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Modular Construction

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1. Introduction

For decades, construction has lagged other sectors in productivity performance, but recently modular construction is attracting a fresh wave of interest and investment on the back of changes in the technological and economic environment. Modular projects have already established a track record of accelerating project timelines by 20–50 per cent, and leading real estate players to save more than 20 per cent in construction costs (Bertram, N. et al. – McKINSEY & Co. 2019). Based on their moderate assumptions, the market value for modular construction in new real estate could reach USD160 billion by 2023 (Bertram, N. et al. – McKINSEY & Co. 2019).

Historically, prefabricated housing has achieved a sustainable foothold in only a few places, for example Scandinavia and Japan. It has been in and out of favour in markets such as the United States and the United Kingdom since the 1950's. Yet there is reason to believe that the current revival could be different. The industry is adopting new materials as well as digital technologies that enhance design capabilities and variability, improve precision and productivity in manufacturing, and facilitate logistics. Multiple factors determine whether a given market is likely to embrace modular construction. The biggest determinants are real estate demand, the availability and relative costs of skilled construction labour, greater reliability of construction products and of course the desire and regulatory ability to capitalize on the perceived advantages of modular construction.

Of course modular construction is not solely found in residential housing but also in administrative, industrial and commercial projects. This means that this form of construction cannot be ignored by construction and engineering insurers.

The goal of this Working Group Paper (WGP) is firstly to try to determine the risks connected with modular construction, not only whilst on-site itself, but during the design, manufacturing and transportation macro-phases of the project.

Working Group members paid attention to the survey and risk management issues as well as the question of potential structural issues and durability. Because of the characteristics of modular construction, risks that are relevant for traditional construction methods could be mitigated or increased and new risks could arise. These are discussed, then supported with coverage considerations for underwriters reviewing a modular risk.

Where Delay in Start Up (DSU) cover is purchased on policies covering modular construction, Underwriters should be aware of how a particular modular construction methodology could impact DSU losses. The WGP discusses the underwriting information requirements and policy considerations for this coverage.

Finally the paper includes a section providing examples of claims on projects.

2. Definition of modular construction

Modular construction has a number of different titles, varying across the industry and geographic region, for example it can be cited as as Modular Integrated Construction (MiC) or Permanent Modular construction (PMC). In this WGP, it is referenced throughout as modular construction.

Modular construction defined in its simplest form, is ‘a process in which a building is constructed off-site, under controlled plant conditions, using the same materials and designing to the same codes and standards as conventionally built facilities’(Modular Building Institute, 2021). Modular buildings may be Type III and V (wood frame, combustible) or Type I and II (steel, concrete, non-combustible) and can have as many stories as building codes allow.

There are a number of ways this build methodology has been harnessed by the industry. We have summarized the key categories of modular construction below:

2.1. Key categories of modular construction

Volumetric modular construction – 3 dimensional units are manufactured at a factory and then transported to site for assembly. They are either self-supporting by being stacked upon one another, or incorporated within a traditional structural frame – critically, however, there is no requirement for a supporting structure (Waste and resources Action Programme, 2007 / Burwood and Jess, 2005). The extent to which modules are fitted out prior to delivery to site ranges from fully finished (including services) to basic structural shell (CPD, 2014). This type of construction is most commonly used for buildings that have consistency and repeatability in their design, for example hotels and student accommodation.

Figure 1: Carmel Place – Source of images: https://www.cityrealty.com/nyc/murray-hill/carmel-place-335-east-27th-street/61313

This paper is focused primarily on this type of modular construction, though some of the risks and underwriting considerations are relevant for the other types of modular construction that are detailed below.

Panelized construction – pre-engineered ‘flat panels’, typically walls, floors and roofs, are brought to site ‘to produce a final three-dimensional structure’ (Ministry of Housing, 2019).

Figure 2: Lifting of wall panel – Source of images: https://www.cleverhomes.net/panelized-sips/

It is possible for a development to use a combination of the above. These are often referred to as ***hybrid or semi-volumetric systems***.

Literature on modular is not consistent in its categorisation of pods – they tend to be considered either as a semi-volumetric system or a category in isolation. For the purpose of this paper, given that pods can be installed in an otherwise conventionally built development, we shall treat pods independently and define them as follows:

Pods – factory manufactured non-load bearing units incorporated into the superstructure of a building (Zurich Insights). These are most commonly utilised for bathrooms.

Figure 3: Bathroom pods – Source of images: https://www.howickltd.com/modular-construction/bathroom-pods

Finally, modular construction also includes:

Sub-assemblies and components – pre-manufactured parts of a home, such a ‘floor or roof cassettes, precast concrete assemblies and preformed service installations and cladding systems’, are installed in a traditional build (Clarke Williams Ltd, 2021/CPD,2014).

Figure 4: Lifting of roof cassette – Source of images: https://www.timberinnovations.co.uk/floor-roof-cassettes/

This paper is focused primarily on volumetric modular construction or semi-volumetric modular construction, though some of the risks and underwriting considerations are relevant for the other types of modular construction that are detailed above.

2.2. Deployment of Modular construction

According to the report by the Modular Building Institute (2019), the global market size of modular construction in 2018 was valued at USD 112.3 billion; the market is expected to continue to grow. Specifically, modular construction has been used in a variety of applications, such as dormitory and hotel constructions; it has also been applied to residential developments as a solution to urban housing shortages.

The adoption of modular construction varies across the globe. In the UK, for example, the installation of bathroom pods is relatively commonplace for multi-occupancy residential and hospitality schemes – they were in fact heralded for their use in the regeneration schemes in Stratford, London after the Olympic Games (The Housing Forum, 2019). The number of volumetric modular construction developments is not akin to other places in the world, with, notably, Sweden, Japan and Singapore embracing this method, but there remain a number of tall notable examples, such as Victoria Hall in Wolverhampton, Felda House in Wembley and CitizenM Shoreditch in London (Doermann, Finzel and Barrot, 2020).

The UK is not the only point of reference for high-rise modular projects, with a number of examples across the world as follows:

1. Carmel Place, a fifty-five unit residential development in Manhattan, United States of America completed in 2016. The modular units range in size between 260 – 360 square feet and are spread across four towers with a maximum height of 35,000 square feet (nine storeys). Modules were fabricated in Brooklyn, and have a steel frame with concrete slabs.
2. La Trobe Tower, a residential development in Melbourne, Australia completed in 2016. The building is forty-four storeys in height, providing 203 residential apartments. Modules arrived to site with bathroom pods installed and a pre-fitted façade, though internal works, including installation of mechanical and electrical equipment, was undertaken onsite (The Possible, 2016).
3. Alt Hotel Calgary East Village, a hotel in Calgary, Canada. The hotel has 155 rooms over ten storeys – the top eight floors are built of modular units sitting atop a two storey concrete podium and three storeys of basement. Modules were constructed in Poland, then shipped to Canada.

The success of these developments, amongst others, is helping drive modular's global growth. Modular construction is projected to hit USD 108.8 billion by 2025, with an annual growth rate of 5.75per cent, (Markets and Markets, 2020).

Figure 5: Star Apartments, Los Angeles – Source of images: https://www.architecturalrecord.com/articles/7997-star-apartments-los-angeles

Advocates of greater deployment of modular construction recognize its advantages. We touch on these advantages throughout the report, acknowledging there are positive risks for underwriters, but as a brief summary, we wish to highlight the following:

1. Ease/speed of construction.
   - 1.1. On-site preparation can be conducted in parallel with factory work.
   - 1.2. Factory operations have intrinsic speed advantages, due to:
     - 1.2.1. The presence of dedicated factory tools
     - 1.2.2. No exposure to adverse weather conditions or site disruptions
     - 1.2.3. Ease of repetition of modules

   Possible time savings are estimated to be up to fifty per cent. (Bertram, N. et al. – McKINSEY & Co. 2019).

2. Exploiting economies of scale
3. Increased product quality due to the regulated quality assurance systems
4. Lower risk of health, safety and security related issues
5. In projects destined for remote and sparsely populated areas, concentrating the bulk of the work in factories can solve issues related to local high costs and a lack of resources and labour.
6. Cost Savings - possible savings could be up to twenty per cent.(Bertram, N. et al. – McKINSEY & Co. 2019).
7. Environmentally friendly – construction generates less garbage and waste. Ability to utilise sustainable materials at scale.

There is no doubt usage of this methodology will grow, for both low and high rise building alike. Modular construction is being encouraged by governments across the world, including for example: the Singaporean government promoting its usage in their Construction Productivity Roadmap; the British creation of a Modern Methods of Construction working group; and the city of New York in its Housing New York 2.0 Plan striving for 300,000 units of housing by 2026 (McConnon, 2020/ Chalillan 2019/ Lubell, 2018). It is also being embraced by a number of organisations, such as the Marriott International, McDonald’s, and Greystar (Doermann, Finzel and Barrot, 2020).

2.3. Modular Construction Process

Modular construction techniques are similar to assembly line car manufacturing and are readily observable on numerous videos on the internet, for example on modular manufacturer websites. Typically, four macro-phases make up a modular construction project.

A **Design** – developer design and plan approval by regulating authorities;

B **Off-site fabrication -** assembly of module components in a factory;

C **Transportation** – transit of modules to the project site; and

D **On-site assembly/installation-** erection of modular units to form the building.

Modular contractors manufacture buildings at off-site locations. They may also operate as general contractors on projects, coordinating the delivery, installation, site work and finish of the building or, alternatively, the modular contractor will be responsible for construction, delivery and installation of only the modules and an overall general contractor will be responsible for the entire project.

Off-site modular construction primarily occurs indoors away from harsh weather conditions preventing damage to building materials and allowing builders to work in comfortable conditions.

Unique to modular construction, while modules are being assembled in a factory, site work is occurring at the same time or in some cases prior to construction. This can allow for much earlier building occupancy and a much shorter overall construction period, reducing labour, financing and supervision costs.

Everything from traditional general contracting to design-build-operate-transfer has been utilized in the modular industry. However, the off-site modular construction requires more coordination during the design/construction process and forces developers to make decisions earlier.

This requirement is changing as the modular manufacturing industry is maturing and evolving to accommodate fast track construction techniques and delivery methods.

A. Design

The design of high-rise modular buildings is strongly influenced by structural, fire and services requirements.

The addition of external balconies, cantilevers or other architectural features can be used to create a layer of architectural interest, while still maintaining structural integrity. Balconies can be attached at the corner posts of the modules or the loads can be directly transferred to the ground. Integrated balconies within the modules may be provided by bringing the balcony end wall within the configuration of the module. However, curvilinear forms, multiple exterior materials, and new window-wall systems add additional layers of complexity.

Many residential developers are utilizing unique designs and complex architectural forms to achieve higher yields and attract wealthier clients in their upcoming high-rise developments. These projects will only be more complex as appetites and tastes of prospective residents grow.

Thus modular construction must be able to accommodate high end finishes, material sourcing from all over the world, and unique floor plan layouts.

This requires consideration of design and the construction process from the outset. However, even open space or unique common areas that are not highly repeatable modules are being manufactured with this technology, as is the case in the Atlantic Yard project (see section 7.3 for details)

There are two basic types of volumetric modular construction that are utilized in high rise schemes and affect the building forms that can be designed:

1. Load-bearing steel modules in which loads are transferred through the side walls of the modules. In this type of design, the compression resistance of the walls is the controlling factor in design. The double layer construction of the modular walls and floor /ceiling with each module having its own party walls/floor/ceiling, enhances the acoustic insulation and fire resistance of the construction system.
2. Corner supported steel modules in which loads are transferred via edge beams to corner posts. In this type of design, the compression resistance of the corner posts is the controlling factor and for this reason, Square Hollow Sections are often used for their high buckling resistance.

Resistance to horizontal forces, such as wind loads and other actions, become increasingly important with the height of the building. The strategies employed to ensure adequate stability of modular assemblies as a function of the building height, are:

1. Diaphragm action of boards or bracing within the walls of the modules – suitable for four to six storey buildings
2. Separate braced structure using hot rolled steel members located in the lifts and stair area or in the end gables – suitable for six to ten storeys
3. Reinforced concrete or steel core – suitable for taller buildings
4. Lateral bracing elements integrated into the building core to transfer load to the core and structural columns near the perimeter of the building

Modules are tied at their corners so that structurally they act together to transfer wind loads and to provide for alternative load paths in the event of one module being severely damaged. For taller buildings, questions of compression resistance and overall stability require a deeper understanding of the behaviour of the light steel C sections in load-bearing walls and of the robust performance of the inter-connection between the modules.

For modules with load-bearing walls, the side walls of the modules should align vertically through the building, although openings of up to eight feet in width can be created in the side walls, depending on the loading. For modules with corner posts, the walls are non-load-bearing, but the corner posts must align and be connected throughout the building height. Additional intermediate posts may be required in long modules, so that the edge beams which span between the posts are not excessively deep.

MEP considerations must be addressed early and consistently throughout the design and construction process. Installing MEP in the modules provides advantages beyond simply installing conduits in the module and installing MEP on-site.

B. Off-site fabrication

After the design is finalized with an architect, construction plans are sent to a factory where the majority of the building is erected. Modular construction uses prefabricated elements for as many building components as possible and/or economically viable for the given scheme. Everything from walls and mechanical systems to painting and carpet can be completed on the assembly line. Steel studs are usually cut to a standard length and shipped to a jobsite where they're cut to the needed size. The studs are created on the factory line to the exact length required. Modular building factories maintain a high level of quality control with inspections at each station, eliminating on-the-fly decisions or unexpected complications that can occur on-site.

Factory construction of modular components varies greatly from static factory floors to conveyer belts to even robotic construction of modules.

Most modular buildings are built from the inside-out with exteriors being attached last. Two layers of plasterboard or gypsum board are attached to the internal face of the wall by screws . Cement particle board or oriented strand board are then attached to the exterior walls . In production, boards may be fixed via air driven nails or screws enhanced by glued joints. These boards restrain the C sections against buckling. This process provides numerous construction advantages that are not physically possible in standard construction.

C. Transportation

Typically it is not feasible to ship modules large distances due to road size and load restrictions. Most modular deliveries are made over the highway and governed by a somewhat complicated web of international and, in the United States, interstate regulations.

In America, it is not rare for a transporter to have to deal with three or more different government agencies to get through a single state. Opinions vary on the complexity of the approval process. Several issues remain such as potential time delays due to the complexity of securing transportation permits for oversized loads, customs issues and most importantly, established dimensional restrictions on modules being transported.

All of the above make it crucial for a developer/ contractor to understand the route a manufacturer must travel before signing a contract with it.

The additional cost of the transportation must be carefully balanced with the additional square footage gained per trip and crane lift cost in a wider load. If there is sufficient economies of scale, the larger volume modules will actually reduce the total transportation cost even though the per trip cost is higher.

Shipping costs are billed separately on a per mile basis and these costs must be weighed against the savings in modular technology. Modular builders have begun utilizing both sea barge and helicopter delivery to islands or particularly remote locations, but this has not yet become widespread. Despite the obvious difficulty inherent in such complicated transport it may often be a more cost effective alternative than utilizing a site built method in expensive labour markets or locations with poorly trained construction trades.

D. On-site assembly/installation

Once the modules are ready, they are shipped to the site and fastened together. Module installation includes matte line connections for MEP, exterior finishes and interior finishes, where applicable.

The tolerances for such connections have decreased considerably over the past fifty years and can be as little as 1/32nd to 1/16th of an inch. The final construction stage includes completing exterior systems such as cladding and roofing components and internal spaces like lobbies, stairwells, and elevator shafts.

The crane is the most expensive part of the installation process with costs of USD 3,500 to USD 4,500 per day, not counting police details or road closures. Since cranes are classified by tonnage the larger the crane the more operational flexibility one has. When selecting the type of crane it is also important to consider operational manoeuvrability of the crane and surrounding airspace.

3. Main risks attributable to modular construction.

Modular construction projects, like any other construction projects with traditional technologies, have to face a large variety of risks, which range from intrinsic to external events. Because of the nature of this innovative method of construction, new risks emerge and the risks that are relevant for traditional construction methods could be mitigated or increased.

This chapter will focus on the insurable risks and in particular from a Contract Works and Delay in Start Up point of view.
Mirroring the previous chapter we shall review the risks in each of the following macro-phases: A) design B) off-site fabrication, C) transportation to site, and D) on-site assembly/installation.

Although we delve into detail on each, we want to highlight that throughout the project it is important to evaluate the:

1. risk management procedures
2. experience of and relationship between the parties involved in the project
3. delivery plan, including construction programme

When investigating modular construction, this WG identified the above as paramount to the successful delivery of a project and should be regarded as critical factors to underwriters when evaluating a risk.

3.1. Design

A key risk in the design phase is that many elements of the building must be set in this early stage, giving developer's limited flexibility.

There is a heavy reliance on the supply chain engaged during this time, with their early involvement being critical to the building delivery. Although this is more of a consideration for professional indemnity underwriters, underwriters of Contract Works policies need to have comfort in the entities engaged - if members of the supply chain go bust there is an increased risk of:

1. Project costs increasing
2. Programme delays elongating underwriters' exposure
3. The cost of module replacement after a loss increasing

The interface with the design and off-site fabrication is also critical for underwriters to review and understand, notably if different trades are engaged for each phase. A lack of project management and clear alignment of responsibility, increases the risks of a problem arising during the build - modular construction requires a higher degree of collaboration from commencement to completion of the project. In the next section, we have focused further on the risks of systematic defects, arising potentially from this design phases or later in the programme, during modular construction.

3.2. Off-site fabrication

The main risk in this phase is that an error in design (as noted above), defect in fabrication or error in manufacturing could occur. If the error or defect was repeated systematically in the modules produced because of the automated process, it could lead to a serial loss.
Quality checks are generally performed on the materials that arrive to the factory (inbound quality check) and on the final components produced (outbound quality check) in order to mitigate this risk; if the quality checks were not performed or not done in an appropriate way, the faulty modules would be delivered to the construction site and installed.

Other considerations need to be given when considering the likelihood of an error or a defect during the fabrication process.

1. The automated process requires higher precision in measurements and tolerances. Indeed specific production machines are used and this enhances the quality of the products
2. Each single module produced can be traceable and in case of issues, it could be identified before it arrives to the construction site. Analysis can also be done on the source of the problem in order to improve the control of the whole production.
3. The factory environment can guarantee a higher quality of the components as they are not exposed to weather and other external events during their fabrication.

All these factors result in an increased quality certainty of the components produced off-site in the factory rather than on-site.

The above shows that fabrication process, because of its intrinsic characteristics, can mitigate the probability of error in design, defects in fabrication or error in manufacturing, but the concern still remains that if an unidentified error or defect occurs, it could affect several components resulting in a single or multiple loss.

Once the modules are produced, they can be stored in the fabrication building or outside, waiting for the shipment to the construction site. Depending on the coverage afforded under the Contract Works policy, attention should be given to the means of storage and possible exposure to events that could damage the modules (e.g. collisions with vehicles circulating in the premises, weather events).

It's also important to mention the cyber risk: the design macro-phase uses dedicated software and the production process is highly automated. For example, BIM software is used and SCADA systems are in place for the supervision of the modules fabrication activities. Errors in design or in fabrication can arise from IT system failures or cyber-attacks leading to serial losses, with the whole module production affected. This could be also very important while assessing Delay in Start Up exposure.

3.2. Transportation

In terms of transportation from the factory to the project site, risk factors include:

1. improper stacking of components,
2. lack of professional stacking tools,
3. lack of professional transportation tools,
4. lack of logistics network,
5. long transit distances
6. insufficient transport road conditions (including the radius of gyration of the road and the limit of the bearing capacity of bridges)
7. transport vehicles not meeting safety requirements, or being inadequate for the size and weight of prefabricated components (or volumetric units/pods)
8. lack of adequate measures to secure the modules in a safe position during transportation

While marine coverages are dedicated to these operations, it is worth checking any interactions with the Contract Works policy should any marine extensions be provided.

The evaluation should focus on the storage and method of transportation of the modular components. Therefore, the attention should be pointed to where and how the modules are stored, taking into consideration their exposure to external events (e.g. weather) or collision with vehicles.

It is important to ensure that the correct method of transportation is selected to cope with the completed modules' dimensions and weight, minimizing the chance of damage (e.g. water services connections).

Distance between the factory and the construction site, and the roads conditions have to be taken into consideration in the risk assessment phase.

It's worth mentioning that sometimes physical loss or damage occurs during storage or transportation that is not identified immediately, so the modules are installed on-site. Then the issue becomes evident later, for example during the testing or even during the maintenance period. In this case it could be expensive to identify where the damage is located, disconnect, remove the module and substitute it or repair it.

3.3. On-site assembly/installation

The first issue that could occur at the very beginning of the installation operations is related to the mismatch between modules and foundations built in situ. Because various parties are involved in the process from the design and fabrication to the installation of modules, there could be a lack of coordination, communication problems and/or different standards used. This could result in an incompatibility between the foundations and the modules. The stability of the entire building could be affected.

As modular elements are used for multi-floors buildings, lifting operations can be critical because of the dimensions and weight of the single module. Appropriate cranes should be used in consideration of the module loads, and the operators should have suitable experience to perform these activities in the correct way

Surrounding properties are part of the evaluation, especially if the project is developed in a densely urban area. Due to the layout of the construction site, cranes may not be positioned in the optimal spot, leading to an increased risk during the lifting operations. Also potential damage to third party properties have to be considered.

Errors during assembly and connection of modules may occur which could become evident during testing activities. For example, issues in MEP connections (e.g. water leakage) during testing, can be expensive and time consuming to repair within the damaged module.

Underwriters need to have assurance of the potential costs of repair, which could be heightened if a module or any prefabricated element suffers physical loss or damage during the on-site assembly phase. Additional costs may arise from the potential difficulty to:

1. Discover damage
2. Repair damage onsite

In certain circumstances, it may not be possible to repair a module and as such it would require removal from the rest of the linked units, exacerbating the cost after physical loss or damage has occurred. Even if repairs can be made on-site, the cost may still be inflated in comparison with the original build cost declared due to availability of materials, cost of labor and issues with access to the damaged part.

The following risks should be considered:

A) Fire risk

From a fire risk point of view it is important to evaluate:

1. fire safety measures;
2. materials used;
3. compartmentation

The modular construction industry has addressed fire safety considerations by means of direct compliance to building codes. Demonstrating direct code compliance is a costly endeavor for modular construction. Moreover, currently building codes were not conceived for addressing the particular design constraints encountered in modular construction. As a result, fire safety solutions in modular construction are inevitably suboptimal in regard to performance and cost.

Information specific to modular construction is not currently included in National Fire Protection Association codes and standards, but a number of NFPA documents have already been identified as places where that information could end up in the future, including NFPA 5000®, Building Construction and Safety Code®, and NFPA 101®, Life Safety Code®(Verzoni, 2019)..

If the modular construction industry could set a standard, or build codes amended in respect of this form of construction, it would give the insurance industry assurance in respect of the fire risk. However, it is important for underwriters to note that an estimated 80 per cent of the built environment in developing nations lacks codes and standards, and therefore lacks qualified code officials, according to experts from the World Bank Group, who were interviewed in October for an NFPA Journal article on fires in shantytowns (Verzoni, 2019).

Compartmentation is a fundamental principle in the fire safety of buildings. Walls and structural elements need to maintain their integrity in a fire for a defined period. Attention to detail at manufacturing and installation is key as fire and smoke will get through even small gaps and spaces in walls, ceilings and floors, so getting the fire stopping right is essential. Consideration also needs to be given to in-life and maintenance works such as upgrades, unit replacements, cabling and plumbing alterations.

Design and manufacturing tolerances may need on-site alignment at the assembly stage to ensure the systems will perform as designed and specified. Connection and continuity of all services at the fire boundary therefore needs to be simple and effective to account for such tolerances.

Key challenges exist in ensuring a design can be effectively realized on-site. A firewall needs to be effective from both sides - plumbing, ventilation, and other services including electrical and data services need to be lined up to ensure the fire compartment’s ongoing integrity.

Different materials are used in modular construction. Timber frame or composite panels with highly combustible insulation material such as polyurethane (PUR) or expanded polystyrene (EPS) are not rare; in those cases, fire could spread more quickly. Fibre reinforced composites (FRCs) have been increasingly used in the modular construction industry owing to its high strength-to-weight ratio, ease of application and flexibility in manufacturing. FRCs can be used in modular construction for both structural and non-structural applications. The major hindrance for composite elements in modular construction is their fire performance. Depending on applications and local regulations, there will be different requirements for FRCs on the fire resistance and vertical flame spread. There is limited information available to structural and façade engineers/designers on fire safety of FRCs especially for modular buildings.

In the fire risk analysis it is important to evaluate if fire divisions are effectively in place, as they could help to mitigate the loss scenario. When modules are linked together there could be gaps through which smoke and fire could spread. Fire compartmentations could also be undermined by drilling the modules in order to install additional services (not included in the design macro-phase): that is clearly a risk aggravating factor.

B) Natural catastrophes

Generally, modular construction allows a shorter construction period compared to traditional methods, therefore the construction site is less exposed to Nat Cat from a time perspective.

On the other hand lifting activities are more susceptible to damage from extreme weather events, and even the structures themselves (e.g. high-rise buildings, steel structures often used in modular construction) could be more affected by heavy winds before the whole structure is made stable. The stability of the structure depends on the connections between modules and connection to the structural core, and small misalignments in bottom floors could translate into large deviations at the top, more severely with greater building height.

As for earthquake, connections between foundations and modules, or between modules should be properly designed and implemented in order to face seismic events. As modular construction is a relatively young technology in comparison to a traditional builds, there is inadequate testing experience of earthquake exposure especially in respect of high-rise buildings.

C) Water

Modular units and connections between the modules are highly exposed to water damage during transportation, storage, lifting and assembling (mainly due to numerous connections and seams). Moreover, as described previously, there could be gaps between modules and damage could occur as water permeates through such gaps.

The construction site can be exposed to heavy damage from rainfall and it is important to check if the water damage mitigation plan (during storage, lifting and assembling) exists. The water damage mitigation plan must also consider internal escape of water.

Regardless of the source of the damage, it is important to note that once modules are stacked upon each other, it is difficult to access and repair the damaged component of the module; this becomes very critical if the module affected is at the base floors of a multi-level building and there is the need to disconnect, remove and substitute it.

4. Survey and risk management

Since modular construction is by nature distinct from conventional construction, existing risk management research for standard on-site construction cannot be directly applied. We have again broken down our review into the four main macro-phases of the process (as per previous chapter).

The aspect of loss prevention must emanate from the Project Management and carry through to supervisors, tradesmen, craftsmen and laborers. There should be a written Risk Register which is updated regularly to identify all critical objectives of the project: Impacts of identified risk factors on loss expectancy, project cost, duration etc. have to be assessed, then mitigation has to be developed case by case. A framework and roadmap for the integration of BIM into managing risks is to be provided.

4.1. Design

Crucial elements are to be identified at an early project stage. The following should be considered while assessing the risks:

1. **tolerances for connections** of the prefab modules have decreased considerably and must therefore be carefully considered: these variances will create issues when units are brought together in stage 3. Plans for dealing with these variations need to be elaborated by the contractors in advance. Insufficient coordination between prefabricated and other components (e.g. foundations) is a key risk.
2. **5 Ps (prior planning prevents poor performance)**. Importance of the design development macro-phase of modular construction cannot be overstated. Nor can ensuring all parties involved understand the limitations on future changes once the construction begins. When everybody understands that the smallest change will quickly erase any benefits of time or cost that a modular delivery model should ultimately provide, the project begins on the right path.
3. **project schedule** should as well be taken into account: too ambitious timeline as a sales argument for modular construction may lead to careless work.

4.2. Off-site fabrication

Factory production needs to be inspected repeatedly. In-plant risk factors (degree of facility's fire protection, fire alarm, air monitoring, mold prevention, storage, cybersafety) are the new ones that have to be considered in addition to general and on-site risk factors. The latter two apply to traditional construction risk management also but need greater emphasis when it comes to modular due to the fact that there are higher value materials at the off-site locations.

The following should be checked while assessing the risks:

1. **coordination between the manufacturer and the trades** is particularly necessary if equipment is to be optimally installed during the production stage.
2. **quality assurance plan** is crucial. All involved parties (including insurers) have to understand when and how inspections take place in the factory. When reviewing, please note that the relevant regulations are those of the project location (not the factory).
3. **risk of cracks** - insufficient strength of prefabricated concrete components and insufficient strength when lifting the prefabricated concrete component.

4.2. Transportation

1. **careful driving** is a must as damage and cracks are often experienced. The condition of the (temporary) roads surrounding the project must be able to accommodate the weight and size of the module delivery.
2. **cold/heat/moisture exposure** during transport is to be assessed. Protection has to be planned accordingly. It is usually not practicable to store large quantities of modules on site. Just in time (JIT) installation prevents unnecessary double-handling. Temporary weather protection may be required to reduce the risk of water damage.

4.3. On-site assembly/installation

1. **coordination**: all major trades (typically MEP contractors) are required to be involved early in the design macro-phase already. That way the design team fully understands which tradesmen will connect the parts and pieces on-site, how the work will be completed and to what level the units need to be finished before a particular trade begins work in order to minimize potential rework
2. **lifting risks**: increased use of cranes is required in modular construction. The crane deployed on site must be able to handle the weight of the modules and its location has to be properly planned so it reaches all blocks for the installation of modules, whilst mitigating exposure to third parties. Lifting and rigging procedures should be in place (e.g. critical lift operations should be defined, regular inspections of tools/cranes/forklifts are required, experienced contractor for lifting operations, certified and tested cranes in accordance with applicable regulations, solidity testing to verify ground condition suitability). Insufficient radius of crane operation and insufficient lifting capacity of lifting machinery are critical issues, especially in volumetric modular construction.
3. **quality inspection**: Lack of:
   - quality inspection methods,
   - technologies to test the quality of connections,
   - quality acceptance method and standard system,
   - catalogue of building parts and components,
   - proper testing and certification of materials and accessories used for component installation
   - could all lead to large losses.
4. **Project management assessment**: Project management should include centralized organization, management and accountabilities for detailed engineering supervision to oversee project execution at the yard and provide high level support and coordination, quality control, planning, cost control, engineering, procurement etc. Module transportation and coordination of the relevant contractors are key challenges during project execution.

   An integrated project management team comprising experienced personnel is required to oversee project execution. Contractors' experience including a contractors'' reference list in respect of the selected technology and type of project, its reputation for meeting schedule and budget is to be assessed.

4.4 Probable Maximum Loss (PML)

As PML estimations for buildings are usually based on fire events there is little difference to other types of construction regarding the loss amount: at the final stage shortly before commissioning the full value is present on site but fire detection and suppression systems are still inactive.

For the alternative PML scenario "earthquake" the structure has to be examined regarding its earthquake preparedness/resilience in critical stages (high value but limited stability). When it comes to stacked modules (see figures 1.5) rigidity might be even higher than at conventional structures.

Attention: if marine cover (transport insurance) or the producing factory is included in the scope, these must be taken into account and could possibly trigger a lower but more probable loss e.g. Normal Loss Expectancy (NLE).

The level of maintenance cover is crucial when it comes to faulty design cover within Contract Works policies, for example: extended vs guarantee maintenance combined with the defective design, material and workmanship exclusion selected.

5. Underwriting considerations

5.1 Policy Interface Issues (on-site vs off-site)

Contract Works policies normally cover suppliers for their on-site activities only. In modular construction, there is necessarily a larger component of off-site activities. It is up to the underwriter to decide to which extent they are covered, taking into account the complexity of the particular project and requirements of the insurance coverage.

A first point to consider is the definition of site within the policy as it could vary between three scenarios:

1. the single address where the building is located (i.e. works site);
2. include named off-site locations (like a batching plant i.e. concrete, or the manufacturing plant of the modules)
3. "anywhere in connection with the project", which implies countrywide or even worldwide cover.

In case the coverage is not limited to the single location of the construction site, such as in the case of Item 2. and 3. above, the underwriter should consider the likelihood of damage away from the construction site, requesting the necessary information from the Insured, and if necessary mitigate their exposure by:

1. specifying the particular named worksite locations in order to assess NatCat or aggregation exposures;
2. Conducting risk survey on the exposed locations;
3. Imposing sublimits and deductibles for locations with high exposure
4. Imposing monetary sublimits of territorial restrictions for damage to unnamed fabrication yards and storage areas.

The coverage could be provided in accordance with standard clauses of Contract Works wordings such as:
Off-site fabrication & Off-site storage.

An underwriter could consider specifying clearly which kind of fabrication yards or manufacturing plants are covered. For example, to exclude any place where original manufacturing is taking place or suppliers' premises where title of the item, part, unit, section or phase is not passed to any Insured Party. This specification is key to ensuring manufacturing activity is not insured, as is the norm for an insurance policy covering a traditional build.

A second point is to consider the effects of all participants being named as insured parties under the policy. If their off-site activities are covered, the possibility of recourse under the suppliers and/or manufacturers' Product Liability policies are reduced.

Finally, given the large logistic exposure to transport the modules on site, any clash with existing Marine Transit policies needs consideration. The existence (or not) of an inland transport sub limit is quite relevant to manage this exposure, as well as additional conditions, such as a Marine 50/50 clause.

It is recommended to define within the Inland Transit Clause which means of conveyance are covered and which are excluded. If loading and / or unloading is included or not, and to specify territorial limits and/or a monetary sublimit.

In order to avoid any interface issues with other Marine Transit polices, it can be specified that the coverage of transportation, loading and/or unloading is provided unless such cover is specifically provided by the Marine Transit insurance policy.

The consequences of a loss or delay in the whole process compared to normal construction are larger. This impacts naturally the Delay in Start Up section and also significantly the supplier extensions, given the Contingent Business Interruption that could be covered (or not) under the construction policy. These aspects are further discussed in Chapter 6.

5.2 Maintenance cover:

Maintenance extensions in construction policies give the insured an extra reporting period – usually 12, 24 or 36 months- to claim for defects that cause physical loss or damage not identified at the date of hand over. An important restriction is that the losses need to occur on site and during the (construction) policy period. Depending on how the site is defined (see scenarios in 5.1 above), results will vary.

For example, if the construction site is defined as a single address and the modules have (off-site) fabrication defects, it can be argued that they are not covered as the common extended maintenance clause contains the following condition:

provided such loss or damage was caused on the site during the construction period

Due to that clear definition of the site and off-site locations is critical for insurance wording.

Also the differences between maintenance clauses (e.g. extended, warranty or Munich Re clause 004, 201) can have a similar effect on cover. In the case warranty maintenance is granted, the design and prefabrication of the modules would be fully insured. If extended maintenance is agreed, then only activities during the construction period would be covered.

5.3 Defects Coverage

Whenever Contract Works wordings include defect exclusion clauses such as LEG2/LEG3 or DE3/4/5 versions, the insured receives a different extent of cover for faulty material, design, or workmanship.

If there is physical loss or damage arising of any of those, the policy will be triggered and insurers would pay an indemnifiable claim, but seek recourse against the supplier or designer for their defective design.

If the insured also has design and manufacturing responsibility, no indemnity from the product liability perspective can be attained as subrogation rights against insured parties may be restricted. An example is if module manufacturing plants are owned by the contractor.

Nevertheless, the question remains if the modular construction activity is considered predominantly as a service (“work”)executed by a builder or a “product” delivered by a supplier. There is a big difference in coverage if the proximate cause of loss is identified as faulty installation or handling on site, versus a defect of the manufactured product. In this situation, if a debate ensues, it will require a judge to define the “predominant factor”. To date tendency is that the “work” interpretation prevails, with modular builders treated as subcontractors (Haskell,2018).

The difference between defect and damage is already a hot topic in standard policies for conventional projects. Introducing manufacturers as third parties to a project aggravates the risk.

5.4 Serial Losses

Module suppliers advertise the better quality of their product, as created under controlled factory conditions. Indeed, adequate and verifiable quality controls on plant (e.g. sampling every X number of modules) could effectively reduce the exposure for insurers (see Chapter 3). Nevertheless, modular construction requires tighter specifications and has different material tolerances, so in case a problem remains hidden and/or only manifests after site assembly, it could multiply to all modules very quickly and cause a significant loss.

It could also be a gradual process, so not all modules could get affected at the same time. Discussions on what constitutes "damage" vs. "indemnifiable loss" would inevitably follow.

Here is where a Serial Loss clause plays an important role in mitigating exposure. Insurance coverage could be drafted to take this additional exposure only up to a certain number of events (application of Serial Loss Clause).

A final consideration is that once established manufacturers have gained experience, the modules for buildings become less complex, so serial loss exposure falls, but underwriters should be cautious as the exposure may increase again if the module design is altered (e.g. higher buildings with more modern geometries).

The quantum of the loss will depend on the stage when the defect is discovered. The most critical situation may occur during the construction phase with defects discovered within modules on lower levels when higher levels have already installed. If Delay in Start Up coverage is provided then this may significantly influence the scale of DSU loss.
Delay in Start Up exposure should therefore be taken into account in a Serial Loss scenario.

Underwriters should also give consideration to the application of the policy deductible in the event of multiple damage events of the same nature. Whether each incident of damage is treated individually, or all occurrences are grouped together as one larger single loss, and how the deductible applies in these scenarios can be the source of prolonged claims discussion. It is therefore worthwhile achieving an agreed, contract certain position on the policy at inception to avoid disputes. Achieving clarity within the wording as to whether the deductible applies to each individual incident of the same damage, or whether it may apply per module, completed apartment unit or even building, will make the position clearer for all concerned.

6. Delay in Start Up (DSU)

In addition to increasing the severity of the loss potential, Delay in Start Up cover being purchased on policies covering modular construction projects can exacerbate certain cover clauses already highlighted within this paper, in particular the defective, design, material and workmanship exclusion and the Serial Loss cover granted.

Underwriters need to assess how the particular modular construction methodology could impact the potential for more costly DSU losses than traditional construction methods.

Calculation of the sum insured

Modular construction methods can be used across a wide range of projects, which may have varying requirements for DSU cover. Ranging from advanced loss of gross profit or revenue to debt servicing or payment of fixed costs. As with any DSU cover it is essential that the underwriter understands the make up of the sum insured and assesses the impact on the insured revenue in the event of a loss.

The IMIA and LEG published 'DSU Tool Box' (IMIA/LEG 2013) is a useful resource for assisting all parties involved in establishing the correct Advanced Business Interruption sum insured.

Underwriting Information

1) Project build sequence

Modular construction by its very nature can lead to significantly reduced site build periods and just in time delivery of modules can create less of a buffer period within the project time schedule, with less scope for time to be recovered in the event of an insured loss.

2) Lead times

Underwriters need to consider:

1. What is the ability of the original modular manufacturing facility to reproduce replacement modules post loss?
2. Is the manufacturing facility experiencing sufficient demand for there to be an extensive wait for new production?
3. Will there be much flexibility when a factory is working on a different production run?
4. Where is the manufacturing facility and how long will transit of materials to the site take?
5. Could transit times be influenced by seasonal weather patterns?
6. Can alternative factories be used to reproduce damaged modules?
7. Are the construction workers and the subcontractors flexible and do they have easy relocation of workload between the modules facilitating the progress and schedule of the works?
8. Will minor damage to a module mean that complete re-manufacture is required in the event of a loss? Will this create longer lead times than repairs or replacement to traditional manufacturing methods?

It is important:

1. to analyse the time schedule to consider a narrow timeframe;
2. to define critical modules, critical path activities, to analyse lead-time for modules;
3. to assess the risks with respect to weather delays, inaccurate quantities, accidental damage, late delivery of essential modules, late supply of equipment, interference of one contractor with the actions of another.
4. to understand the extent to which modules can be repaired onsite

Any errors in supply or fabrication can translate into significant delays. Usually the average lead-time for standard modules are assessed as a period of 10-16 weeks.

Scope of cover

As with all DSU policies, it is important that the policy language reflects the intension of the cover and features particular policy exclusions. Some elements worthy of consideration for modular projects include:

1) Suppliers and Manufacturers extension

Thought should be given to the perils and sub limit granted should a suppliers and manufacturers extension be offered. Certain modular methods can place more time and risk on the manufacturing process than at the site. It is important that underwriters consider the risk of the manufacturing premises including the fire and environmental perils. Even if cover is restricted to FLEXA perils only, many modular materials can have high combustible loads so a thorough assessment of sprinkler and fire fighting protections is required.

If such cover is granted, then accumulations should be checked across multiple policies where projects are sourcing their modules from the same manufacturing facility.

2) Delays due to redesigning, adding or improving the insured property

Due to the multiplication potential of a design issue on a repetitive modular project, any cover given for redesigning the manufacturing process could be very costly and go against the intent of the underlying Contract Works cover (for example the defective design, material or workmanship clause and extent of cover for serial losses)

3) Progress monitoring

As with DSU cover for any type of construction project it is recommended that underwriters work with project teams to monitor project progress, allowing a much clearer picture of insured delays versus non-insured delays should a loss occur and subsequently making it easier and quicker to adjust claims. This is particularly relevant for modular projects which can have more rapid time schedules than more traditional construction methods.

4) Time exclusion

Thought should be given to increased DSU time exclusions should the lead time for manufacturing replacement modules be deemed prolonged compared with traditional build construction.

5) Maximum Indemnity period

Due to shorter build periods and therefore reduced rebuild periods following a loss, the DSU sum insured may be compressed over a lesser maximum indemnity period leading to a larger per week claim potential.

7. Case studies and claims

Here are some loss examples from modular construction projects. It is however important to note that the advancements in modular construction, especially driven by the technology available to industry professionals now, is relatively new. Consequently, there are not a significant number of claims to discuss at this stafe.

7.1. Fire in Hotel and Bird Observatory on the Shetland Islands, UK

The 106-bed Moorfield Hotel was built in 2013 from modules constructed in a factory in Northern Ireland out of structural insulated panels– combustible polyurethane insulation held between two sheets of oriented strand board, a product made from compressed wood flakes.

Volunteer firefighters on the tiny island (population of only 60) found themselves facing a fire they could not hope to contain. Additional firefighters landed in helicopters and arrived by ferry. But like the hotel, the observatory was reduced to a pile of wreckage. The fire brigade didn't have the equipment to deal with it.

The modular boxes were stacked on top of each other, with some gaps between them – a risk identified earlier in this WGP. Gaps or cavities can potentially run straight through from the facade to the core of the building, so when a fire gets into the cavity it is just going to spread from one compartment to the next. Building regulations require these cavities to be fitted with barriers so fire cannot spread.

Lessons learned:

A lack of adequate compartmentation; absence of the fire-proof inner walls; and wide usage of combustible material were likely to be key factors in the uncontrollable spreading of fire.

The presence of a systematic error throughout the building, a key risk of modular construction, appeared to contribute to the severity of the fire.

Source: https://www.bbc.com/news/uk-scotland-north-east-orkney-shetland-57942459

7.2. Cracks during construction of a hotel

The hotel's façade is formed out of prefabricated brick elements that are glued together in the factory and hung from the top on site. Cracks appeared shortly after installation on 180 of the total 600 prefabricated elements mainly along the glued joints. As a temporary measure to create safety against further cracking and collapsing, metal strips had to be applied along the sides of the prefabricated brick elements.

The prefabricated elements could not be repaired on site. Consideration was given to numerous repair options:

1. The idea came up to apply a carbon fibre reinforcement to all façade elements in order to resist the tensile forces that the joints were not able to cope with.
2. One option was to modify the whole attachment to the wall from hanging to standing.

The final decision was to disassemble and dispose the prefabricated elements and lay new bricks using traditional build methods.

Further issues arose thereafter,

1. The original design to hang down glued bricks from the top turned out to be unsuitable for the present application.
2. Due to the extended repair time the underlying plastic membrane was exposed to the weather without the façade's protection and needed to be replaced as well.

The total loss estimate (dismantling, scaffolding, masonry works, staff and experts) was approximately EUR 3.5 million

Lessons learned:
The cause of this claim lies with the improper design and prefabrication of the elements; however, it serves to highlight the difficulty of repairing and/or replacing manufacture built elements on-site. Underwriters, when considering modular construction developments, should engage with their client to understand to what extent they have considered how on-site damage to off-site fabricated components will be repaired. A lack of consideration by Insured's here, could not only cause disproportionate losses under the Contract Works section of the policy, but also heightened the risk of an elongated programme delay.

7.3. Defective material used for prefabricated elements that led to serial losses.

The project was the construction of onshore Liquefied Natural Gas (LNG) complex in arctic climatic conditions.

The implementation of the LNG plant installation was based upon modularization of the LNG plant. Modules were fabricated in overseas yards before being shipped to the remote site in a limited weather window, prior to installation. The project required the fabrication and assembly of approximately 240 modules with some potentially greater than 7,000 tones in weight.

Assembling of the LNG plant modules at the above mentioned yards included the application of a special coat to protect structural steel members, pipelines and tanks from the effects of hydrocarbon fires, cryogenic spills and splashing.

The type of coat applied depends on the intended purpose of a module:

- Fire retardant coat (passive fire protection, hereinafter – PFP),
- Passive fire protection (PFP) + cryogenic spill protection (hereinafter – CSP): PFP + CSP.

In winter period cracking of fireproofing coating and cryogenic spill protection was observed. Investigation showed that cracking occurred due to inherent properties of material used for coating under the extreme low temperature at site. The temperature differential between fabrication conditions and installed conditions in the Arctic resulted in a high level of thermal stress, which significantly reduced the capacity of the PFP system to withstand mechanical stresses. Consequently, usable strain levels in the coating were exceeded.

Following the inspection it was noted that PFP-painted modules showed evidence of peeling mainly on areas which were painted at shipyards by means of a pressure jet apparatus. On areas which were painted manually (by means of a paint roller) there was almost no peeling, which demonstrates how relevant the painting method/technique is for the occurrence of defects.

Preliminary loss figures were assessed as USD15m, though the actual sum of loss was lower as there were different types of cracks from hairline cracks to disbandment.

New coating material, certified for the conditions of the site, was used for repair. Additional surveys of modules were organized at site and at the collection yard.

Lessons learned:

This loss teaches us:

1. the materials should be certified for the climate conditions of the site**.** Manufacturer should test it in nature (not computer model approximation);
2. detailed information regarding quality control of material (incl. chemical composition) for critical technological pipelines and equipment at fabrication plants is required in order to check that all materials are installed in accordance with project specifications;
3. Principal should control methods and quality of paintings provided by Contractor. Thickness of PFP coatings should be checked and measured on the site and results are documented;
4. Due to high risk of serial losses for such type of projects it is recommended to sublimit the Passive Fireproofing Protection damage to LEG-2 and in monetary amount.

8. Conclusions

Modular construction has become increasingly popular, providing faster and more cost effective construction projects. There is no doubt usage of this methodology will continue to grow, for both low and high rise building alike and also in distanced industrial projects. Due to the nature of this innovative method of construction, new risks emerge, whilst the risks that are relevant for traditional construction methods can be mitigated or increased.

While assessing the risks connected with modular construction, underwriters and risk engineers should be aware of that risks arise not only on the construction site, but also during design, manufacturing and transportation. All of these risks should be carefully defined and assessed.

Throughout this WGP, we have highlighted the key risks and underwriting considerations for each macro-phase that are associated with modular construction rather than a traditional build. These include, but are not limited to:

1. The requirement for design to be set and agreed before the project can commence, with engagement from a key trades early in the process, presenting developers with potential supply chain reliance.
2. Close monitoring and control during manufacturing process is key, with inwards and outwards quality checks are needed to reduce the possibility of defects and serial losses afterwards
3. Heightened cyber and transportation risk
4. Issues connected with the mismatch between modules and foundations built in situ
5. The crane being deployed on site being able to handle the weight of the modules and the need for its location to be properly planned so it reaches all blocks for the installation of modules
6. Before the whole structure is made stable, modular buildings are highly exposed to winds and heavy rain during construction process.
7. There is not enough testing experience of earthquake exposure to modular buildings during construction, especially in respect of high-rise buildings.
8. Cost and complexity of repair may increase once modules are installed on-site
9. Heightened DSU exposure due to potential long lead in times

Although we have delved into each macro-phase, it must not be forgotten that the relevance of the following factors across the whole project is paramount to its success:

1. Detailed and robust risk management procedures
2. Experienced project team, that has the ability to co-ordinate and manage the various project phases
3. A clear delivery plan set at the design phase, for which all parties are aware and can adhere to

With modular construction, underwriters need to consider the merits of each scheme to determine if the positive risk mitigation inherent in this build methodology, with the controlled factory environment, outweigh the potential negative risk

9. Appendix 1 Key exposures of modular construction

Exposure	**Key considerations**	**Relevant chapters**
Manufacturing defects	Evaluation of risk management procedures/experience of parties involved in the design/manufacturing process is important in case defect coverage is provided. Serial loss scenarios are to be considered (incl. impact on DSU section).	3 4 5.3
NatCat: - hurricanes, tornadoes, cyclones - earthquake	Heavy wind is especially critical for high-rise buildings. The structure should be suitable to the extent of this exposure. Cautious approach for locations with high earthquake exposure is recommended due to limited experiences of testing of modular structures for seismic forces impact.	3 4
Fire	Module units compartmentalize fire and reduce fire spread under ideal conditions. Evaluation of the type of used materials and fire safety measures is required.	3 4
Water	High exposure (incl. heavy rains) during transportation, storage, lifting, assembling can be reduced by water damage mitigation plan	3 4
Rigging/Lifting risks	Lifting and rigging operations can be critical because of the dimensions and weight of the single module, high exposure due to usage of cranes. Lifting and rigging procedures that mitigate these risks are to be assessed. Surrounding properties/potential damages to third party properties have to be considered too.	3 4
Transportation risks	The evaluation regards mainly the way of storage and the way of transportation. The experience of involved parties, size of modules and variable transportation regulations/restrictions are to be taken in account too. High risk of potential time delays. Experience of transportation companies and proper coordination of all parties involved in the logistics of the project is the key issue.	3 4
DSU	Any errors in supply or fabrication can translate into significant delays. Shorter buffer periodCritical elements, critical path activities are to be identified, lead-time for modules is to be assessed. DSU exposure should be taken in account in serial loss scenario.	6

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