FLOATING STRUCTURE AND WIND TURBINE TRANSPORTATION PROCEDURE

Deliverable nº 5.1

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Project full title: *Demonstration and benchmarking of a floating wind turbine system for power generation in Atlantic deep waters*
This document outlines the transportation and logistics works that will be implemented in the frame of the Floatgen project. This procedure describes the methods and means envisaged for the transportation of the floater and Wind Turbine components. Finally the launching of the floater and the transportation of the FWT to the offshore site will be described in detail.
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1. EXECUTIVE SUMMARY

The deliverable 5.1 “FLOATING STRUCTURE AND WIND TURBINE TRANSPORTATION PROCEDURE” is presenting the construction and assembly works jointly done by GAMESA, BYTP and IDEOL. The document outlines the transportation plan for all the components of the FWT: the hull parts, the wind turbine and the mooring components. In addition we describe the launching of the hull, the assembly of the wind turbine onto the deck and finally we provide details on the towing procedure of the FWT to the offshore site.

2. INTRODUCTION

Construction site, WT integration and offshore site engineering has lead to the selection of a the “quay of Charbonniers” in Saint-Nazaire for the floater construction. It is the Contractors responsibility to bring all the components of the hull as well as the wind turbine components and the mooring system, to the port of Saint-Nazaire. All the constituents will be brought by road, or by cargo ship. In order to handle the parcels of any size, the port is equipped with all the facilities, and some temporary storage places where needed.

2.1 DOCUMENT REFERENCES

Standards and regulations

[R01] International Regulations for Preventing Collisions at Sea, 1972 amended 1996
[R02] Noble Denton – Guidelines for marine transportations – April 2002
[R03] IMO guidelines for ocean towing, resolution A765 (18)
[R04] DNV-OS-H201 Load Transfer Operations
[R05] IMO Code of Safe Practice for Cargo Securing and Stowing

Project documents

[S01] G02-CN-HYD-5508_Towing_Analysis
[S02] G02-MS-INS-9824_Towing Method Statement
[S03] G02-MS-CON-9607 Launching and harbour towing Method Statement
[S04] G02-MS-MAR-9704 Wind Turbine Integration Method Statement
[S05] G02.DW.INS.9387.00.A1 Mooring equipment arrangement on quay (draft)
FLOATGEN is co-financed by the European Commission’s 7th Framework Programme for Research and Technological Innovation.

Other publications

[T01] Le Grand Port Maritime de Nantes - Saint-Nazaire – Haut Comité Français pour la Défense Civile et Economique des Pays de la Loire – March 2011

2.2 ACRONYMS

AIS Automatic Identification System
CROSS Centre Régional Opérationnel de Surveillance et Sauvetage
DGNSS Differential Global Navigation Satellite System
FWT Floating Wind Turbine. The whole floating system producing power to the grid. It includes the wind turbine, the floating foundation and the umbilical system.
Hs Significant wave height
Kt knot
MWS Marine Warranty Surveyor
nm Nautical mile
SOG Speed Over Ground
TP Transition Piece
Tp Wave spectrum peak period
WTG Wind Turbine Generator
3. MOORING SYSTEM TRANSPORTATION

3.1 MOORING COMPONENTS

3.1.1 ANCHORS

The anchors will be purchased from a specialized company which will also be responsible for the delivery to Saint-Nazaire. The foreseen anchors, depending on selected design will have a mass of 12T to 18T with additional ballast filling the fluke. Each anchor will come in 2 parts (fluke and shank), measuring respectively about 7mx4mx1m and 3mx7mx3m.

Main foreseen suppliers are in the UK or in Netherlands. Both suppliers have manufacturing facilities close to quayside allowing transportation by special truck directly from factory to quay without limitations due to oversize convoy.

Anchors will be loaded from quayside to cargo vessel with vessel or shore cranes. The anchors will be too large to fit in standard containers so they will be stored and lashed either on top of other containers, deck or inside hull. Special care is taken with seafastening of the items, approved by Marine Warranty Surveyor prior to the voyage.

After sea transit, anchors will be offloaded in Saint-Nazaire harbour, in Penhouet Basin where the mobilisation of the offshore installation vessel will take place. The elements will be offloaded with vessel or harbour crane and stored at project storage area.

3.1.2 CHAINS

The mooring chains will be purchased from a specialized company which will also be responsible for the delivery to Saint-Nazaire. Each mooring line will include a bottom and a top chain segment, respectively 60m and 45m long and about 10T weight each.

Chains can either be transported in bundles or in containers, depending on transportation means used.
There are several options, in France, Europe or Asia. In the first two cases, transportation by road (containerised), river or sea (bundles or containerised) could be performed, while if coming from Asia, sea transport will be required.

Chains will be transported directly to Saint-Nazaire port, where they will be offloaded and stored at project storage area.

### 3.1.3 FORGED FITTINGS

The forged fittings will be purchased from a specialized company which will also be responsible for the delivery to Saint-Nazaire. The various items will weight in total circa. 10T to 12T, packed in several pallets or wooden crates. They can be transported as such or containerised.

Several potential suppliers have been identified, all of them in continental Europe. Therefore the preferred transportation mean for those item is by road, either packaged in pallets/boxes or containers. For some suppliers, partial transportation by sea may be interesting which will require transportation by containers.

Delivery will be done at Saint-Nazaire harbour, either by truck or cargo vessel. Equipment will be offloaded by harbour means (cranes, forklifts) and stored at project storage area waiting for mobilisation.

### 3.1.4 NYLON ROPES

The nylon ropes will be purchased from a specialized company which will also be responsible for the delivery to Saint-Nazaire as well as the provision of the spooling reels and lifting gear.

The nylon ropes will be spooled at factory onto reels suitable for road transportation and at suitable bending radius. Each reel will weight circa. 14T including the line. There will be a total of 9 reels (one per nylon rope segment purchased)
Supplier has been selected, and manufacturing plant is located in Belgium. Supplier is planning to ship reels by truck to Saint-Nazaire (oversize convoy, requiring an escort car and specific route) as it is the most competitive solution.

Once arrived in Saint-Nazaire, reels will be offloaded by harbour cranes and stored at project storage area.

### 3.1.5 PERMANENT BuoYS

The permanent buoys for nylon ropes will be purchased from a specialized company which will also be responsible for the delivery to Saint-Nazaire. The various items will weight in total from 12T to 24T (depending on whether minimal quantity is ordered or quantity for marine growth compensation), packed in several wooden crates. They can be transported as such or containerised.

Several potential suppliers have been identified, all of them in Europe. Therefore the preferred transportation mean for those items is by road, either packaged in crates or containers.

Delivery will be done at Saint-Nazaire harbour by truck. Equipment will be offloaded by harbour means (cranes, forklifts) and stored at project storage area waiting for mobilisation.

### 3.1.6 CLUMP WEIGHTS

The 6 clump weights to be installed on top mooring chains will be purchased from a specialized company which will also be responsible for the delivery to Saint-Nazaire. Each item will weight 20T. The weight should not allow packaging in pallets or containers so the clump weights will probably be transported loose, on trucks. They will be equipped with a suitable handling rigging.

Screening for potential suppliers has not been performed yet, but it is foreseen that a local steelworks manufacturer will be selected given the naval industry subcontractors network in
Saint-Nazaire area. Therefore the preferred transportation mean for those items is by road, on truck.

Delivery will be done at Saint-Nazaire harbour. Equipment will be offloaded by harbour means (cranes) and stored at project storage area waiting for mobilisation.

3.2 LOGISTICS IN SAINT-NAZAIRE AND STORAGE

3.2.1 PROJECT STORAGE AREA

All the equipment that will be required at time of offshore installation (including mooring system components) will be stored on a dedicated project storage area after their delivery waiting for the mobilisation on the installation vessels.

This area will be rented to Saint-Nazaire harbour and will ideally be located close to a quay where the mobilisation of the installation vessels can take place, in Penhouet Basin, near Quay des Charbonniers.

This area is well connected to road network and is used as the main port terminal for heavy lifts and bulky items loading onto cargo vessels, and is commonly used for temporary storage of shipped items.
It is estimated that a 2,500m² area will be required to store these mooring components (refer to [S05]). Depending on packaging of some items (mainly forged fittings) a sheltered area may be required to protect items from rain.

### 3.2.2 LOCAL MEANS

Logistics in Saint-Nazaire harbour will be managed mostly with local means which are widely available. IDEOL will contract a maritime agent (see below section 3.2.3), to manage the logistics interface with Saint-Nazaire port and the administrative side of work.

Many companies are operating within Saint-Nazaire harbour and can provide handling and lifting services (refer to Erreur ! Source du renvoi introuvable.).

It is foreseen that the following services will be required on site for transportation and handling:

- Heavy crane: 25T@15m, can be a mobile crane or a rail-mounted harbour crane
- Mobile crane: 25T@5m, revolving or rolling
- Forklift (heavy): 20T capacity - lifting a 20’ container
- Forklift (light): 2T to 5T capacity, for pallets handling
- Set of rigging for lifting of items

### 3.2.3 AGENT

Management and sourcing of local workforce, lifting and handling means will be performed through a maritime agent who is also qualified for stevedoring operations.

The maritime agent will also be in charge of managing the logistics procedures and paperwork, including interface with customs if required for elements imported from outside UE.

The agent will also manage the various aspects of the installation vessel support such as port master interface, rental of quay and fenders, providing useful contacts for ship-chandling, etc.

Preliminary discussions on various subjects related to Floatgen project has been conducted with SOGEBRAS, one of the most active shipping agent operating in Saint-Nazaire. SOGEBRAS is therefore foreseen to provide the maritime agent services for the logistics but also installation phases of Floatgen project in Saint-Nazaire.

### 3.3 LOAD-OUT ONTO INSTALLATION VESSEL

#### 3.3.1 LOADING OF EQUIPMENT

Mobilisation of the offshore installation vessel will take place in Saint-Nazaire harbour, in Penhouet Basin. The inbound mooring components will be transported from project storage area to the final mobilisation quay, where they can be loaded on installation vessel. Harbour cranes and means will be used for handling.

The installation vessel for mooring lines pre-lay will be a large Anchor Handling Vessel (AHV), circa. 80m to 90m long. The rest of the equipment can be loaded with the vessel moored alongside quay.
Mooring components will be lifted from quayside onto vessel deck where they will be repositioned if required with vessel cranes. Finally all equipment stored on deck will be seafastened to ensure a safe sea transportation and installation operation.

The load-out of mooring system components is described in the mooring pre-installation method statement (refer to [S06]).

### 3.3.2 SPOOLING OF NYLON ROPES

The mooring lines will be transpooled from their transportation reel (specifically designed) onto the AHV storage drums.

![SPOOLING OPERATION](image)

The storage reels will be lifted and installed on a spooling winch that will be placed facing AHV storage drums (either on deck or on quay, in which case the AHV will be moored stern-to-quay). The spooling winch will pay out the nylon ropes, which will be transferred and picked-up by AHV drum. A small tension (circa. 5T as a minimum) will be applied to ensure rope layers pack correctly on AHV drum and avoid damage to nylon rope during installation.

The transpooling of nylon mooring ropes is described in detail in the mooring pre-installation method statement (refer to [S06]).
3.3.3 LOAD-OUT OF CHAINS

The chain will be taken out of storage area and brought alongside quay in bundles with its lifting slings in place. Bundles will be lifted onto installation vessel deck.

Installation vessel is equipped with suitable gipsy wheels for loading chains into its chain lockers. Chains will be connected to each other with dedicated rigging to form a long section and ease handling and retrieval of chain segments from lockers.

In the unlikely situation where the installation vessel is not able to transfer the chains in its lockers (or if suitable room is not available) then the chains will be laid flat on deck, untwisted, and lashed for sea transportation.

3.3.4 ANCHOR ASSEMBLY

Anchors will be transported in 2 parts (plus connecting elements) and thus will need to be assembled during mobilisation to avoid this operation to be performed offshore.

The assembly of the fluke with the shank of the anchor will be done following supplier instructions. It consists in engaging the anchor shank in the fluke, placing the shank at the correct angle, locking the shank with the supplied pins and welding the plates locking the pins.

Anchors assembly will therefore require lifting means as well as welding capacity. This can be performed either on vessel deck, where anchor can then be dragged on deck to its final
position for lashing, or on quayside, where the assembled anchor is then lifted on vessel deck.

### 3.3.5 LASHING

The various elements that will be loaded on vessel deck will undergo seafastening and lashing to ensure their stability during the transportation to offshore site and throughout the offshore installation operations.

The deck of the installation vessel will be equipped with D-eyes, anchor points or steel frames that will provide suitable points of attachment for lashing. The lashing will be also connected to the side walls of the deck. Lashing will be mostly made of chains tightened with turnbuckles or chain binders. Additionally, if containers are used on deck for storage of items, pallets or boxes, ISO corner locks will be used.

Seafastening and lashing will be performed according to recognised standards such as Noble Denton Guidelines for Marine Transportations [R02] or IMO Code of Safe Practice for Cargo Securing and Stowing [R05]. Seafastening will be reviewed and validated by a MWS.

![Figure 4: Seafastening of Anchors on Deck](image)
4. FLOATER TRANSPORTATION

This chapter aims at presenting the transportation scheme of the floater. It covers the components transportation from the manufacturing site up to the yard and the transportation of the floater itself from the construction site to the WT integration site.

4.1 FLOATER CONSTRUCTION SITE

The floater will be built on a yard of Saint-Nazaire port, owned by the Grand Port Maritime de Nantes Saint-Nazaire (public organization). Load bearing capacity of the quay is compliant with the foreseen construction and launching activities. An occupation contract with the Port is being signed for the duration of the works.

Several ways of communication lead to Saint-Nazaire. A motorway is feeding the hinterland. The road to the south is naturally passing through the Cheviré bridge which truck capacity is 44 ton.

All of the rail traffic of the port cross Le Croisic, Saint-Nazaire, with possible segregation from Savenay, either towards Nantes, Angers, the Paris region, the center and the South of France, or towards Pontchâteau, Redon, Rennes and the West of Brittany.

Very few river transportation is possible beyond Nantes, situated 60 km upstream Saint-Nazaire.

Accessible by a well-marked out channel, in the daytime and at night, an access of the port can be made by, more or less, all the weather conditions.

The intended berth where the floater will be built is part of a steady water basin (Penhouët basin) that will highly facilitate the launching of the structure with no tide range to manage. The quays are made of masonry with an embankment behind made of sand and alluvial muddy over the bedrock.
The Quay of Charbonniers can be reached by a heavy load road that is suitable for any kind of truck, ready mix concrete truck, overload trailer etc...

The construction site will be prepared several weeks in advance with the assembly of all the lodgings, offices, lavatories. One tower crane will be brought on the site and assembled with mobile crane. Construction aids and various equipment are also brought by trucks on the site. See below figure for detail on construction site lay out.
It is to note that the construction of the floating foundation into a dry dock has been discarded due to some incompatibility with the Floatgen project.

4.2 FLOATING STRUCTURE COMPONENTS TRANSPORTATION

In order to perform the floater construction many components must be brought to the yard. Main components are the concrete, the reinforcement steel, the post tensioning tendons and ducts, the embedded items, the deck equipment. All the construction aids will be brought by road: tower crane elements, scaffolding, offices and lavatories, mobile crane, a complete set of formworks, tools and construction aids.

Some of the deck equipment is possibly coming by cargo in the port: the transition piece, the Mooring interface structures (heavy steel parts), the deck winches etc... depending on the selected manufacturing site. The port is equipped with fixed cranes and low bed trailers in order to offload any vessel and store the equipment closeby the construction site.

4.2.1 CONSTRUCTION FORMWORKS
Regular formworks and stays are hired for the project. Formworks are assembled on the site with basic elements coming from the renter. All the equipment will be brought to the site by truck.

Some particular element of the construction required tailor made formworks, bought for the project (special corner for instance). In this case the factory will arrange an oversize transportation to the site with a dedicated planned route.

The intended sequence of the construction requires that two complete sets of formworks will be used to perform the construction, block by block.

4.2.2 REINFORCEMENT STEEL

In general, for heavy construction such as the Floatgen floater, the reinforcement steel is brought pre-assembled on the site. A designed factory (in less than 100 km radius) will be manufacturing the steel packages that are compliant with the local transportation plan (road size, free height) and transport them to the site on trailers. Steel is then offloaded on the preparation area ready for implementation into the formworks.

It is intended to install 700 ton of steel to complete the floater construction, or the equivalent of 30 trailers of about 24 ton each.

4.2.3 READY MIX CONCRETE

Ready mix concrete made in factory benefited these last years of improvements of the techniques of elaboration of the concrete (Ready-mixed concrete) and its implementation on construction site: pumped concrete, coffering more successful, safer and better adapted
to needs - formworks, tables, coffering tunnels, slippery coffering. The quality of the concrete is improved, there as well as its finish, in particular thanks to the self-compacting concrete. The industrial production of the ready mix concrete is a quality factor of concrete. Ready mix concrete will be brought from the factory to the site in less than 30 min and shall be placed into the forms within 1h30 maximum, in order to guarantee the quality of the product. It is intended to place the concrete into the formworks with concrete pump, either by injection (self-compacting concrete) or poured from the top. The total volume of concrete for the completion of the floater is 1800 m3, or the equivalent of 300 concrete trucks (typical 6 m3), to be staged in 5 month of works. Several ready mix concrete factories are established in a very close perimeter around the construction yard.

![Concrete Pump Pouring Illustration](image)

**FIGURE 8 CONCRETE PUMP POURING ILLUSTRATION**

### 4.2.4 HEAVY STEEL PARTS

Some of the deck equipment will be manufactured in the Port of Saint-Nazaire. Saint-Nazaire is a major place for the ship construction (STX shipyard with subcontractors) as well as the ship conversion and repair, thus many boiler works and steel forging workshops are established in the port. Alternately the heavy steel parts could be brought oversea by cargo. The port is equipped with all the logistic and storage area to handle the heavy parcels such as the transition piece.
(50 ton), the mooring interface structure (6x 8 ton), the i-tube (8 ton), the boat landing (8 ton), the top connectors (6 x 6 ton).

A tentative of required area for the equipment storage is presented here below:

![Diagram](image)

**FIGURE 9 - 850 M² ARE ENVISAGED FOR THE DECK EQUIPMENT STORAGE TO BE INTEGRATED ON THE FWT**

A Maritime Agent will be contracted to operate the parcel move and storage upon client requirements.

### 4.3 FLOATER SKIDDING, LOAD OUT AND LAUNCHING

#### 4.3.1 GENERAL DESCRIPTION

IDEOL and BOUYGUES TP have developed a methodology to perform the launching of the completed floater at sea, in the port of Saint-Nazaire. After clarification process with the major heavy lifting operators established in Europe it is understood that the most suitable technique is the use of SPMT trailers (Self Propelled Modular Trailers) to load the floater on a launching barge. The launching will then be performed into the JOUBERT dock which draught is suitable for the project. The dock is usually used as a repair ship lock that communicates with the Penhouet basin through a lock door.

The launching works will be completely subcontracted to a service provider which manages regularly this kind of heavy load transportation, for big projects. Equipment will be fully
certified as maritime rules and insurers request. For interface purpose a MWS will review the procedure and attend the operation.

FIGURE 10 FLOATGEN PROJECT SITUATION

4.3.2 ENGINEERING

4.3.2.1 LOAD SPREADING ON THE QUAY

Prior to the commencement of the construction the question of the load bearing capacity of the yard must be solved. High loads on the ground will be applied when working with the tower crane for the concrete works and during the construction of the floater itself. The embankment where the construction will be performed is being assessed by an geotechnical engineering program that will validate the intended construction constraints. At completion of the construction the transfer with SPMT is carefully monitored in term of load applied on the ground. It is calculated that the load will not be greater than 8 ton per
square meter on the total length of the transfer with the trailers, which is acceptable by the Port.

FIGURE 11 SPREADING OF THE LOAD ONTO THE GROUND UNDER THE TRAILERS

4.3.2.2 FLOATER LOAD OUT

Before the mobilization of the barge in the port of Saint-Nazaire, this one will be mobilized in the Contractor yard (abroad) to start the implementation of the steel grillage on the barge deck.

The principle of grillage envisaged is the following one:

FIGURE 12 INTENDED SUPPORT INSTALLED ON THE LAUNCHING BARGE
2 lines of support situated in the edge of the barge on a length about 40m and 4 lines of supports situated partially central of the barge under partitions concrete, which length is about 9m60 each.

It is crucial that the load out engineering is done in conjunction with the floater designer and the heavy lift Contractor in order to grant the structural integrity of the floater as well as the stability of the convoy.

Calculation must be carried out for the load spreading under the ro-ro ramps as it spreads high efforts on the quay. Load spreader items would be mobilized under the ramps if required.

4.3.2.3 FLOATER LAUNCHING

The immersion of the floater into the Joubert lock is the second point that must be highly studied and monitored. The total available draught of the lock is, by construction, of 13.75m above the keel blocks (which height is 1.50m).

### FIGURE 13 CALCULATION OF THE HEIGHT OF THE SYSTEM FOR IMMERSION

The serie of item height can be decomposed as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floater draught</td>
<td>6.30 m</td>
</tr>
<tr>
<td>Clearance floater - support</td>
<td>0.50m</td>
</tr>
<tr>
<td>Floater support</td>
<td>1.50m</td>
</tr>
<tr>
<td>Barge depth</td>
<td>6.10m</td>
</tr>
<tr>
<td><strong>total</strong></td>
<td><strong>14.40m</strong></td>
</tr>
</tbody>
</table>

### TABLE 1 VERTICAL HEIGHT OF THE LAUNCHING SYSTEM
From the table above one sees that it is necessary to remove the keel blocks (h=1.50m) to success the launching. The removal of the dock floor tins will be scheduled during a repair period of a ship when the dock is empty.

Engineering shows that a suitable barge for the launching is **6.10m deep** (20 feet), which is quite common in the naval industry. Some suitable barges have been identified in the North Sea.

### 4.3.3 MOBILIZATION OF EQUIPMENT

#### 4.3.3.1 SPMT TRAILERS

A set of 200+ axis of SPMT trailers will be mobilized to carry the floater from the construction yard to the launching barge.

The position of trailers under a load can be different for every combination of a set. To solve it, every module is equipped with a programmable controller who memorizes the position of modules altogether by the intermediaries of their coordinates X and Y angles.

Considering the transfer speed, the brake capacity of the trailers and the uneven ground on which the trailers will be working then the net tonnage of each axis is considered 31 ton per axis line.

![FIGURE 14 TYPICAL 6 AXIS SPMT TRAILER DATA SHEET](image)

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The stability of a combination of SPMT is granted by an adaptable hydraulic suspension according to the combination. In the case of a normal operation a suspension on 3 points will be made by the creation of 3 zones of oil. This signifies that the units are hydraulically connected each other in 3 different groups of trailers. The load is constantly supported by 3 lifting points (resultant force) which guarantees the stability during the transfer.

4.3.3.2 LAUNCHING BARGE

Intended launching barge is 91.40m 27.0m x 6.10m (or 300’ x 90’ x 20’). Deck strength is 15 t/m² for a total acceptable dead weight of 10,000 tons. As a reminder the floater is less than 5,000 ton for launching.

The barge will be mobilized from North Sea with its own tug boat. The barge will necessary be NOT equipped with a pump room and permanent deck equipment as it will be sunk into the dock.

The following drawing presents a suitable barge for the works.

4.3.4 FLOATER SKIDDING AND LOAD OUT

Contractor will mobilize a set of SPMT trailers to the yard for the load-out of the floater.

After unloading the trailers, they will be assembled to the required configurations and tested for the correct functioning of the trailers.
All SPMT trailers will be positioned under the floater, which is placed on supports (from the start of the construction) with sufficient height, to make installation of the SPMT’s possible. The SPMT will be positioned under the item on the marked positions. With the hydraulic suspension of the SPMT, the trailer deck will be raised until the SPMT touch the floater. Sufficient lashing (chains) will be installed between SPMT and floater.

At BOUYGUES signal, the supervisor gives the operator the order to take over the item’s weight in steps of 10%. During taking over the weight, Contractor will observe the SPMT, item and supports.

Meanwhile, the barge will be prepared with winches and ballast pumps. The connection points for the roro-ramps will be positioned and welded on the barge’s deck. After finalizing the preparations, the barge will be positioned against the quay for the load-out. Fenders will be placed between barge and quay. The barge will be held in position with help of winches, which will be attached to mooring points on the quay. By means of a mobile crane, the roro-ramps will be placed from quay to the barge. The roro-ramps will be fixated to the connection points on the barges. On both sides (barge and quay) of the ramps, wedges will be placed.

Once the barge-preparations are finished, the item will be transported towards the quay and the load-out operation can commence. During the load-out the following points will be checked continuously:
- Item to be transported.
- SPMT trailers.
- All lashing connections.
- Winches, including wires and mooring points.
- Roro-ramps.
- Level of the barge

Once the first wheels enter the (pre-ballasted) barge, the barge will be ballasted according to the ballast calculations (by barge supplier). The SPMT’s drive the item onto the barge. During the load-out the barge will be ballasted to keep it levelled with the quay. Once the SPMT with item is in correct position, the item will be placed on its grillage/supports. The load of the item will be transferred to the barge in steps of 10%, during the unloading all lashing chains will be removed. After the load set-down on the barge is complete, the SPMT’s will be lowered until sufficient height is reached for removal of the SPMT trailers from under the item. The SPMT’s will be driven over the roro-ramps onto the quay.

**FIGURE 17** BARGE LOAD OUT

The roro-ramps will be removed with by means of the mobile crane. The tension in the winch wires will be removed, so that they can be removed from the mooring points. The barge will be positioned against the quay, so that the remaining activities can be executed. The item will be fixed to the barge (river fastening).

The SPMT trailers will be disassembled from each other and loaded in trailers for transport back.
4.3.5 LAUNCHING THE FLOATER

Two harbour tugs will handle the barge to the JOUBERT dock. At the location, the “Forme JOUBERT”, the barge will be held in position by means of shore winches. The tug boats will get out of the dock. Then the JOUBERT dock will be dried, so that the barge will be lowered onto the dockfloor tins. During the drying of the dock, the barge will be ballasted in order to keep the barge in place during the flooding of the dock. Once there is sufficient ballast water inside the tanks, the dock will be flooded until the concrete floater is floating above the barge with sufficient clearance. Some liquid ballast could be placed into the floater compartment to balance the floater, if needed.

By means of the shore winches, the floater will be pulled away from the barge. The dock will be dried again in order to pick up the barge from the dockfloor. When complete dock is dried, the ballast water inside the tanks of the barge will be de-ballasted.

**FIGURE 18 SEQUENCE OF FLOATER LAUNCHING INTO THE JOUBERT DOCK**

FLOATGEN is co-financed by the European Commission's 7th Framework Programme for Research and Technological Innovation.
When the barge is empty, the offhire survey will take place. The JOUBERT dock will be flooded after completion of the offhire survey. All equipment can be demobilized.

**4.3.6 TOWING BACK TO THE INTEGRATION BERTH**

At completion of the launching into the Joubert dock, the floater will be towed out of the JOUBERT dock with 3 tugboats, and securely moored on the foreseen integration berth in Penhouët basin.

Clarification with Saint-Nazaire Port and Pilotage has led to the following configuration for the port towing.

![Port Towing Arrangement with Local Tugs](image)

**FIGURE 19 PORT TOWING ARRANGEMENT WITH LOCAL TUGS**

It is required by the Pilotage and tug Captains to keep the convoy as rigid as we can, to ensure maximum manoeuvrability. All precaution will be taken to preserve the concrete floater from impact or damage during the tow: installation of fenders and hull protection, low operation speed, favourable weather window.

The Port is equipped with 7 tug boats suitable for the works, operated 24/7 with short notice so that it will not be required to mobilize a tug from external harbour to perform the harbour tow.
5. WIND TURBINE TRANSPORTATION

5.1 GENERAL

The WTG will be procured by GAMESA from an already existing and functioning WTG. GAMESA will dismantle the elements on an existing onshore wind farm, transport them to facilities where they will be overhauled and adapted to the needs of Floatgen project and re-conditioned.

The WTG tower will however be built specifically for this project purpose and will follow a different transportation route.

All elements will then be shipped from Bilbao to Saint-Nazaire. These operations will be managed by GAMESA Logistics department, following pre-defined procedures [S07]. At this stage it is not yet decided whether the WTG tower and other components will be transported on the same cargo ship.

5.2 WIND TURBINE TOWER

WT Tower will be made in 2 parts. Weight and dimensions of these parts are given in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>Weight (Ton)</th>
<th>Length (m)</th>
<th>Breadth (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom</td>
<td>77</td>
<td>25</td>
<td>5.2</td>
</tr>
<tr>
<td>Top</td>
<td>56</td>
<td>33.5</td>
<td>TBD</td>
</tr>
<tr>
<td>Total</td>
<td>133</td>
<td>58.5</td>
<td>n/a</td>
</tr>
</tbody>
</table>

**TABLE 2 WT TOWER WEIGHT AND DIMENSIONS**

Tower will be manufactured by a supplier selected by GAMESA. Although final decision for tower manufacturer has not been made yet, the manufacturer most likely to be selected is WINDAR TADARSA, based in Avilés on Spain North shore.

WINDAR TADARSA facilities are located on an industrial area within 2km of a loading quay and associated storage area for wind turbine tower components.
Tower sections will be transported from factory to loading quay on trucks. The distance is very short and this operation is done on a routine basis by the manufacturer. The tower sections are handled with transportation beams and lifting eyes that are bolted to tower sections flanges.

Those handling components need to be designed specifically for this project as the tower sections are manufactured specifically for Floatgen project.

The tower sections will then be lifted and sea-fastened onboard a cargo ship heading to Saint-Nazaire. Depending on selected ship, quay cranes could be used for the works.
Once loading is completed, tower sections are lashed to cargo deck and transit to Saint-Nazaire can start. Sea route from Avilés to Saint-Nazaire is circa. 280NM long.

5.3 ROTOR NACELLE ASSEMBLY

The Rotor Nacelle Assembly will be transported in 2 elements: the RNA itself and an air outlet to be installed on top of RNA. Weight and dimensions of these parts are given in Table 3.

<table>
<thead>
<tr>
<th>Part</th>
<th>Weight (Ton)</th>
<th>Length (m)</th>
<th>Breadth (m)</th>
<th>Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RNA</td>
<td>74.5</td>
<td>10.5</td>
<td>3.504</td>
<td>3.845</td>
</tr>
<tr>
<td>Air Outlet</td>
<td>1</td>
<td>4.166</td>
<td>3.284</td>
<td>1.026</td>
</tr>
</tbody>
</table>

**TABLE 3 RNA WEIGHT AND DIMENSIONS**

The RNA will be prepared in GAMESA facilities close to Bilbao. It will then be transported by road to Bilbao harbour. Low bed truck shall be used and truck will be treated as an oversize convoy.
The RNA elements will be loaded on cargo ship using either ship or harbour cranes, and lashed for sea transport. The air outlet will be packed in a wood cage for sea transport while the RNA has a specifically designed support cradle.
Sea route from Bilbao to Saint-Nazaire is circa. 250NM long (less than 1 navigation day with conventional cargo).

5.4 HUB

The Hub will be transported in 2 elements: the hub itself and a nosecone to be installed at the front tip of the hub. Weight and dimensions of these parts are given in Table 4.

<table>
<thead>
<tr>
<th>Part</th>
<th>Weight (Ton)</th>
<th>Length (m)</th>
<th>Breadth (m)</th>
<th>Height (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hub</td>
<td>21.5</td>
<td>3.6</td>
<td>3.6</td>
<td>3.8</td>
</tr>
<tr>
<td>Nosecone</td>
<td>0.137</td>
<td>2.372</td>
<td>2.372</td>
<td>1.270</td>
</tr>
</tbody>
</table>

**TABLE 4 HUB WEIGHT AND DIMENSIONS**

The hub will be prepared in GAMESA facilities close to Bilbao. It will then be transported by road to Bilbao harbour. Low bed trailer shall be used and truck will be treated as an oversize convoy.

![Figure 25 Hub Road Transport Configuration](image)

The hub elements will be loaded on cargo ship using either ship or harbour cranes, and lashed for sea transport. The nosecone will be packed on a wood pallet for sea transport while the hub has a specifically designed support cradle.
5.5 BLADES

The 3 blades will be transported as a single piece each. Dimensions are given for each blade in the below Table 5:

<table>
<thead>
<tr>
<th>Weight &amp; Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (Ton)</td>
</tr>
<tr>
<td>7.125</td>
</tr>
</tbody>
</table>

TABLE 5 BLADES WEIGHT AND DIMENSIONS

The blades will be prepared in GAMESA facilities close to Bilbao. They will then be transported by road to Bilbao harbour. Low bed truck shall be used and truck will be treated as an oversize convoy. The blades are the longest parts of the WTG and extra care will be brought to their transportation.

The blades will be handled with transportation cradle and support that are bolted to blade flange and clamped around blade wing section.
FLOATGEN is co-financed by the European Commission’s 7th Framework Programme for Research and Technological Innovation.

The blades will be loaded on cargo ship using either ship or harbour cranes. A tandem lift with two cranes will most likely be required to ensure a proper control of the blade orientation during the lifting operation, and especially at landing. The lifting slings will be connected to the cradle and support.

Once lifting is completed, blades will be lashed for sea transport. Lashing will be connected to cradle and support.

**5.6 ACCESSORIES AND ADDITIONAL COMPONENTS**

Other tools and accessories will be delivered to Saint-Nazaire to assist with the WTG integration, commissioning and operation. In addition some parts of the WTG will only be installed in Saint-Nazaire once the WTG is integrated onto floater. Some parts will also be installed inside the transition piece and must therefore also be installed on site.
In total 7 containers of additional material and equipment will be delivered:

- 3 Toolkit containers
- 4 Parts containers

Each container will be a standard 20’ marine container, with a gross weight under 20T.

Equipment will be loaded in GAMESA facilities near Bilbao, and will transit by road to Bilbao harbour where they will be loaded on the same cargo ship as the other WT components (except maybe for tower).

### 5.7 OFFLOADING IN SAINT-NAZAIRE AND STORAGE

All WTG elements will be offloaded in Saint-Nazaire harbour and stored waiting for the integration phase. The offloading quay will be located inside Penhouet Basin to avoid long transportation to the storage area.

Elements arriving by cargo ship can be offloaded either by ship cranes or by harbour cranes, and placed on trucks to be transported to storage area. All elements are equipped with suitable lifting gears and transportation cradles required for this.

The storage area will require to be 100m x 60m with a ground load bearing of 5T/m². It is foreseen to use the same area for storage of the components and for preparation before lifting to avoid interim transportation within harbour after offloading. This area will probably be adjacent to but different from mooring storage area described in section 3.2.1.

WTG components will be stored in accordance with the lifting and integration sequence to also simplify these operations.
The containers can be stored anywhere as they can easily be moved around.

### 5.8 Wind Turbine Integration

Wind turbine integration will be performed by GAMESA with the support of IDEOL for the management of the ballast system. The method for integrating the WTG onto the floater is described in reference document [S04]. The detailed WTG elements assembly procedure is described in [S08].

This operation will consist in lifting the WTG elements with a dedicated crane for their storage and preparation area onto the floater. Each element will then be bolted to its predecessor by specialized personnel while the ballast of the FWT is adjusted to maintain an even trim.

The assembly area will require to be 100m x 60m with a ground load bearing of 52T/m² under the assembly crane (soil can be locally reinforced with load spreading material to comply to the acceptable load bearing capacity of the quay).
At this stage, all the separate components shipped by container will be unpacked and installed on the FWT.

Pre-commissioning of the entire floater and WTG will then follow to ensure the assembly is ready for towing to the offshore installation site.
6. FLOATING WIND TURBINE TOWING

FWT towing at sea will be subcontracted to a specialized company. A Marine Warranty Surveyor, working on behalf of the CAR insurer, will be contracted for marine survey prior to the departure (work procedures and towing survey). A MWS Representative will attend the tow with offshore personnel on board the towing tug.

FWT towing is divided in two different phases: the harbour tow and the seagoing tow. Configuration for harbour tow is a rigid convoy (tugs in contact with the FWT), configuration for the open sea towing is more classical (two tugs in the bow and one single tug at the aft with towing chains and wire). Both arrangements are outlined in the following sections. It is likely that the overall towing will be done by BOLUDA, the Tow Contractor of the Port of Saint-Nazaire.

6.1 AUTHORIZATION

The following administrative procedures have to be taken prior to the tow:

**Airfield licence**: project must meet the requirements of the civil and military Agencies for safety during transport to offshore site.

**Maritime Transport Licence**: the project must meet the requirements of the Maritime & Coastguard Agency and other regulatory requirements for navigational safety during transport to site.

**Prevention Plan**: This document must be agreed and signed prior to the deployment.

**Coast Guards (CROSS)**: Notice to Coast Guards shall be done with sufficient delay

**Port Pilotage**: Pilotage is part of the tow (harbour part)

**Insurance**: Insurance scheme with tow Contractor for the FWT must be finalized.

In addition a Marine Warranty Surveyor will be implicated in the marine spread mobilization and sea fastening prior to the departure and will issue a Certificate of approval when procedure will be approved. Noble Denton guidelines [R02] as well as IMO rules [R03] and SOLAS [R01] will be used as standards for the ocean tow works.

6.2 PORT AVAILABLE FLEET
BOLUDA is the towing Contractor of Saint-Nazaire Port whose fleet is composed of:

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Type</th>
<th>Displacement</th>
</tr>
</thead>
<tbody>
<tr>
<td>CROISIC</td>
<td>Azimuth Stern Drive 60 T</td>
<td>620 T</td>
</tr>
<tr>
<td>VB POULIGUEN</td>
<td>Azimuth Tractor 40 T</td>
<td>353 T</td>
</tr>
<tr>
<td>VB NANTES</td>
<td>Azimuth Stern Drive 60 T</td>
<td>389 T UMS</td>
</tr>
<tr>
<td>VB BRETAGNE</td>
<td>Azimuth Stern Drive 60 T</td>
<td>389 T UMS</td>
</tr>
<tr>
<td>GUERANDE</td>
<td>Azimuth Tractor 40 T</td>
<td>353 T</td>
</tr>
<tr>
<td>ST MARC</td>
<td>Azimuth Tractor 38 T</td>
<td>445 T</td>
</tr>
<tr>
<td>PORNICHET</td>
<td>Azimuth Tractor 38 T</td>
<td>353 T</td>
</tr>
<tr>
<td>ST BREVIN</td>
<td>Azimuth Tractor 38 T</td>
<td>445 T</td>
</tr>
</tbody>
</table>

**TABLE 6 AVAILABLE TUGS IN SAINT-NAZAIRE**

![Available 60T Bollard Pull Tug Boat](image)

**FIGURE 31 AVAILABLE 60T BOLLARD PULL TUG BOAT – PORT OF SAINT-NAZAIRE**

If required it is accepted that an external vessel (with more power) comes into the harbour to handle the floater and tow it to the offshore site.

### 6.3 HARBOUR TOW
Port Pilotage will lead the manoeuvre from the WT integration quay to the port exit, then an offshore Manager (or tow Master) working in behalf of the offshore installation Contractor will take over and proceed to the overall offshore towing and hook up works.

WTG provider will turn and secure the WTG nacelle in an appropriate heading for the safe passage in the lock (90° heading compare to the lock). The personnel is allowed to work on board the FWT for rigging the towing lines in the harbour and shall disembark after modification to the ocean configuration towing [503].

The following drawing outlines the harbour configuration of the tow:
The above convoy configuration will be arranged for the departure, the lock passage and the very beginning of the voyage at the entrance of the channel.

It is intended to work with two tractor tugs (40 ton bollard pull) in the FWT bow, and one Azimuth Stern Drive vessel (60 ton bollard pull) in the FWT aft. The tugs are moored to the FWT with cable wired, securely turned on with deck winches, and synthetic ropes as required.

Once the convoy get to the entrance lighthouse (“Grand Charpentier”) then the sea going tugs will take over the FWT and the open sea towing works will commence.

### 6.4 SEA GOING TOW

As per Ref. [R02] the environmental conditions that shall be considered for the towing analysis correspond to standard condition (table 7 below); they are detailed in the table below. For information, towing force has also been computed for calm and normal conditions, with 2 and 3 knots towing speed over ground (SOG).

<table>
<thead>
<tr>
<th>LC Conditions</th>
<th>Load Case 1 (LC1)</th>
<th>Load Case 2 (LC2)</th>
<th>Load Case 3 (LC3)</th>
<th>Load Case 4 (LC4)</th>
<th>Load Case 5 (LC5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant Wave Height (m)</td>
<td>Standard conditions</td>
<td>Normal conditions</td>
<td>Normal conditions</td>
<td>Calm conditions</td>
<td>Calm conditions</td>
</tr>
<tr>
<td>Mean Wind speed (m/s)</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Mean Surface Current speed (m/s)</td>
<td>Uniform wind velocity profile</td>
<td>Uniform current velocity profile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Towing speed (knots)</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

| TABLE 7 ENVIRONMENTAL LOAD CASES STUDIED |

Towing analysis has confirmed the use of a single tugboat (90 TBP) on the bow OR two tugboats in parallel tow (60 TBP), with the following parameters [S01]:

FLOATGEN is co-financed by the European Commission’s 7th Framework Programme for Research and Technological Innovation.
Towline pull required (TPR) depends on the number of tugs, their power (Bollard Pull) and their efficiency.

Two functioning configurations are proposed. Final contract (BIMCO towcon type) will be decided upon vessels availability and season of the operation.

The FWT is considered to be unmanned during the towing from towing configuration change ("Grand Charpentier" lighthouse) to the offshore site (SEM-REV) [S02].

The navigation route shall be agreed with port pilotage and tow Contractor. As the convoy is very large and speed is very slow, it is intended to get out of the navigation channel as early
as possible, upon Pilotage proposal. Sailing out of the channel will avoid any risk of interference with regular navigation.

The proposed route (yellow drawing) is 29 nm (or 15 hours @ 2 kts SOG), which is a sensible reduction of transit time that is taken out from the favourable weather window. Alternately the channel navigation route is 40 nm (20 hours @ 2 kts SOG).

6.5 SPECIAL EQUIPMENT FOR THE TOW

A set of equipment will be mobilized on board the FWT for the safe towing from Saint-Nazaire to the installation site. The towing works shall be compliant with the international standards [R01][R02][R03] and validated by MWS.
6.5.1 NAVIGATION LIGHTS AND SHAPES

The FWT shall carry the lights required by the International Regulations for Preventing Collisions at Sea, 1972 amended 1996 [R01], and local regulations (especially aeronautical regulation).

Navigation lights shall be independently operated (eg from gas containers or from independent electric power sources). Spare mantles / bulbs should be carried, and fuel and power sources should be adequate for the maximum anticipated duration of the towage plus a reserve.

It is desirable that a duplicate system of lights be provided.

The object being towed shall exhibit (towed object is considered as an inconspicuous, partly submerged vessel or object):

- two additional all-round white lights at or near the extremities of its breadth
- A stern light
- a diamond shape at or near the aftermost extremity of the last vessel of object being towed and if the length of the tow exceeds 200 meters an additional diamond shape where it can best be seen and located as far forwards as is practicable.

6.5.2 VARIOUS EQUIPMENT

International regulation will command the FWT owners to operate the tow with the following equipment:

- A system of portable pumps such that any one tank can be emptied in 4 hours for an unmanned barge
- A generator with sufficient capacity to operate the bilge pumping system, the navigation aids (lights and AIS) and the WTG simultaneously. Additional fuel tank will be installed to provide enough fuel for at least 72 hours of continuous pumping.
- A boarding party should be appropriately equipped with survival suits, lifejackets and communication equipment.
- An AIS transceiver will be operating during the whole time of operation for an easy follow up of the convoy from the shore.
At completion of the towing the FWT is set up in hook up configuration for the last phase of the offshore installation.

### 6.5.3 AUTHORISATION FOR SAILING

Towing procedure will be approved by French Maritime Authority. CROSS will be warned with sufficient notice and will issue a special information (notice to mariners).

Project insurance will provide a green light in relation with a favourable weather window for operation.