

Findings from the Expert Interviews (Chapter 2)			
No.	Question	Assumption/ Initial Comment	Interviewee
1 Problem Space			
1	Do you agree on this and where (regarding site and logistics management) do you see the most potential to overcome these challenges?	In literature, poor productivity and safety issues are identified as common problems on construction sites, caused by elemental constraints and shortcomings in the industry (referring to the chart below).	
	<ul style="list-style-type: none"> - Very conservative industry and lack of innovation as main drivers - Primary drivers for not getting the full potential out of site and logistics management. Reason is the lack of innovation as well as the conservative industry. Also education as workers don't have the skills to use technology. - Mentality of CM is to daily face the challenges of site logistics, moving material around without a long-term master plan - Designer are estimating site layout in big projects although they never worked as a site manager. A lot of theory. Lack of practical experience - And "I experienced that often that when it gets into a hand of a site manager. He can spot the first 20 mistakes immediately." - On the other side, you have the site manager who cannot use Revit or another modelling software. His knowledge stays in his head and he manages the site from day to day because he knows how it should be done. Dare him to be sick. <p>Potential</p> <p>Mostly concerning productivity but safety is always an issue as well. Lack of site planning in general. --> Contractor integration into scheduling.</p>		Consultant 1
	<ul style="list-style-type: none"> - Generally agrees on the assumption and classifies productivity and safety issues more into internal challenges - When planning a construction project, it is important to prioritize the planning of what's happening on site --> underprioritizing construction site plan, e.g. procurement schedule - Current practice is characterized by poor planning which leads to a non-consideration of constraints on site and a poor overview of procurement, usage and rental processes - Most potential in the planning phase and related to that in the monitoring phase --> enable a bilateral information flow between planning and construction for adjusting what is planned - Logistics problems are mainly related to the work of subcontractors and thus, planning should also be considered from the detailed perspective of subcontractors - However, subcontractors cannot cope with this responsibility as their approach is more based on a day-to-day problem solving mentality --> "subcontractors are not looking as far enough ahead to have that degree of planning that we need" - Information technology can help to manage this, especially the more detailed and complex it gets 		Consultant 2
2	How can technology improve site logistics management and why is updated data from the construction site important?	Missing integration of BIM and IT at the construction site is a big shortcoming of the industry, resulting in weak site monitoring and project management because of one-way information flow and lack of structured data?	
	<ul style="list-style-type: none"> - WHY: There is no incentive to use BIM on site because the construction workers want to focus on their main activities and don't want to give feedback to the model, which requires a lot of work. However, an updated model is super useful as it holds updated data and site or logistics managers could get information about construction progress automatically and don't have to use their time to get the information. - "That gives the construction management a great overview of where things are happening, what activities are being made where" - Not much consideration for TCIs, but it would be beneficial! But also needs to get updated feedback of these items to manage the construction site properly. - Updated data about progress of the activities is most important, because that's where the logistics, the needed TCIs and materials is linked to (Information about type, quantity, location, use) - In Morten's opinion Exigo is the first company trying to fully integrate in an effective way to report progress in still on a detailed level (Exicute) 		Consultant 1
	<ul style="list-style-type: none"> - Logistics in general is a big problem in construction as there is little space and things need to be moved around constantly (Equipment is blocking the site causing waste in construction activities) --> This requires a dynamic planning of the complex construction processes - CiFe-Study: How many alternatives do you look in to before making a decision? --> 2.5 alternatives per decision general in construction and on site this number is even less - Due to construction complexity decisions in construction are made on very little alternatives and a simple analyze of these alternatives "So if you if you want to buy a car, you look at four or five cars and when I wanted to buy a house I looked at 20 houses, but in construction, we often make decisions on very few alternatives." --> Automatically generate alternatives and evaluate it on the design outcome (based on different indicators as costs, time, sustainability or resources) --> Sometimes it is better to trust technology (machine learning and AI) over human knowledge --> Rules for algorithms can be derived from best practices or professionals and the solutions can be derived automatically from technology BUT sometimes only the precise and required outcome is defined and AI is iterating the best path for getting the output - Another big issue in construction is that nobody wants to write something down, track and monitor processes and progress --> IT can help to receive this data automatically 		Consultant 2
3	From your experience, how are temporary construction items managed and what would be the benefit of more and updated data about these items?	There is a lack of attention and information regarding temporary construction items. Temporary works is only included as an estimate or percentage of the total cost but is often not planned and monitored properly.	
	<p>Deployment: - "Either tenderlist where the designer lists up a lot of different potential things he thinks that the site might need for temporary works. Or it is just a percentage of the total cost and the designers will never be wiser because the information flow never gets back."</p> <ul style="list-style-type: none"> - TCIs are just ordered on an assumption and deposited until needed. sometimes it is not needed, or sometimes the site is running out and has to reorder TCIs. I--> <p>iterative management approach from day to day.</p> <ul style="list-style-type: none"> - Would be much easier if this information is linked to the model and a 3D-site model would be created - Site manager is the only guy who can manage the site. If he is sick, everything falls apart. "I'm scared of, if a guy like that leaves or gets sick for a week..." --> The site plan is solely in his head --> Blocking information flow as it is not documented and planned. That's the problem! <p>Operation: - No information about equipment and TCIs when to use them. Will be looked for and found immediately before or during the activity has already started. Look-ahead plan and lean management isn't working.</p> <ul style="list-style-type: none"> - No information means a big stock of TCIs on site to prevent shortcomings, resulting in a lot of inefficiently used space on a construction site. <p>Benefit: - Planning ahead what TCIs are needed for the specific building parts already in design phase. With contractor integration in the design phase, this knowledge can be achieved and established early (IPD)</p> <ul style="list-style-type: none"> - If the linked data is there, the contractor would know exactly the amount of TCIs he needs to order and when and for which location. --> Based on progress monitoring, you can then just adjust the site management and logistics planning as well. 		Consultant 1
	<ul style="list-style-type: none"> - Example: In a previous job, a situation was experienced where an intern was supposed to find a movable scaffolding platform on site but nobody knew where it was and they paid the renting bill for two years --> In the end the construction manager paid much more in rental fees than the material would have cost because nobody knew where it is - Assumption is correct --> TCIs are not really planned only a percentage of the total costs and it is not sure what is there on site, who is using it (booking of tools, machinery), and sometimes they just disappear because they are neither planned nor tracked --> Have some positive impact in costs but a lot in time saving! - HILTI has a system with RFID and GPS sensors ☑ People are more and more aware of it 		Consultant 2

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2 Solution Space			
4	What data would be beneficial to track? What type of temporary construction items (e.g. formwork, supporting struts and safety barriers)?	Real-time tracking of temporary construction items has potential to reduce waste, costs and safety hazards.	
	<ul style="list-style-type: none"> - Data to track: Picture of element, weight, size, count of different types, function, location, safety risk factor (1-10) --> Extra attention on specific type of tasks when installing TCIs - Real-time information about formworks and scaffolding and supporting structures. That's something that would be nice to know where it is at all times, as these items are constantly on site, moved around and reused frequently. For big machinery, more advanced IoT could be used to measure their operation. 		Consultant 1
	<ul style="list-style-type: none"> - How to plan TCIs depends a lot on the type of TCI: <ol style="list-style-type: none"> 1. Bigger items as mobile platforms, bigger scaffolding, site trailers, fences, bigger machinery, which all does not float around frequently in a construction site can be modelled as a site model --> Would be great to automatically integrate this in BIM 2. Items that are moved around and used frequently should be estimated and planned but doesn't have to be visualized in a 3D-model --> Equipment company rentals might already offer the service of planning formwork based on a 3D model - Formwork as a TCI example makes sense because it is important that it is planned --> Needs to be planned by the subcontractor (e.g. supplier) as it needs to fit their work processes --> Therefore, data from BIM and schedules need to be linked to TCI data from subcontractors, in order to plan (not a project based and closed application) --> Linked data can be interesting to use in this case - Example: iTWO software is using rule based planning for its estimation system by applying quantity queries on properties from BIM objects in a model --> iTWO can code through the given BIM model to extract quantities of things that are based on rules and geometry (e.g. meters of safety barriers around holes in slabs) 		Consultant 2
5	Where do you see the most potential as a focusing area of the research? What should be the primary research objective?	Five recommendations for developing a solution are derived from the state of art review.	
	<ul style="list-style-type: none"> - 4D-BIM is already existing, just not frequently implemented - In order to realize step 2-5, step one needs to be established first --> Therefore the focus should lie on the development of a simple way to plan TCIs and then use this information to improve logistics and site management 		Consultant 1
	<ul style="list-style-type: none"> - First: Make better planning to integrate TCIs but in a simple way --> no geometry needed - Then: "If you fix the planning, the next step that makes your planning better is to have better and faster data flow on how your site actually looks at what is going on site." --> Tracking - Geometry of TCIs is not needed in a model and therefore a rulebased interpretation and quantity take-off of these items with information about location is sufficient --> focus on quantities, when (time) and what (type of TCI) and where (location) - With IoT, the location information can then be tracked and verified in comparison to the schedule - TCIs can then be visualized on a location level with the schedule to review what type and how many TCIs are needed where and when on site rather than on a detailed model level. --> That's all what matters - Interesting is also the feedback loop for design consultants as an automatic and rule-based planning might has an impact on the design --> If the rule tries to use as much standardized formwork as possible to increase productivity, the design should be adjusted according to this --> Answering the question, to what degree can standard formwork being used for a specific design, might define a new criteria for evaluating a design alternative 		Consultant 2
6	How can temporary construction items be tracked? How should the tracked data be received, processed and then used to add value to the project?	An IoT- and cloud-based platform for data processing and exchange will enable a real-time tracking system.	
	<ul style="list-style-type: none"> - The reason why RFID tagging hasn't been fully integrated into the construction industry is because there is a of resistance from the workers to manually scan the tags as their sensor range is pretty small. If somebody forgets to scan an item, the whole dataset is wrong and will confuse the schedule. - Sensor needed that automatically sends data to receiver --> 5G technology for automatic tracking on a precise level, cheap and no need for a local transmitter. Only a small antenna needed communicating with the cellular connection (mast at site if no connection) - Sensor would need GPS for the exact location, gyroscope for movements and storage space for holding information about the task and item. - Requirement: Technology which doesn't affect workers job. Construction workers don't need to do anything about it because they have their jobs because they want to build not because they want to be logistic managers and that would be necessary - Cheap (50-100 crowns) and easy to implement in order to make business case out of it 		Consultant 1
	<ul style="list-style-type: none"> - IoT technology is already used intensively in other industries and can be copied in a mature level to construction industry --> Parameter for implementing IoT-tracking to improve the process is costs (if it is economically beneficial) --> HILTI on Track: GPS Chip which has a data net (5G) to send small amount of data about location of HILTI tools --> IoT-sensors must be provided by the supplier --> Also benefit from them where their products are --> intrinsic motivation of the supplier to use IoT, but the technology can then also be offered as a service to construction sites to track these items on site. - Future Scenario: Boston Dynamics SPOT-dog with RFID scanner can make a tour on site at night and register every time he comes close to a RFID tags and by that track items on site and see where items are located --> Then based on these findings, a location model can be made out of it 		Consultant 2
7	Is it possible to extend the application Excute and use it in this thesis?	Recommendation 2 and 3 can be integrated into Excute, providing an existing platform to test the system.	
	Yes, for progress monitoring and also the link to visualize data		Consultant 1
	Question not asked to the Interviewee		Consultant 2

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3	Other comments		
	<p>Activity Tracking --> Iteratively developed the idea by reasoning and looking at it, from a business case perspective</p> <ul style="list-style-type: none"> - Link building parts of the model to TCI-requirements in a database and get updated information with progress monitoring of activities --> a resource graph of the used items, using progress monitoring of related tasks to present passive real-time information about TCIs - The easy way: When planning, create a small scale database with information and data about TCIs (formwork, etc.) connected to different location based activities --> track the number of construction items, but the task which was related to the construction items <p>"you have planned it, because you know the size of it. And you have planned that they need this much formwork to do this activity in that location" --> make a small ecosystem where it is all integrated</p> <p>Benefit:</p> <ul style="list-style-type: none"> - Benefit from having it in your plan, because then it's set up, so you can easily track it when you are operating the site. - Benefit from tracking the quantities of it of each type you need and when you need it - Only ONE INPUT is needed --> progress monitoring will result in information about (the cost of, the time, the schedule, the logistics, the site operation) --> Raise productivity, less waste on construction site, as Site Manager or Safety Manager can focus on their real job <p>Task-Flow:</p> <ul style="list-style-type: none"> - a demo of having a small data warehouse which has the items and you can link it to activities and stuff 		Consultant 1
	<p>Proof of concept:</p> <ul style="list-style-type: none"> - Difference in activities between building a nuclear power plant and a kindergarten --> 80% of the activities was were the same, you're just in a different scale, but you still need to do the same steps. So you I think you could definitely rather quickly build up a database where you have these, you know, more and less generic tasks with the generic equipment that you need. And machinery and temporary constructions. 		Consultant 1
	<p>And if you've assembled at your peak time, if you need 50 forms to do your formwork. But you only at that peak time, you have a whole year where you only need 20 pieces beforehand. Then it will be nice that you could automatically just say to the logistics centre at your contractor headquarters something that okay, send out 20 pieces, so it arrives at this date. And then when you are reaching, you know, the next step of the piece you said 30 more stuff like that could be a nice thing to like make a small ecosystem where it is all integrated</p>		Consultant 1
	<p>Meeting with Ole</p> <ul style="list-style-type: none"> - Use of reusable formworks in Denmark, which are that cheap - Ask Ole if they rent TCIs or have it in a warehouse <p>Project:</p> <p>Use of plans and construction site of SDU in Odense (talk again to Morten)</p> <p>Case: an example of that and then check with the contractor how the system is simulated, then we can ask them is that the amount of forms you actually have on site? You know, yeah, it could be an interesting to check with a reality to have something.</p>		Consultant 1