PIP - Flanders Hydraulics Research

'Wave Flume for advanced research on the influence of waves on coastal defences'

Final Market consultation Report

Programme Innovation Procurement (PIP) Department of Economy, Science and Innovation	
Contracting Authority	**Waterbouwkundig Laboratorium (WL)** **Flanders Hyudraulics Research (FHR)**
External Moderator	

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1 Executive Summary

This document is the final report of the market consultation for **Wave Flume for advanced research on the influence of waves on coastal defences** ('wave flume' for short), which ran from December 2019 until March 2020 with Addestino as an external moderator for Programme Innovation Procurement (PIP-EWI). The document contains the fully elaborated results of the trajectory and outlines the potential priorities and next steps for drafting the tender specifications of an innovative public procurement project.

Flanders Hydraulic Research (FHR), with the support of the Programme for Innovation Procurement, aims to procure a Wave Flume, suitable for wave testing, delivered as a turnkey project. The starting point for the wave flume project is the precise construction of the wave flume itself. The supporting system should include an automated filling and emptying pumping system, the wave generator, as well as any other control and safety systems to fulfil the requirements of the European Machinery Directive.

A structured process has been followed to map out the innovation potential for 'Wave Flume' with the following steps: a project scoping workshop, a workshop with the project owner to asses value, and a state-of-the-art analysis. Culminating in an open market consultation with interested industry partners.

The conclusions of the market consultation for the 'Wave Flume'-project are threefold.

As a first conclusion: the project 'Wave Flume' is non-trivial because of the high precision required in the construction of the wave flume. This is typically a concrete construction, with a glass-steel segment, where the entire construction needs to form a perfect cuboid with millimetre precision and the glass needs to withstand the specific stresses involved in wave flume testing. In the concrete construction business centimetre tolerances are the norm, let alone dimensioning glass panes like the ones required here. Even though wave flumes are being constructed across the globe, this does not imply that the required knowledge is immediately available locally. The expected lifespan of a wave flume is up to 30 years and beyond. Therefore, no hands-on experience is readily available with local construction companies.

This leads to a second conclusion: because wave generator (paddle) suppliers are international companies with little to no knowledge of the Belgian construction market, i.e. which are the reputable companies that can deliver with millimetre precision, is the selection of a local contractor for the construction of the wave flume difficult for a wave generator supplier without a local facilitator.

As a third conclusion: the project 'Wave Flume' is innovative from an execution perspective. FHR would like the entire flume project to be delivered as a turnkey project. This requires integration across different knowledge domains: precision construction in steel and glass, automation and safety, and the wave generator. Which, in turn, implies an overarching system integrator. An additional difficulty is that in the initial project setup of FHR the wave generator was out of scope.

Another insight is the need to clearly define terminology with regard to roles and responsibilities, procurement models and process steps. Throughout the process and workshops these definitions have become intertwined and therefore need to be stated clearly to avoid confusion

Process steps refers to the sequence of tasks over time. Consequently, after the order of steps has been defined then the scope is clear. After that, the parties involved in each step can be defined as well.

Procurement model refers to the turnkey aspect of the 'Wave Flume' project, i.e. the involvement of FHR in the execution of the project. Single turnkey means a single requirements specification is defined upfront and all intermediate steps; selection of suppliers and equipment, progress follow-up etc. are handled by a single party without involvement or control of FHR. A double-turnkey procurement means a procurement in two parts, with independently specified requirements, yet each delivered without involvement of FHR. Therefore double-turnkey allows more control than single turnkey, as there are now two separate specifications, possibly at different times and with different suppliers.

Closely related to the procurement model is the final definition of roles and responsibilities, i.e. which party or parties, will be held accountable for the success of the wave flume as a whole: is the end-result suited for state of the art wave flume testing as envisioned by FHR? Put differently, a turnkey procurement does not automatically imply end responsibility unless this responsibility is defined.

The state-of-the-art analysis, discussion with experts and knowledge institutes, indicated that the wave generator suppliers have the most experience and therefore can supply the correct specifications to wave flume builders. Also clearly indicated was that full turnkey deliveries do exist but aren't the most common approach. More common is double-turnkey: the construction on the one hand, and the wave generator, automation and safety on the other. But without a clear definition of which party assumes responsibility this might put the end responsibility with the project initiator, something FHR aims to avoid.

The advice, after market consultation, for Flanders Hydraulics Research is to forego the procurement of the entire wave flume project as a single turnkey procurement. Instead, a three step, double-turnkey approach is recommended. This would mean that first a wave generator must be selected, out of which the specifications for the wave flume can be derived. Construction can then commence followed by automation and integration of the wave generator. In this scenario, the end-responsibility can either lie with a 3rd party, i.e. an integrator taking responsibility for the quality of both deliveries and the success of the entire project, or with FHR.

2 Objectives & Scope

2.1 Project Background and approach

This final report describes all steps leading up to an innovative procurement for the 'wave flume' project and presents an overall synthesis of the results. This report aims to enable the contracting authority to better prepare the tender documents and form the basis of the tender to be launched.

The report summarizes the findings of the market consultation were the demand-side (the contracting authority) and the supply side (potential suppliers) met during a face-to-face workshop . The main goal of the market consultation is to share and collect knowledge and insights, as well as to formulate a tangible proposal from the perspective of the different participants.

This report aims to answer the following questions:

- What is the scope of 'Wave Flume'?
- Where is the innovation potential for this project from the perspective of the users as well as from a technological perspective?
- What is the approach for an innovative procurement as framed by the Flemish innovation procurement programme?

Addestino Innovation Management was appointed by PIP, and acting for FHR to facilitate this preliminary stage of 'Wave Flume'-project.

Addestino's approach consists of three essential parts:

- Addestino is a multidisciplinary team that has the capacity to realize breakthrough innovations across business, technology and user experience
- Addestino employs an iterative end-to-end methodology which reduces risk and accelerates product- and service development.
- Addestino possesses thorough technical knowledge and applies this pragmatically in different industry sectors (telecom, healthcare, energy, transport, electronics, etc.) and a variety of environments (start-ups, SME, multinational corporations and universities, government)

During the preliminary phase of the 'Wave Flume'-project, Addestino acted as an external moderator. The external moderator facilitates and coordinates workshops and encourages interaction between the different parties involved. As external moderator Addestino aims to serve the 'common good' and align all participants towards the common goal resulting in the launch of an innovative procurement. Addestino also supplies the necessary experience in innovation processes through its approach in managing the discussions, workshops and the overall process.

This report is, therefore, the conclusion of a structured process to map out the innovation potential for 'Wave Flume'. The ultimate goal is to scope and frame the question towards the market within the framework of the Flemish Programme Innovation Procurement.

The preliminary phase of 'Wave Flume' ran from December 2019 until Mach 2020 with the following process steps:

1. **'Scoping' workshop with the contracting authority FHR ,** in which the scope of 'Wave Flume' is determined, the underlying problems are explored, and initial solutions are identified. At the same time each specific problem is evaluated according to the expectations set by the Procurement of Innovation Programme.

2. **Workshop with the project owner** to capture the perspective of the project owner and the end-users of the wave flume. As a starting point, the existing tender for the construction of the wave flume was used as a reference for the innovation potential as seen by the project owner. This was then expanded to the entire project, including safety and automation – and the dependencies with the wave generator were identified. This resulted in several use cases prioritized on value for the project owner.

3. **State-of-the-art analysis and expert interviews** to identify the approach taken by existing and ongoing wave flume projects. Industry experts and knowledge institutes were consulted for their advice on the best approach to build a new wave flume.

4. **Workshop with interested industry partners** to further refine the current state of the industry and to identify the risks and innovation potential from a technological perspective

5. **Final report** based on all gathered information during the project.

3 Positioning

3.1 Project stakeholders

3.1.1 Vlaams Departement Economie, Wetenschap en Innovatie (EWI)

The "Procurement of Innovation Programme (PIP)" of the "Department of Economy, Science and Innovation" aims to strategically employ the substantial buying power of the Flemish Government (and the broader public sector) to foster innovation. To this end PIP stimulates governmental entities to spend part of their purchasing budget on innovative projects, particularly the development or purchasing of innovative products and services that allow an optimisation of public sector services or to better respond to societal challenges. In this way PIO contributes not only to a more performant public sector but also supports the competitiveness of companies.

PIP offers support to governmental organisations and provides co-financing in the development and validation of innovative solutions. This can be improved products and services, but also new ways of working or organising work.

3.1.2 Flanders Hydraulics Research (FHR)

FHR undertakes theoretical and practical research on, among others, the effect of waves on our coastline. In order to do such research, a wave flume is required to verify theoretical calculations and models on scale models. These results can then be used to design and validate various coastal defences.

The current wave flume with wave generator has been in service for over 40 years and has reached the end of its useful life. Flanders Hydraulics Research aims to construct a new wave flume to reach a higher precision for its measurements – using state-of-the-art laser measurements and optical cameras and fully automated test runs.

3.2 Preliminary Phase

3.2.1 Problem Definition

The starting point for the wave flume project is the precise construction of the wave flume itself. A precise construction of the wave flume can avoid unwanted side effects (e.g. reflections) when generating waves inside the flume. Additionally, the sidewall of the flume should have a large glass section to allow for precise optical measurements. The complete system should include an automated filling and emptying pumping system, the wave generator, as well as any other control and safety systems needed to fulfil the requirements of the European Machinery Directive.

These requirements have previously been captured in a tender for the construction of a wave flume, however, the results of the tendering process did not meet the project's expectations. Therefore, a new tender is being prepared based on a requirements analysis and market consultation.

3.2.2 Scope of the solution

Flanders Hydraulics Research aims to have the entire wave flume delivered as a turnkey project. The aim is not necessarily to design and build a novel wave flume, even though this is not an obvious undertaking in itself, the goal of the project is to provide FHR with a state of the art facility for performing wave tests.

Explicitly in scope are:

- The construction of the wave flume, including
  - A smooth floor, a glass side wall section, the ducts feeding the flume, the electrical infrastructure…
- The automation and safety system required to fulfil the Machinery Directive
  - To control the pumps, secure personnel access, …

Explicitly out of scope are:

- Data acquisition, the wave generator and its engines, the underground reservoir

To define the different aspects of the elements in scope, the user requirements were identified and prioritized according to their value.

During the steps later in the process, it became increasingly clear that the wave generator and the wave flume's specifications are closely intertwined. Consequently, a key question to answer was how to orchestrate the procurement of wave flume and generator.

4 Value assessment

From the expertise available within Flanders Hydraulics Research several key persons were identified to map out the most important requirements, from FHR perspective as the primary user of the wave flume, as well as a project organizational point of view. A non-exhaustive list of use cases was created based on the existing construction tender and scored on value for FHR. Each requirement from the tender was phrased as a use case, where FHR provided the rationale (i.e. the 'so that') and the value scoring. This scoring shows the innovation potential from the perspective of the user.

4.1 Requirements and Value assessment

The use cases list the requirements for the wave flume project. This list was assembled with project stakeholders and users of the wave flume. This list was then prioritized on how crucial each use case is for the wave flume project.

- A value of 0 means "without this use case the wave flume can be used as intended without issue"
- A value of 13 or 20 is interpreted as "extremely important"
- A value of 100 means "cannot do without, the wave flume becomes useless"

Because the list of use cases was derived from the original tender it contained a large number of use cases that are relevant and required for the project, i.e. were scored very high, but weren't expected to carry a very high risk, i.e. aren't fundamentally difficult to deliver.

In the end relatively few use cases remained that were considered driving the decision process, these are listed underneath.

4.1.1 Construction Requirements

14. *The flume can withstand*
- water mixed with other materials (e.g. sand) for an equivalent water column of 4.5m
- 500kg vertical pressure - on the wall,
-moment of 400Nm - on the wall
so that heavy machinery forklift/wheel loader can enter the flume. Value:40

This combined use case brings together the structural requirements from either filling the flume with more than just plain water or from the need to access the floor of the flume with heavy equipment.

17.The flume is a stiff and perfect rectangle/cuboid: under all water levels including empty, within +- 3mm along the axis, walls perpendicular and straight etc. The walls/floors are smooth (metric TBD), The floor is level (+-2.5mm), The inside edge between walls and floor have a radius less than 5mm... and is watertight so that the flume is suitable for wave testing. Value:100

This use case describes, on a very high-level, the requirements of a wave flume in order to be suitable for wave testing.

20.1 *Where the wave paddle will be installed a tolerance of +/- 2mm on the height of the walls is required so that I can mount a wave board at one end of the flume:* Value:100

This use case assumes that the tolerances on the construction on the placement side of the wave generator need to be even tighter.

4.1.2 System Requirements

40. *I can have the entire installation conforming with the European Machinery Directive (incl. documentation, plans, CE, …) so that I am compliant with all relevant laws and regulations*. Value:40

6. *I can operate the entire installation from a single location (i.e. the operator room) incl. wave generator so that the operation is efficient and ergonomic and safe, I can control any part of the machine in case of failure/risk.* Value: 40

Both use cases refer to the European Machinery Directive. The former from a legal perspective, the latter from a practical operational perspective.

4.1.3 Project requirements: Turnkey

I can choose the supplier, type, model of wave board myself so that I have full control over all detailed aspects of the wave generator. Value: 40

This high-value use case identifies the turnkey aspect of the entire wave flume project. In the initial scope of the project the wave generator was explicitly out of scope, hence the requirement for full control over the choice of wave generator. But despite the interdependencies with the rest of the project it still is a requirement to put full responsibility of the project with a single party, which is not FHR.

5 Assessment from a technology perspective

The innovation potential from a technology perspective is assessed through the planning poker technique. Experts and industrial partners assess each use case based on the risk, i.e. the likelihood of not adequately delivering the use case. This scoring shows the innovation potential from the perspective of the supplier.

- The lowest value on the scale is 0: “no risk at all”, a solution exists and can easily be implemented
- A middle value of 8 means “solutions exist but additional effort will be required”
- Values above 20 means “there is a chance a solution may not be found”
- The maximum value of 100 implies “defying the laws of nature” i.e. cannot be done.

5.1 Assessment by partners from industry

The early notion that a large number of use cases are relevant and required by the project, i.e. had a high value score, but did not carry a large risk, i.e. not fundamentally difficult to deliver, was confirmed by the partners from industry.

These low-risk use cases were not assessed, or even discussed during the market consultation.

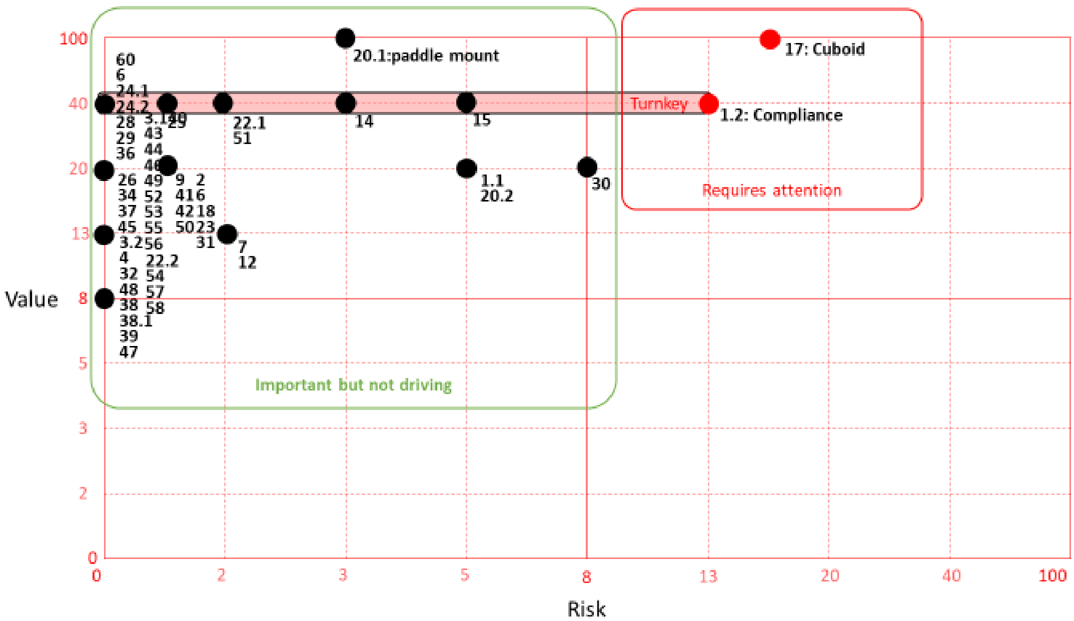

Figure 1 Overview of Use Cases

Nr.	I can…	So that…	Value	Risk
1,1	I can have the entire installation delivered as "a single machine" (cfr. Safety regulations)	so that the end-responsibility rests with the integrator (WBL is not the integrator, ask is for turnkey solution)	20	5/13 (cfr turnkey)
1,2	I can have the entire installation conforming with the European machine directives (incl. documentation, plans, CE,…)	so that I am compliant with all relevant laws and regulations	40	0.5/13
2	I can have a long-lasting wave flume (EOL: 30yr construction, 15yr mechanics, 10yr electrics) [cfr. Turnkey includes wave board lot2) [proposal needs to include qualitative statements why system will last for lifetime]	so that WBL makes a sound investment	20	1
3,1	I can/need to do planned (preventive) maintenance less than 5 days/yr I can/need to do unplanned (curative) maintenance less than 5 days/yr	so that the number of testdays is maximized, unplanned maintenance does not threaten project deadlines	13	1/13 (ok if standard use)
3,2	I can/need to do planned (preventive) maintenance less than 5 days/yr	so that OPEX is minimized, required manpower is minimized	13	-
4	I can/need to do unplanned (curative) maintenance less than 5 days/yr	so that OPEX is minimized, required manpower is minimized	13	-
6	I can operate the entire installation from a single location (i.e. the operator room) (incl. wave generator)	so that the operation is efficient and ergonomic and safe. I can control any part of the machine in case of failure/risk	40	0
6	I can have an overview of the entire installation from a single location (i.e. the operator room) (incl. wave generator)	so that the operation is efficient and ergonomic and safe	20	1
7	I can have guaranteed 'next 5 business day repair' SLA for: SW/HW mechanical defects (i.e. workaround/repaired or replacement parts)	so that downtime is minimized	13	2
9	I can operate the entire installation from dedicated control unit/PC('s). PC is part of deliverable (not required to be in VO network)	responsibility for guaranteed safety/operational stabilty rests with integrator - turnkey solution	20	1
12	The entire wave flume, excluding wave board, will be operational by end 2021 (project duration from start to finish: 9months + 3months wave generator and final integration)	as a stake in the ground for reasonable project duration	13	2
14	the flume can withstand water mixed with other materials (e.g. sand) for an equivalent water column of 4.5m 500kg vertical pressure - on the wall moment of 400Nm - on the wall	so that heavy machinery forklift/wheel loader can enter the flume	40	13/3
15	The walls are 2.5m high with a tolerance of +-2mm from wall to wall, longitudinal tolerance is more relaxed	so that measuring instruments can be precisely mounted on top of the walls (see also mounting of wave board)	40	5
17	**The flume is a stiff and perfect rectangle/cuboid:** **under all water levels including empty:** within +-3mm along the axis, walls perpendicular and straight etc. The walls/floors are smooth (metric TBD), The floor is level (+-2.5mm), The inside edge between walls and floor have a radius less than 5mm ... and is watertight	the flume is suitable for wave testing	100	13/20
18	The insides will be coloured evenly in a 'light' colour. (imperfections are not hidden behind discolorations etc, contents inside the flume can be seen)	I can do visual inspection of the flume and any objects inside the flume,	20	1
20,1	where the wave paddle will be installed a tolerance of +/- 2mm on the height of the walls is required	so that I can mount a wave board at one end of the flume	100	3
20,2	I can have, at one end of the flume (location of waveboard), tighter tolerances for "perfect cuboid" : -0/+2mm distance between walls, floorlevel +-1mm, radius floor-wall 0,5mm)	so that there's a minimal gap between wave board and flume	20	5
22,1	I can have a section on both sides of the side wall of the flume: clear and suitable for optical meausurements, scratch resistant, with limited hindrance (see 22,2) of structural supports with the same tolerances as "ideal cuboid"	I can perform visual (e.g. camera) dataaquisition - with minimal visual distortion (i.e. minimal computational correction preferred)	40	2

22,2	I can have transparent sections, over a length of 51m, ideally with segment size 1mx2,5 widthxheight, but flexible requirement TBD	so that cost vs measurement flexibility is optimized	13	-
23	I can replace each transparent panel individually	so that a broken panel can be easily replaced in case of breakage/scratch	20	1
24,1	I can have a clearance of 1m around the physical access to the underground reservoirs (access is located under the platform)	so that I can safely/comfortably walk around that area	40	0
24,2	I can have physical access to the water reservoirs i.e. as a person	so that I can perform maintenance and inspection of the underground reservoir	40	0
25	I can use the underground reservoir to fill/drain the flume (water reservoir will be filled(partially) with rainwater collected elsewhere	so that I don't need to use tapwater/dump in the sewer	40	1
26	I can see the water level (and water level alerts) of the underground reservoir in the central controle unit	so that I know the available volume for filling and draining. (it's the operator's responsibility to ensure sufficient capacity in the reservoir and to prefill if needed)	20	-
28	I can fill the flume automatically: if underground reservoirs are empty pumps will stop (no further action it is operator responsibility to foresee capacity in reservoir) (draining is always possible due to built-in overflow)	so that the pumps will not "run dry"	40	-
29	I can manually control valves and pumps of the filling/draining system. (this is not part of automatic filling and control/safety systems remain in place, ie. Not a full system override)	so that I can do drain/filling operations separate from automated filling - e.g. maintenance	40	-
30	I can automatically fill and drain the flume to a set waterlevel - within +/-0.5mm, at a set fill rate between 10-100m3/h	so that waterlevel is as accurate and as fast achieved as possible (see also location of multiple in/outs)	20	2/8
31	I can enable/disable each inlet/outlet of the flume individually from the central control (and can see their status from the central control - but no automated checking of obstruction of in/out required)	so I can build a model on top of some of the in/outs	20	1
32	The inlets/outlets will be evenly spaced along the floor of the flume and will not disturb the "level" of the floor (i.e. will be flush with the floor)	so that the flume can be filled as rapidly as possible - level will stabilize faster if in/outs are spread out	13	-
34	I can easily access the valves and pumps (and they do not block passage)	so that maintenance and replacements can be done quickly	20	-
36	I can rest assured the flume will not be overfilled/overflow to a hard max fill level. (part of safety system)	so that safety is guaranteed	40	-
36	I can rest assured the flume will not be over filled/overflow to an adjustable max fill level.	so that the model/instruments inside the flume will not be flooded	40	-
37	the platform can withstand a load of 150kg/m2	so that I can walk on a platform along the flume	20	-
38	I can remove the segments of the surrounding platform	so that instruments can be easliy placed from above along the flume	13	-
38,1	The segments of the platform shall be closed	so that safety is guaranteed of the people underneath (e.g. nothing can be dropping down to the people working under the platform)	13	-
39	I can remove the covering/cage of the waveboard (covering placed to conform to the machine saferty guidelines)	so that maintenance is simplified (ideally the protective covering does not need to be removed for maintenance, i.e. does not hinder operations/installation of models/equipment)	8	-
40	I can easily work in the space underneath the platform surrounding the flume (min height 2,2m) - including emergency lighting	so that I can easilty work underneath	40	-
41	I can acces the wave flume in 4 different locations from the top of the flume (i.e. these are not doors but e.g. ladders). Those accesses must not disturb wave propagation (i.e. flush with construction or removable)	so that walking distances between accesses is 'doable', access is safe ("een veilig arbeidsmiddel")	40	1
42	I can access the wave flume even if a model has been installed inside - height of access (ladders) must be variable	so that I can mount a model inside the flume	40	1

43	I can access the flume with "rolling stock" from one end of the flume (opposite side of generator). - access must be the entire width of the flume (when closed the access can withstand a water pressure of 2,5m without leaking)	so that I can use heavy machinery to build the model	40	-
44	I can not activate the pumps when the access to the flume is open.	so that safety is guaranteed	40	-
45	I can have a control unit sitting atop the flume, with sufficient space	so that I can work in an ergonomically sound environment	20	-
46	I can see the model inside the flume from the control unit	so that I can do visual inspection of the flume and contents (this is about logical positioning of the equipment inside the control unit)	40	-
47	I can review cameras mounted in and around the flume from within the control unit	so that important areas (for safety) can be monitored - even when not visible from control unit (e,g, (cameras mounted underneath the cabin)	8	-
48	I can connect the wave board via the electrical infrastructure of the flume (separate 'bord') [one main system with electrical subsystem]	so that we have one integrated system	13	-
49	I can connect 220V/24VDC equipment along the flume (IPXX power sockets)	so that measuring equipment can be safely powered	40	-
50	I can rely on an ISMS (integrated safety management system) that includes the wave board	so that I have one safe system	40	1/5 (spec not defined)
51	I can lock all accesses to the flume (access to the flume must be 'requested' and 'validated' by ISMS before access is 'granted' e.g. door is opened, ladder released)	so that I have one safe system	40	2
52	normal operations must be possible without password, advanced user profiles must be able to be defined	so that not everyone has full control over all aspects of the system (e.g. change safety levels)	40	-
53	I can execute an emergency stop from the control cabin as well as from other locations along the flume	so that "machine guidelines" are satisfied	40	-
54	additional emergency stop buttons can be added afterwards (by integrator and by WBL) (or moved e.g. wireless)	so that I can put emergency stops where needed at that particular time (necessary locations cannot be predicted)	13	-
55	I can disable (and remove power from) parts of the installation (e.g. pump) without removing electrical power from the entire flume - rest of operation can continue	so that partial equipment maintenance can be done without disturbing tests	40	-
56	in can see all active locks(disabled-vergrendelingen) while in the central cabin and on the locked device in question,(locks shall be logged/visualized	so that safety is guaranteed	20	-
57	I can extend the safety system with my own subsystems (extension according to existing locking system)	so that equipment can be added later (should not be a closed system)	20	-
58	I cannot access the flume unless water level is below a certain minimum (can be 0, i.e. for main access at end of flume)	so that safety is guaranteed (i.e. water level is part of safety system)	40	-
60	I can lock the system according to 4 different modi: maintenance, testing, filling, construction	so that safety is guaranteed	40	-

The following use cases were discussed in detail:

5.1.1 Construction requirements

14. *The flume can withstand*
- water mixed with other materials (e.g. sand) for an equivalent water column of 4.5m
-500kg vertical pressure - on the wall,
-moment of 400Nm - on the wall
so that heavy machinery forklift/wheel loader can enter the flume. Risk:3/13

This two-valued assessment stems from the unknown material of the floor. If the entire floor is made from concrete no problems are expected. If, however, the floor was to be made of glass than additional precautions would have to be taken.

17.The flume is a stiff and perfect rectangle/cuboid: under all water levels including empty, within +-3mm along the axis, walls perpendicular and straight etc. The walls/floors are smooth (metric TBD), The floor is level (+-2.5mm), The inside edge between walls and floor have a radius less than 5mm... and is watertight so that the flume is suitable for wave testing. Risk: 13/20

Reaching these tolerances is non-trivial for construction companies that haven't done work like this before. Standard tolerances are in the order of centimetres while here we demand millimetre tolerances. In other words care must be taken and the cost will be in proportion to the tolerances demanded.

There can be an impact on the construction itself: e.g. one could opt for an entire glass-steel construction, or detailed finishing afterwards: e.g. an epoxy layer and/or repeated machining until tolerances are met. This is expected to mainly impact the time-on-site and as a consequence the overall cost of the project.

Possibly the tolerances could be relaxed in some places: e.g. tolerances on the waterline are indeed crucial but given the depth of the flume the tolerances of the floor aren't that important.

20.1 *Where the wave paddle will be installed a tolerance of +/- 2mm on the height of the walls is required so that I can mount a wave board at one end of the flume:* Risk:3

Cfr. Use case 17. But low *additional* risk, small deviations could still be compensated by the wave generator. Worst case a metal construction could be fitted, but this is not a recommended solution.

5.1.2 System requirements

40. *I can have the entire installation conforming with the European Machinery directives (incl. documentation, plans, CE, …) so that I am compliant with all relevant laws and regulations*. Risk:0.5/13

The risk assessment largely depends on what FHR requires. A "full CE" would require a full risk analysis and all difficulties this entails, a "limited CE" on the other hand poses fewer difficulties.

The value expected from this use case refers to the European Machinery Directive, Cfr 4.1.2.

6. *I can operate the entire installation from a single location (i.e. the operator room) incl. wave generator so that the operation is efficient and ergonomic and safe, I can control any part of the machine in case of failure/risk.* Risk: 0

Not an issue according to the participants

5.1.3 Project requirements: Turnkey

Turnkey. I can choose the supplier, type, model of wave board myself so that I have full control over all detailed aspects of the wave generator. Risk: depends on turnkey approach

All participants agreed that a turnkey-procurement where one party takes responsibility for the entire successful procurement is inherently risky. Who is best positioned to take which risk, and how that should be decided varies between participants.

Several arguments against a turnkey approach:

- Turnkey is risky: means giving up control and the supplier will choose whichever solution is cheapest instead of delivering quality.
- Turnkey is giving up control: if full control is what is wanted, then one must invest the time and effort, i.e. no turnkey.
- Turnkey is risky for wave generator providers: the construction market is inherently local, and they do not know the Belgian market.
- Turnkey requires more time: It might be difficult to find the right persons
- Turnkey is expensive: the risk premium will affect the cost

Four different models, each which different trade-offs, were discussed and assessed:

1. **Turnkey with one responsible supplier**
   This approach does happen in the industry but usually for smaller flumes and not for projects of this scale. Given the local construction market and the international suppliers an active role is required to bring these two together.
   Risk: 3 / 13
2. **Select wave generator first, then write the specifications for the construction part**
   This is a common approach for projects of this scale.
   During the discussion it became clear that the automation and wave generator need to be included as well.
   The interface between both sub-deliveries needs to be carefully managed, as neither party takes end-responsibility for the integration. The end responsibility will rest with whomever picks up the integrator role.
   Risk: 0 / 13
3. **Two entirely separate lots: construction and wave generator**
   A common practice, but does not honour the turnkey requirement
   Risk: 3 / 13
4. **Hire a separate consultant to track the entire project.**
   Not a common practice.
   Moreover the consultant will not carry the end-responsibility.
   Risk: 3/8

6 Conclusion of the preliminary phase and recommendations

Based on the above risk assessment and feedback during the market consultation, it seems a standard procurement procedure is feasible. Both the requirements towards construction and system integration are feasible, however some trade-offs on cost and total project time may be required.

There is a clear need to define terminology with regard to roles and responsibilities, procurement models and process steps. These definitions have become intertwined and therefore need to be stated clearly to avoid confusion.

Process steps refers to the sequence of tasks over time. Consequently, after the order of steps has been defined then the scope is clear. After that, the parties involved in each step can be defined as well.

Procurement model refers to the turnkey aspect i.e. the involvement of FHR in the execution of the project. Single turnkey means a single specification is defined upfront and all intermediate steps; selection of suppliers and equipment, progress follow-up etc. are handled by a single party without involvement or control of FHR. A double-turnkey procurement means a procurement in two parts, each without involvement of FHR. But double-turnkey allows more control than single turnkey, as there are now two separate specifications, possibly at different times and with different suppliers.

Closely related to the procurement model is the final definition of roles and responsibilities, i.e. which party or parties, will be held accountable for the success of the wave flume: is it suited for state-of-the-art wave flume testing as envisioned by FHR? Put differently, a turnkey procurement does not automatically imply end responsibility.

The choice of procurement model and its effect on who takes end responsibility is the key for the 'Wave Flume' project: Single turnkey, double turnkey or no turnkey at all, and with which responsibility for the success of the project as a whole. Given the scale of the wave flume and the many objections from industry against a single turnkey approach, a double-turnkey approach is recommended. With an active role and responsibility that is defined upfront to maintain control over the project. This active role could be taken up by WBL or a dedicated integrator. This role will take end-to-end responsibility for the success of the wave flume project as a whole.

As for the steps to follow, it is recommended to select the wave generator first, then specify the construction requirements, and finally the final integration and automation. In this arrangement, the wave generator supplier becomes involved in the construction project but not committed to its procurement according to the specifications. Furthermore, a dedicated role will be required to support the contracting authority in the selection of construction partners, as well as the follow-up of the construction and final approval of the quality of the construction delivery. Then full responsibility of the entire project including automation and integration of the final delivery can be assumed by this dedicated role.

If a single turnkey procurement would be preferred, i.e. 1. Turnkey with one responsible supplier, it is important to realize this will require additional time and incur additional costs, including additional risk towards selection of the wave generator. Even in this approach an additional active role is required to build a consortium where international suppliers and local suppliers can find each other. A possibility to kick things off could be a directed information campaign or a match-making event.

Even though option 3. two entirely separate lots, and option 4. a separate consultant, were scored with comparable risk as options 1 and 2, they put significant risk with Flanders Hydraulics Research. The risk assessment during the market consultation in which FHR did not participate, only the industry partners were consulted. Given that the objective of a turnkey approach is to put responsibility with a 3rd party both options aren't relevant here.