this list of tips, we learned that we should prioritise the 'external' resources. Indeed, we needed to interview professionals in the construction industry to gather testimonies and experiences. This task was more complicated than expected. It was therefore important to initiate it at the beginning of the project. Indeed, we have no control over the availability and schedules of our interlocutors, which can compromise the set schedule.

To sum up, the most important lesson we learnt from this project is the importance of good project management in order to achieve success. It is important to divide the tasks, to

organise regular meetings to present our personal progress, to link the work done by everyone, to make sure we are going in the same direction and to follow the schedule if we want our project to be successful. Without good project management we can get lost in the project and the deliverables may not be what we want.

6. Reflection on learning and unlearning

- **Knowledge, practices or attitudes gained during the project**

During this project, we learned how to organise ourselves as a group in an efficient way: we needed to hold regular meetings in order to move the project forward. This was not easy, as we all had very different schedules, but setting up a solid organisation was the first and perhaps most important thing to do.

From an individual point of view, the knowledge acquired depends on the member.

Indeed, Denis and Thomas had knowledge of the construction sector and Antoine had some experience from an internship. However, the rest of the members had to read up and acquire some skills and knowledge necessary for this project.

This may sound trivial, but we also had to improve our English in order to write the documents and interview our interlocutors properly. For this we could rely on the stronger skills of some of the group members.

Of course, there was other knowledge and skills that had to be acquired for this project that we cannot remember or detail here.

It was also critical for the project to learn or at least to improve in video editing. Indeed, none of us had any real skills in this area. So we relied on online tutorials to help us gain this vital knowledge.

- **Attitudes, practices or knowledge discarded/found obsolete during the project**

In order to carry out this project we also had to unlearn some knowledge or habits.

First of all, we had to unlearn some of the experiences of working in groups that we had had. Indeed, it is important to keep the organisational and communication skills acquired before, but each person in a group works differently. It was therefore important to adapt our knowledge in this area to each other's experiences in order to find the right compromise between the six of us.

When interviewing our construction contacts about security and digital, we also had to unlearn some things.
Denis led this exchange in the majority. He sometimes had to put aside his knowledge of this field to allow less directed questions to emerge and to be open to other types of answers than those he could foresee from his own experience.

Finally, we all had to unlearn our writing habits from our respective universities in France in order to meet the requirements of this assignment.

7. Acknowledgments

We would like to thank Mr Bassam Hussein, our teacher, for his teaching, which allowed us to have the keys to carry out this project.
He was patient with us and taught us the tricks of the management trade in a fun way.

We would also like to thank all the external actors who contributed to the project, through advice and interviews, especially Jérôme Saint-Macary for giving us his time.

8. Références

Hussein, B. (2018). The Road to Success: Narratives and Insights from Real-Life Projects, Fagbokforlaget.

Raelin, J. A. (2001). "Public Reflection as the Basis of Learning." Management Learning**32**(1): 11–30.

9. Appendix

- **Appendix.1: Pre-report**
- **Appendix. 2 : The investigation or the literature review report**
- **Appendix 3 : Link to the video presentation**

Appendix.1: Pre-report

TPK 5100 - Applied Project Management

Pre-report

Group 38

Focus of the investigation and its importance

For the project assignment we choose to do the following approaches : Conducting an empirical investigation (interviews, surveys, questionnaires) using project practitioners to gain insights on one or several issues of the selected topic. Scope and requirements of these empirical studies should be discussed and agreed upon with the course instructor. We will apply this with the next subject :

Digital / Numeric transformation in the construction project

We choose this subject because the construction projects have greatly evolved with the use of new technologies and they are still in transformation. The digital transformation for construction projects makes it possible to have more efficient modeling tools, clearer construction plans. Digital transformation also concerns management tools, which makes it possible to streamline information and have more data. These data are important for decision-making and reactivity.

Plan of our project and stakeholders involved

The aim is to address the topics presented in the following proposed structure of the report (the structure may change between this and the one that will be applied in the final report):

- Introduction
- Quick presentation of the sector and history
- Different step of the digital transformation in this sector
- Presentation of different tools used today :
    - GIS (Geographic Information System)
    - Review of document and plan review (cloud)
    - Management tools (organization of worksites, …)
    - 3D Plan modeling software
    - Creation of a twin building in numeric
    - Other numeric tools, ….
- Possible innovations :
    - Geolocalisation of the workers in the worksite to increase the safety (trucks, …) already use in different quarries
    - Digitisation of outdoor plans
    - Robotization
    - Others innovations
- Expériences :
    - If it is possible an interview of a project manager in Norway or in another country
    - Experience of one of the student in the group (2 years in a French gas transport company as assistant project manager on an 80 km pipeline construction project, monitoring of different other project in this company) + experience of people in this company
    - Any other people we may meet or read about in the press
- Outcome of the use of numeric tools in project
    - Increase of the safety
    - More information available during the project and the operation phase
    - Good quality of the construction with numeric control
- Limits to the use of digital tools in projects
    - You still need qualified and experienced workers in constructions, a majority of the task aren't numeric
    - When you have to numeric think to do you can lose in efficiency at different step of the project
- Conclusion

Risk assessment plan

In this project, we will make a study on a subject, we will not have many risks but we will try to make this risk analysis.

Risk	**Type of the risk**	**Risk-mitigation**	**Probability**	**Impact on project success**
Failed to find a person to interview	Organizational	Try to contact people on linkedin	Medium	Low (because we can have feedback on french companies)
Failed to find a person to interview in the period scheduled	Organizational	Try to contact people on linkedin quickly	Medium	Low (we will adapt the plan and write a part of the report and write the part of the interview in this after (even if we already started to make the video)

Skills we need to acquire

We need to acquire knowledge on the digitalization of construction projects to be up to date on the latest advances. This will allow us to conduct interviews that are all the more relevant.
On the other hand, we must learn to use management tools (WBS, planning, success criterion…) effectively, to be able to submit our 3 deliverables by the deadline.

Success factors

- Clarity of project purpose
- Adequate project planning
- Project follow-up and feedback
- Effective communication
- Team skills : knowledge about the subject, experiences in other projects

Project schedule

Project Assignment TPK5100 - Group 38 - Digital / Numeric transformation in the construction project											
N°	Task	Duration	Reponsible	Week 38	Week 39	Week 40	Week 41	Week 42	Week 43	Week 44	03/11/2022
1	Working on the pre-report	1 week	Everyone								
2	State of the art, search for studies similar to ours	1 week	Y, F								
3	Layout of the introduction (presentation of the construction sector, history of the development of this sector...)	1 week	A, D								
4	Research and presentation of the emergence and evolution of digital technology in this field	1 week	Y, F								
5	Research and explanation of existing digital solutions and tools	2 weeks	A, Y, F								
6	Research and presentation of the different possible and expected innovations	2 weeks	A, Y, F								
7	Research and interwiew of a project manager in the construction sector	4 weeks	D, T, E								
8	Writing of the final report	3 weeks	Everyone								
9	Report summarizing our evaluation and reflection of our own project	2 weeks	D, F, E								
10	Video Presentation summarizing our efforts and reflections	2 weeks	A, Y, T								
11	Final Review Due date : Submission of our work	1 day	Everyone								

D : Denis Albouy
A : Antoine Decrocq
F : Franck Laborde
E : Elise Leve
Y : Yanis Roussin
T : Thomas Vigroux

Roles and responsibilities in the project

To be efficient and organized on this project, roles and responsibilities will be assigned to everyone.

Denis Albouy will be the project leader. Indeed, his experience in the construction industry acquired during his studies and his professional background allow him to have a good vision of the project and to supervise its progress efficiently.
He will also be responsible for the "technical" parts of the project, such as interviewing experts of the sector to bring his experience to these discussions.
He will be supported by Thomas Vigroux who has followed the same studies and therefore has a good knowledge of the functioning and the stakes of this environment.

Antoine Decrocq, Franck Laborde, Elise Leve, Yanis Roussin have followed "generalist" engineering studies in France and therefore have different experience of the construction sector.

They will mostly be in charge of the less technical parts of the project, such as researching articles and information on digital transformation in the construction sector and writing the report.

However, their proadvice will ensure that our study is coherent and understood by people outside this field. They will also contribute their own skills to different parts of the project (video editing, managerial skills, software management...)

We also thought about assigning parallel responsibilities to ensure that the project was completed on time.
Therefore, Antoine Decrocq and Franck Laborde will be responsible for managing and respecting the schedule.
As we are not native English speakers, Elise Leve and Yanis Roussin will be responsible for proofreading and spell checking the report.

Communication plan

To ensure good communication within the group we will take fifteen minutes each week to share our research and work and note the progress of the project. This way we can make sure that everyone is progressing correctly and check the consistency of the results between the different parts. It's Denis Albouy who will be in charge of leading this discussion.

Conclusion

As you can see, the aim of this empirical study will be to better understand how digitisation in the construction industry is leading to changes in working practices and future innovations. We will conduct the production of these deliverables as a real project team trying to follow the plan given earlier.

Appendix. 2 :
The investigation or the literature review report

Academic year 2022-2023

TPK 5100 : Applied Project Management

Teacher: Bassam Hussein

Empirical Study Report

Influence of digital transformation on safety in the construction sector

Group 38:

Albouy Denis

Decrocq Antoine

Laborde Franck

Levé Elise

Roussin Yanis

Vigroux Thomas

Abstract

Worker safety is a major issue for a company and it must be ensured that its employees can work in safe conditions at all times. In construction work, especially outdoor work, the risk of accidents is obviously higher than the average. It is therefore interesting to understand how it is characterised and how each company is concerned about it and tries to reduce this risk by using different methods. One of these methods may involve digital tools. Indeed, these tools are now at our disposal and are already used to manage projects but it is interesting to see how they contribute to the reduction of accident risks or to the reduction of the severity of accidents. However, some of these tools can have an opposite effect if they are badly deployed and this is also a parameter to be taken into account in order to understand the subject.

This report will therefore attempt to address these issues by drawing on personal testimonies as well as on the literature available in various media. These data will be cross-referenced to summarise the deployment of these methods, their possible evolution and the positive and negative aspects of some of these tools.

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Introduction

The building and infrastructure construction sector is a sector particularly affected by employee accidents. Indeed, their operations being outdoors and using dangerous or heavy materials and tools are clearly the cause. Companies in this field have an interest in reducing the number of accidents for many reasons (efficiency, economic, quality of construction, quality of life, atmosphere, ethics, ...). In this fight against accidents, companies in this field have received an ally that has changed the world: the digital revolution.

The objective of this report is to answer the following question: ***The construction sector, like other sectors, is undergoing major changes in the way it works as a result of the arrival of digital technology. How has this affected and is affecting the safety of workers on site and the safety of building operations?***

To produce this empirical study we have drawn on the literature as well as on the valuable testimonies of professionals in the sector.

Related works

1. Sector analysis

The economic sector of construction includes all activities related to the design and construction of public and private buildings, industrial or not, and infrastructures such as roads or pipelines. It is one of the leading sectors of economic activity. Many studies show that unsafe behaviour is the main cause of construction accidents. Safety education and training are effective ways of minimising unsafe behaviour by people.

The economic sector of the global construction industry accounts for 13% of the world's gross domestic product (GDP) and 7% of the total global workforce employed in 2019, with the global market dominated by Chinese companies (21%), far ahead of US companies (15%).

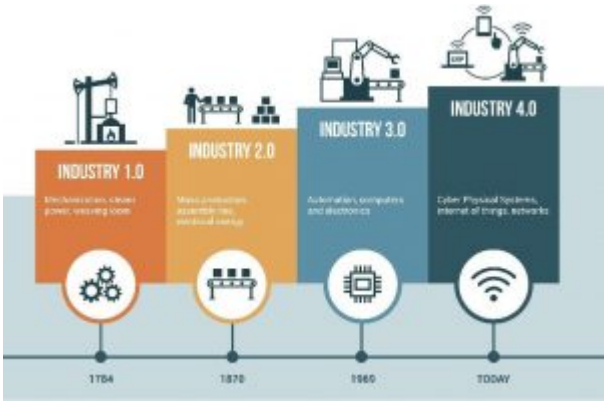


Figure 1 : Industrial revolution

Like all fields, industrial revolutions have always had an influence on working methods. For example, the first industrial revolution brought new machines to the building sites and thus increased efficiency and the ability to carry out even larger projects. In our case we want to look at the digital transformation in this sector and in particular at the changes in working methods with the novelties of the 4th industrial revolution.

2. Tools

It is important to understand how some of the tools of digital transformation are used and work in this environment.

- **Project Management Software:** Obviously in construction projects project management is a priority, planning is very important. It is therefore necessary to use planning tools such as MS Project or Smartsheet to have up-to-date Gantt charts in order to be able to organize the teams according to different deadlines. Similarly, this information must be extracted and used in a project monitoring dashboard in order to have real time project progress and indicators to monitor on the same visual. This

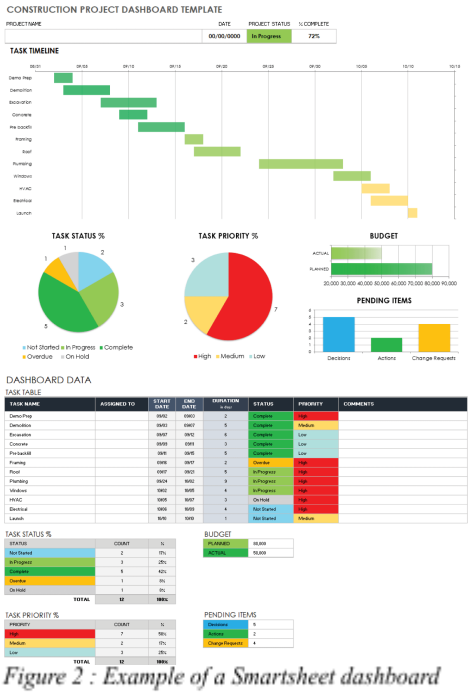
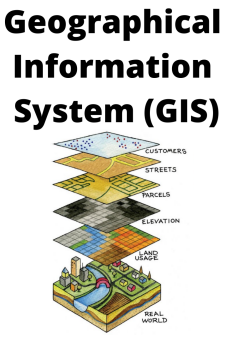


Figure 2 : Example of a Smartsheet dashboard

visual is available for project managers, supervisors and team leaders on duty and sometimes also for all workers. This category also includes document review software, which allows documents to be classified for the maintenance and use of buildings. This software also makes it possible to know who has validated which documents and whether all the specialists concerned have been consulted and have given their agreement.



- **GIS (Geographic Information System)/3D plan:** These tools are extremely important as they allow us to locate ourselves on infrastructure sites over considerable distances. Moreover, the use of these software programs allows one to gain in efficiency and in quality of work during the study phase of the building sites. Indeed, it is possible to display all the information (relief, environmental subjects, forest, rivers, parcel delimitation, soil condition, ...).

Figure 3 : Picture which explains GIS

- **Numeric twin:** The digital duplicate provides a better understanding of the constructed system. It is possible to list all the information known about the building and to understand how it is built and, above all, how it should be used. This method allows to reduce the costs of maintenance operations and especially the interventions. This clearly has an impact as reducing the number of operations to be carried out will reduce the risk of accidents. Also, if an operation is to be carried out, it is easier to simulate how it can generate a risk situation (especially on used structures such as gas pipelines, high-voltage lines or other).

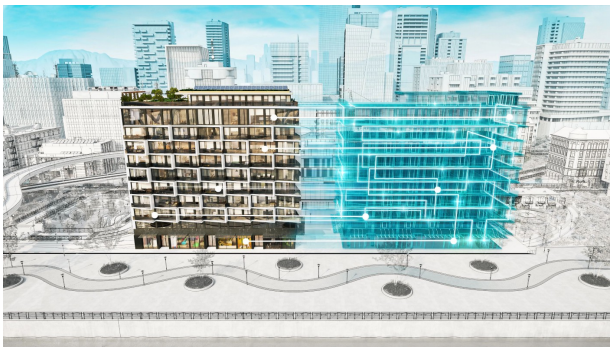


Figure 4 : Picture presenting a numeric twin of a building

- **Robotization:** Robotisation is obviously a tool that is already being used and will be used more and more, because on construction sites many tasks involve tools or heavy equipment. In addition to the weight, these tools and materials can be sharp, difficult to handle or more generally dangerous. Therefore, the use of robots logically reduces the number of accident risks. Beware, however, of human-robot coactivity, which can also reduce efficiency and increase the number of accidents if not properly supervised. We can also think of the use of exo-skeletons to prevent operators from forcing themselves or breaking their backs, for example.

We can also discuss a lot of other information and tools that are used in this field. Indeed, there are many articles or sites that present many other tools that can be used to improve the quality of life of people in this field.

Method

To work on this topic we had 3 axes of analysis. These three axes were our guideline and allowed us to think in a methodical way during our work.

➔ The first axis was around press articles or documentation that was available online. We therefore monitored important information. This part also allowed us to better understand the subject and to prepare the next two axes which required more knowledge than this one.

➔ The second part was the exchange with a professional in Norway. For this axis, the difficulty is to find a professional in Norway who wants to answer us. So we decided to contact a number of them on Linkedin. We have targeted profiles working on project management or HSE issues in large companies such as NCC for example. However, the pool of professionals has been greatly reduced because in Norway many users lock their Linkedin profile and it is therefore very difficult to contact them. This was a bit surprising compared to what is done in France (some of us in the working group have already had multiple exchanges with professionals without any difficulty in France). We also drew up the list of questions below to help us guide the exchange so that this exchange really helps us in our work. These questions are indicative and other questions may be asked as the discussion develops.

List of the questions:

- What digital tools do you use?
- Have you noticed any improvements in security since the introduction of these digital tools?
- How did you implement these digital tools? Have you encountered any difficulties (reluctance of workers, disorganisation of the company, etc.)?
- What are the limits of these tools?
- Are you satisfied with these tools?
- Are there any other tools that you would like to implement?
- Do you have any data/figures to share with us? (end of interview)

➔ Finally, the last axis consists of feedback from a member of the group, Denis Albouy, who has been working in France in this field for more than two years. He summarised his thoughts on this subject as well as those of his colleagues with whom he was able to discuss these subjects prior to the elaboration of this empirical study and during the course of completing the information. This testimonial text is therefore Denis' experience crossed with feedback from colleagues of his at Terega, including in particular the feedback from Jérôme Saint-Macary, one of his direct colleagues and who is responsible for the project presented in the text and who has several years of experience in this field

Findings

Firstly, it is interesting to summarise what has been analysed on each of the 3 axes before to do some conclusions or discussions.

a) Literature findings

First of all it is necessary to have a figure concerning the number of accidents at work in the world, a first report of the International Labour Office (ILO) dating from 20 years ago estimates the number of accidents at work and occupational accidents at : " *270 million occupational accidents and 160 million occupational diseases each year - these are conservative estimates* ". However, these figures have not really improved compared to what could be expected. Indeed, a report by the same organisation currently estimates figures of around " *340 million occupational accidents and 160 million victims of work-related illnesses annually* ". However, this increase can be qualified by the fact that the world's population has increased between these two dates, including the number of people able to work, from 2.88 billion in 2003 to 3.46 billion in 2019 (before covid) according to world bank data. The number of accidents at work and occupational diseases has therefore not increased proportionally and has even decreased slightly. We can also note that medicine has developed and that occupational diseases are more easily detected.

After doing some research we realised that there are various points that influence security through digital developments. Indeed, with some information, we can observe that digital technology has made it possible to reduce the number of road accidents via different tools (reversing camera, assisted braking system, ...). It is noted that every year about 1.3 million people die in road accidents worldwide according to an article published by the World Health Organisation (WHO). However, the reduction in the number of road accidents is a reduction in the number of accidents to workers, both during their working day with work vehicles and when travelling to work (which in the event of an accident is considered in some countries to be an accident at work).

Another point of view is that digital technology makes it possible to verify the tasks performed by workers and thus to reduce human error. Indeed, human error is the primary source of accidents as mentioned in an article in the "safety and health magazine" which states that 80 to 90% of accidents at work are due to human error. It is therefore essential to reduce the number of human errors on construction sites to increase the safety of workers.

b) Interview

In this section we have tried to contact a large number of professionals who have worked or are working in companies such as NCC or Isachsen Gruppen AS. However, we had difficulties in getting answers from project managers or project officers concerning safety issues in these companies, as some of them did not have the time to give us in this short time.

For this reason we were not able to get a specific interview, however we were able to talk to an infrastructure project manager for Terega (who is the colleague of the head of a group member) in France. Their testimonies are therefore cross-referenced in the following paragraph.

c) Safety experience at Terega

First of all, it is important to know my working environment. For more than two years now I have been an apprentice at Terega, a company specialised in the transport and storage of gas in the south of France with about 500 employees and owner of more than 5000 kilometres of gas transport networks (only in big axis). In this company I work as a project manager in the infrastructure project department. Our task is to carry out pipeline construction projects in order to replace existing ageing pipelines. In particular, I am working on a project with an experienced colleague on the construction of a segment of almost 70 kilometres. I have also been able to see the way of working on other sites of the company. "*In this project we are constantly trying to take into account as much as possible the safety issues of the people working on site*".

First of all, to talk about the contribution of digital technology, we can compare with what was done before. As part of this project we found the archives of the construction of the first pipeline in 1974 and in particular the paper plans which as you can see were certainly well done but do not allow us to go into detail. Today, we have detailed plans that can be added on software such as Google Earth or Qgis that we use on a daily basis, including on site.

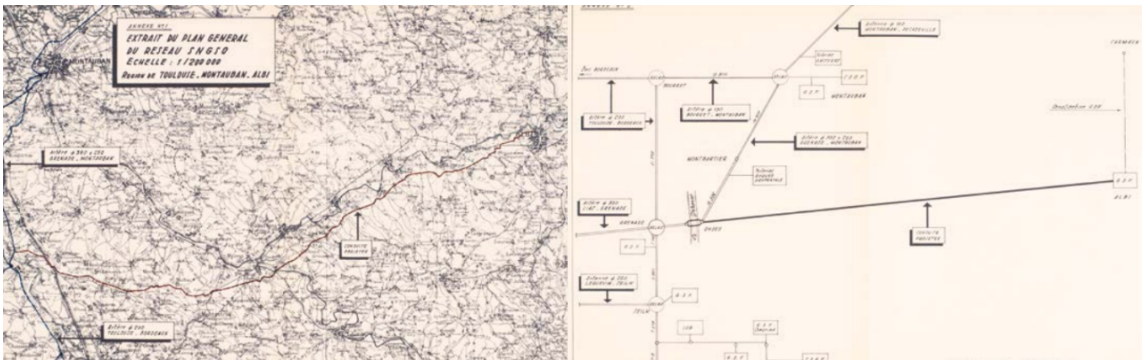


Figure 5 : Old REVA pipeline map (1974, Terega)

Digital technology and its development also allows Terega to succeed better and better its objective of reducing the number of accidents. Indeed, these tools allow a better planning of the building sites and thus make it possible to reduce the number of useless or badly prepared operations and in particular with our software of documentary follow-up Babel to ensure the checking of specialists on the protocols. In addition, the plans and locations are communicated with the emergency services closest to the construction site and in the event of an incident, this allows for a faster response.

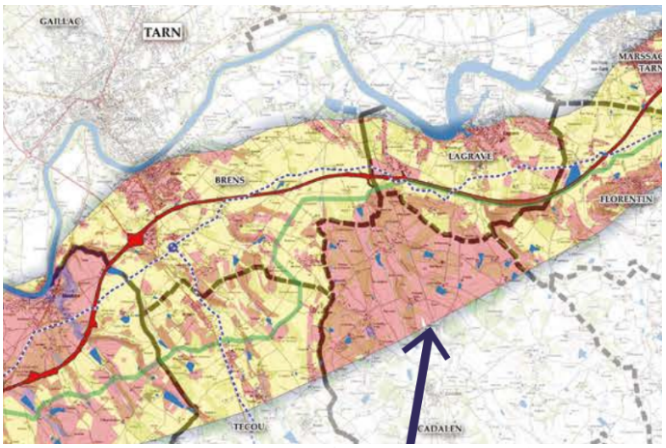


Figure 6 : New REVA pipeline map (2022, Terega)

For example, in the project presented, we are currently in the study phase, but *"as soon as a service provider goes to carry out on-site surveys, he informs us by e-mail of the intervention sites, which enables us to warn the municipalities and the emergency services in order to react in the event of an incident"*.

In the summer of 2021, we also carried out tests by equipping a team of workers with GPS units that were linked to a screen located in the cockpit of an excavator. With this invention, the operator used the technology to provide a warning before a potential contact with an employee. However, this innovation received mixed reviews for a number of reasons, not least of which was the fact that it was an extra piece of equipment for the operators and the operator to wear. This innovation was derived from a way of working that currently exists in many quarries in France, but which obviously was not so easily made available on our sites. Obviously, new reflections are underway to try to reintroduce this mechanism under a new operating mode.

We are constantly trying to add digital tools to improve the safety of workers on site, but we must not forget to take into account and involve the main stakeholders. Indeed, if the addition of a new process is not well presented to the operators, it will be very difficult to make them apply it properly. Of course, you have to pay attention to safety issues, but you should not think only about that either, because that would have the opposite effect and would also impact on the financial, quality or other parameters of the project.

Discussions and conclusions

All these evolutions allow the projects of construction several major benefits as we could see previously.

- Efficiency : Tasks can be completed faster and in better quality. Indeed, with these and future tools, it can be clearly observed that some time is lost and therefore by reducing the duration of a job, the number of accidents per job is improved. We will also have an improvement of our construction quality, this will notably help the safety of the people on site (what has been partially built on a construction site is therefore classified as safe and therefore theoretically we cannot have any incident that would lead to work accidents).
- Quality : A better quality building will reduce the necessary intervention costs. In addition to being a selling point, this implies that less maintenance will be required. This will reduce the number of dangerous periods for operators.
- Working environment : workers will feel less unsafe while working, which will contribute to the improvement of working conditions, and their tasks will be "easier" or less "unpleasant".

However, the construction trades are labour intensive and involve a significant amount of manual labour. We should not think that the use of digital technology and its development can solve all the problems in this sector. Indeed, many tasks are necessarily carried out by humans and the experience of the operators cannot be removed from the technology. Technology can be at most an additional tool but cannot replace humans on many tasks. For example, on outdoor sites we can clearly see the particularities of each location, which is often different. As explained in the feedback from Terega on the possible innovation of locating workers outdoors, it may be a good idea in theory but in the field it also adds fatigue to the excavator operator and an unergonomic object to move for the workers on the ground.

We can therefore qualify the evolution of the number of accidents thanks to digital tools. They are necessarily an asset to increase safety, but in an environment like construction and with sites that are all different from each other, there are many limits. We can obviously welcome the tools that reduce the risk of road accidents or controls that reduce accidents at work. We can also talk about exo skeletons which will solve many occupational diseases, in particular the back problems of employees who have worked all their lives on construction sites.

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Appendix 3.
Link to the video presentation

https://drive.google.com/file/d/1mrtanJhPsJBYe2gKpyt0XwtsxFcnqQfL/view?usp=sharing