Removal of dumped war ammunition in the North Sea

Report - Summary

Program	PIP PROGRAMME FOR INNOVATION PROCUREMENT
Contracting authorities	EWI Vlaanderen is mobiliteit & openbare werken

1 Executive summary

This document represents the executive summary of the final report on the market consultation for the PIP-project 'Removal of dumped war ammunition in the North Sea'. The Programme for Innovation Procurement (PIP), in cooperation with the Department of Mobility and Public Works – Maritime Access, aims to carry out a test on 'De Paardenmarkt' dumpsite which demonstrates in what way (i.e. by using which innovative techniques) a unit of ammunition could be located and brought to the surface safely and in a time- and cost-effective manner. By doing so, Maritime Access intends to contribute to the overall discussion on what to do with the ammunition dumpsite on the sandbank 'De Paardenmarkt'. The conclusions of this market consultation are grouped in 3 areas.

As a first conclusion: the project 'Removal of dumped war ammunition in the North Sea' is very innovative and extremely hazardous from the demand side's perspective. A clearing of an ammunition dumpsite of this size, containing chemical ammunition over hundred years old, and being completely buried in a shallow sea environment, has never been done before. The full scope of the envisaged test operation is described by a combination of 29 use cases. These are considered to be one interconnected whole, which means that no prioritization was made between the individual use cases, not even in terms of innovation value.

As a second conclusion: this PIP-project is very innovative from a technological point of view. Discussions with international experts from the industry and knowledge institutions revealed that for at least half of the number of use cases, specific development and effort is required to obtain a solution for this clearance test. The retrieval part of the test was considered doable, as long as the circumstances are not skewed to extremes. To be able to select the right salvage techniques for this, specific development would be required on the detection methods to localize units of ammunition and determine their properties. However, in order to draw conclusions about the entire dumpsite, all specific conditions across the entire site should be mapped, and a salvage test should be carried out in each one of them. The latter is not part of the initial scope of this PIP-project. Concerning the imposed boundary conditions for the test, the industry players spotted more issues. Prohibiting certain phenomena (like percolation and emission of chemical agents in the environment) to take place, they deem unrealistic as these could already be present today. To prove that the test operation would not enlarge or speed up any environmental issues, there is a need for fast measuring methods and more analysis on the current situation and present phenomena on 'De Paardenmarkt' dumpsite. Lastly, given the amount of uncertainty, it was considered a challenge to obtain all necessary permissions from all responsible authorities to be allowed to conduct the test.

As a third conclusion: Before a test on the real dumpsite is possible, first a number of uncertainties have to be clarified, for which a lot of specific development and extra analyses on the dumpsite will be required. Therefore, it is advised to conduct the entire PIP-test with all its required new developments first in a safe and controlled environment representing the riskiest conditions on the dumpsite, but without any real explosives or dangerous chemical substances. To this end, a replica-environment will have to be designed and constructed at sea. In this zone, 3 competing consortia would be asked to carry out the described PIP-test with different techniques, after which the results would be evaluated on multiple dimensions. In parallel to this track, the various conditions on the real dumpsite should be mapped further, which also serves as a valuable input in the design of the replica-environment. To this end, there are already different initiatives running.

2 Use cases

To describe the functional and non-functional needs of the demand side on the envisioned test operation, a set of 29 use cases was written. These use cases were presented on the market consultation session to a large panel of international experts from the industry and knowledge institutions to assess the risk of being able to implement them.

For this PIP-project the use cases were split in 3 categories.

Functional use cases
These translate what has to be achieved in the envisioned test. In other words, based on what will we be able to say the test was successful or not and what do we want to get out of the test.

Boundary condition use cases
This covers all which has to be guaranteed within the framework of the test, such as mandatory safety aspects.

Process use cases
These entail all procedures to adhere to, to be allowed to execute the test. Among others this encompasses which permits to obtain, which parties to consult or inform about the operation, so that they can take the necessary actions within their responsibilities, …

The next few subsections list and describe these different use cases.

2.1 Functional use cases

Use case 1.1: As a bidder I can locate precisely (position and depth) an isolated unit[1] of ammunition, so that I know where the object can be found for retrieval.
By precisely locating units of ammunition within the dump site it is possible to identify an isolated unit of ammunition and demarcate the environment around the spotted material such that there is a safe distance with respect to the surrounding objects. The positions and depths of the detected units of ammunition can later on also be used for future scientific research.

Use case 1.2: As a bidder I can determine the size, mass, type, and condition of detected ammunition, so that I am sure to use the right recovery method.
Depending on the type of recovery method, the type and condition of the ammunition is possibly irrelevant to retrieve it safely. Given the scarce amount of factual information on the ammunition present on the Paardenmarkt dump site, it is of public interest to determine the type (e.g. conventional or chemical) and condition (e.g. armed or not, a connected cluster of multiple pieces or not, integrity of the ammunition) of the ammunition before or during the retrieval process.

Use case 1.3: As a bidder I can discover the condition of the sediment surrounding the detected ammunition (e.g. stability of the seafloor), so that the right method of retrieval can be chosen that doesn't pose a threat to the marine environment.
It is not the intention to e.g. let neighbouring objects subside or to disrupt the oxygen-deficient environment around neighbouring ammunition and as a consequence speed up the corrosion process.

[1] *Unit: A unit of ammunition within this context can signify 1 piece or a cluster of multiple pieces of ammunition, as can be encountered as an identified object on the Paardenmarkt dump site.*

From the condition of the surrounding sediment it is also possible to estimate the current level of corrosion of the present shells in situ.

From the retrieved specimen of the surrounding sediment the necessary amount of samples need to be handed over to researchers of the Belgian Defence laboratories (DLD) for further scientific analysis on the general condition of the Paardenmarkt site. To this end, these samples need to be packaged and conditioned in a guaranteed safe manner, before being handed over to DLD.

Use case 1.4: As a bidder I can retrieve any type of ammunition, irrespective of the condition, so that I can salvage any object found on the Paardenmarkt site.
When a detected unit of ammunition is selected for retrieval it has to be recovered irrespective of what the type or state of the unit appears to be during the recovery operation. In this way the scenario where an initially selected unit of ammunition has to be left behind on the dump site, needs to be excluded. Hence it can be assured that the same method of the test is also applicable for retrieving other pieces of ammunition on the Paardenmarkt dump site, and also the test is relevant to scale.

Use case 1.5: As a bidder I can on 1 or multiple locations on the Paardenmarkt site salvage ammunition within a sufficiently short period of time, so that the test is relevant to scale and I obtain a more representative idea on the needed time for a salvage operation covering the entire dump site.
In this manner the test has to demonstrate that the solution is possibly scalable to the entire ammunition dump site. Or that the required method to clean up the remaining ammunition on the dump site can be deducted out of the experience of carrying out the test operation.

Use case 1.6: As a bidder I can determine the relevant boundary conditions that have (also) led to the success of a single test operation, so that I can deduct the relevance of this test for the clearance of the entire dump site (i.e. to which extent are these boundary conditions applicable to the entire Paardenmarkt dump site).
By measuring these parameters for the entire area of the Paardenmarkt site it could be deducted on which other locations of the area this test method possibly would have been successful. As a consequence, the representative nature of the test can be determined.

Use case 1.7: As a bidder I can measure the required time to systematically locate and retrieve ammunition in a certain zone of the dump site, so that I can estimate the total effort to clear the ammunition of the Paardenmarkt site.
In other words, the test needs to demonstrate that ammunition in a certain zone can be salvaged within a sufficiently short period of time and that predictions can be made on the required time and scale of an operation to clear all other remaining ammunition on the Paardenmarkt site.

**Use case 1.8: As the Belgian Ministry of Defence I shall take over the units of ammunition (irrespective of the type) retrieved by the bidder from the test zone, so that I can identify the ammunition and decide on how to process it further.*
The practical arrangements on where and how to offer this ammunition (e.g. on the beach, on a ship, etc.) have to be made by the bidder with the Belgian Ministry of Defence and all local authorities in charge, based on the proposed test method. In this way, neutralizing and processing the retrieved ammunition is not part of the test scope of the bidder. The Belgian Ministry of Defence can cover this part if the required mandate is obtained from the Belgian Minister of Defence and approval of the proposed test method by the authorities in charge (see use case 3.3).

2.2 Boundary condition use cases

**Use case 2.1: As the Flemish Government I shall determine the zones on the Paardenmarkt site where the bidder has to consider a certain amount of locations for the test, so that the most risky zones can be excluded from the scope of the test, but nonetheless to a certain extent it is still possible to draw relevant conclusions for the clearance of the entire ammunition dump site.*

It is the intention of the test to be as much representative as possible for cleaning every area of the Paardenmarkt site, but to avoid extreme safety risks some zones will be excluded. It is therefore not the objective to retrieve a single isolated unit of ammunition on the outer edge of the site, and neither units in clusters in the central part of the dump site. The actual location(s) to consider for the test will therefore lie in between these two extremes and foresee sufficient distance with respect to other clusters of ammunition.

Use case 2.2: As a bidder I can retrieve ammunition safely from the seabed on the chosen location(s), irrespective of the type and state of the units, and subsequently hand them over to the Belgian Ministry of Defence in a guaranteed safe manner, so that the situation during and after the test remains secure.

It is the general principle of the entire operation that everything needs to run secure for people and the marine environment. To this extent it has for example to be guaranteed that there will not occur any decomposition of ammunition or contamination of the marine environment with chemicals.

Use case 2.3: As a bidder I can be sure that the other present ammunition will not be impacted by the salvage operation of the selected ammunition by e.g. maintaining sufficient horizontal and vertical distance, so that the situation during and after the test remains secure.

To guarantee that the test will not influence the condition and environment of the not-selected ammunition, a sufficient amount of distance has to be maintained at every intervention with respect to these other objects.

Use case 2.4: As a bidder I can determine the relevant environmental parameters (e.g. wave height, current) and measure these during the test, so that the test can be carried out securely.

The necessary intervals of environmental parameters within which the proposed test method can be carried out securely, need to be determined. Examples of such parameters can be for example the height of the present waves, magnitude and direction of current, etc.

**Use case 2.5: As a scientist I can measure the environmental parameters (with regard to the marine environment) on T_0-level[2], during the operation, directly after it, and sufficiently long after the operation, so that I obtain an accurate time lapse on the impact of the test on the environment.*

It is important to first know the background values on T_0-level[2] frequently and sufficiently in advance for the relevant environmental parameters like the amount of sediment, quality of the sediment, the biodiversity, concentrations of chemical substances, quality of the water, etc. so that the impact of the test operation on the marine environment is monitored.

[2] *This corresponds with an interval of measuring values (with a minimal and maximal) and an average over time.*

**Use case 2.6: As a scientist I can observe percolation to the underlying layers of fresh water, so that I can identify the impact on the fresh water supplies.*

To be able to exclude contamination of the neighbouring layers of fresh water with chemical substances from the Paardenmarkt site, the percolation present in the area needs to be identified.

Use case 2.7: As a bidder I can make sure there will be no percolation of chemical substances to the underlying layers of fresh water, so that there is no risk for the fresh water supplies.

Besides monitoring the percolation (use case 2.6) the bidder should take the necessary precautions to avoid this, so that there is no risk on contamination of the fresh water supplies with substances of the Paardenmarkt site.

Use case 2.8: As a bidder I can guarantee that there will be a zero-emission of chemical substances to the environment, so that I can guarantee the safety of the environment (as there are currently no safe threshold values on explosive and chemical warfare substances within the environment).

In general, the applicable legislation dictates that there may never be substances emitted into the environment. Specifically on the thresholds of concentrations of present explosives and chemical substances of ammunition within which still safely can be operated, nothing is known. As soon as such threshold values are available (e.g. inspired by the results of the Strategic Basic Research [SBO] project 'Dumpsites of munitions: Integrated Science Approach to Risk and Management [DISARM]' of VLIZ) it is sufficiently to guarantee that none of these chemical threshold values are exceeded.

Use case 2.9: As a bidder I can make use of fast measuring methods (order of magnitude in minutes) to determine the chemical environmental values within the neighbourhood of the test, so that I can sufficiently fast react on exceeding these threshold values of chemical substances.

To be able to comply with the emission standards (use case 2.7 & 2.8) the environment of the test area needs to be monitored on concentrations of the substances present. The current measuring methods on the Paardenmarkt site are insufficient and don't give fast enough results.

**Use case 2.10: As a scientist I can determine the spread and ecotoxicological effects of the possibly emitted chemicals on all relevant species of the marine environment, so that I can assess the impact on the environment at realistic concentrations.*

For this purpose, also all residual products and chemical reactions of the active chemical substances of the ammunition present need to be considered. To estimate the potential spread of these substances, a model like COHERENS[3] can be refined or the necessary data can be delivered to this extent.

Use case 2.11: As a bidder I have to document everything of the execution of the test operation, so that it is clear which actions have and which actions have not been carried out on the Paardenmarkt site by the bidder.

By for example video recording all actions of the test operation, there is no doubt on what is done on the Paardenmarkt site and what has been discovered, so that scientists can incorporate the gained insights in their research on the site.

[3] COHERENS is an open-source ocean circulation model created by different European institutes and MUMM (Management Unit of the Mathematical Model of the North Sea).

Use case 2.12: As a bidder I have to respect safety distances with respect to the ammunition during the operation according to a table determined in an expert discussion, so that the safety on site can be ensured.

A number of guidelines have come out of an expert discussion on which minimum distances have to be respected between the ammunition and e.g. the low-water mark, windmills, underwater cables, buoys, etc.

Use case 2.13: As a bidder I am responsible for the residual risks associated with this test, so that the responsibilities around this test are covered.

The Flemish Government will create the setting into which this test operation can be carried out. To limit the multitude of risks related to such an operation, a number of boundary conditions will be set. Subsequently, the bidder needs to comply with these boundary conditions, and also take responsibility over the residual risks.

2.3 Process use cases

Use case 3.1: As a bidder I can determine the exact risks and impact related to this test operation based on profound scientific insights and experiments, so that the person ultimately responsible can take the right go/no-go decision.

The local authorities in charge carry this end-responsibility for every activity. Therefore, they need to have the right view on the risks and impact related to this operation on the Paardenmarkt site. These risks can for example be related to: the type of shell (thickness of shell, content/composition, …), condition of the shell, etc. It is up to the bidder to share the required convincing scientific insights and experiments with the person carrying the end-responsibility, so that he/she can take a well-considered go/no-go decision for this test.

**Use case 3.2: As a scientist I can assess the risks of a potential explosion of ammunition, so that the necessary safety precautions can be taken.*

Based on the monitoring of the Paardenmarkt site and the proposed plan of the test operation, scientists need to assess the risks of a potential explosion by the test. In this way the necessary safety precautions can be taken.

Use case 3.3: As a bidder I have to obtain approval for my proposed approach of the test operation from the authorities in charge for such an operation, so that I can carry out the test in the proposed manner.

As such the bidder has to obtain approval for his proposed operation from the Belgian minister of the North Sea and the other responsible authorities, on advice of the Belgian Ministry of Defence. The approach of the bidder has also to be checked by the MRCC (Maritime Rescue and Coordination Centre) and MIK (operational part of the Belgian Coast guard) to be sure it complies with their guidelines.

Use case 3.4: As a bidder I have to acquire the necessary general permits for this kind of salvage operation on the Paardenmarkt site from the responsible authorities, so that I know the right preconditions to execute this pilot operation.

To this end there has to be made a risk analysis for the Belgian Federal Government as prescribed in the MRP (marine spatial plan for the Belgian part of the North Sea) which goes into effect as of 20 March 2020. This obligated risk analysis will entail for example that: the general and specific risks associated with the bidder's approach should be identified; the probability that these risks will occur

needs to be assessed; the frequency at which these risks will occur needs to be assessed; measures and their impact on reducing the risks should be specified; the severity of the risks when they cannot be mitigated needs to be assessed.

For the Federal Government there will also have to be submitted applications to obtain samples and analyses on the Paardenmarkt site, a/o by the Belgian Defence laboratories (DLD). The necessary certificates on the proposed approach of the test will also have to be obtained from the Mobility and Transport Federal Public Service (FPS) . Also, the Flemish Agency for Nature and Forests will have to be involved in order to start the right permit procedures and take the necessary measures, e.g. with respect to the bay of Heist. Furthermore, in case e.g. vehicles are required on the beach, the necessary permits should be obtained from the coastal municipality.

Use case 3.5: As a bidder I have to consult all involved authorities and impacted companies, so that the necessary safety plans and procedures can be made.

On the Belgian Federal Government side the following departments need to be consulted to jointly make a plan of action for the execution of the test: the Ministry of Defence, the Health, Food Chain Safety and Environment FPS, and the Science Policy Federal Public Planning Service (PPS). The Ministry of Defence should for example in this way be able to assess which means and people to foresee for this operation.

On the Flemish Government side there should be discussed with the MRCC on which measures to take e.g. for the laying of buoys, input for the safety perimeter, etc.

On a provincial level the province of West Flanders and the governor should be involved in time so to work out the necessary actions and coordination, like preparing an emergency and intervention plan such that in the event of an incident (e.g. detonation under or above water, deflagration, fire, release of toxic agent under or above water) the procedures and means are known.

Locally, the impacted companies have to be contacted to make the necessary arrangements on which procedures to follow to be able to carry out the test operation. This entails for example the neighbouring LNG terminal of Fluxys and the exploiter of the present gas and telecom pipelines.

Use case 3.6: As a bidder I should notify the province, the MRCC, and the maritime police when to initiate their safety procedures, so that the perimeter around the area of the test can be delimited and secured, and a message to all seafarers can be sent.

This is the execution of all procedures during the test operation, as determined in use case 3.5.

Use case 3.7: As a bidder I should promptly prepare a communications plan together with the local government (municipality, province, harbour authority), so that all involved parties receive the necessary communication in a consistent and timely manner.

In this way the police district, civil protection, and fire departments know what the operation will entail. On a Flemish level the divisions of Maritime Access, Coast, and Pilotage desire to remain informed on the test. Likewise, the present companies in the harbour and the Dutch government should be informed on the test. Also, the media and civilians should be informed so to avoid any misunderstandings.

**Use case 3.8: As an authority in charge I have to take responsibility on the activities I have approved, so that the test can be executed by the bidder and the Ministry of Defence can process the handed over ammunition.*

3 Feasibility assessment via the market consultation

On 10th October 2019 a large number of experts from the industry and knowledge institutions gathered on the market consultation of this PIP-project. During this session the use cases were presented for the experts to assess the technological risks.

This innovation potential from a technological perspective was determined via a 'planning poker' technique. Planning poker is a 'best practice' to estimate among others: value, complexity and required effort. This technique is supported by estimations and consensus of domain experts.

The used scale of planning poker scores has to be interpreted as follows:

0 No issues, of the shelf solutions exist.

2 – 3 A frequent problem, a few special cases might exist but can definitely be solved.

13 Not a standard problem at all. A solution requires important decisions, thorough thinking, and specific development. A decent chance at success if provided with sufficient time and resources.

20+ There is a chance that a solution cannot be found.

100 Impossible, requires breaking physical laws.

3.1 Feasibility scoring

The resulting scores of the different use cases in the market consultation is summarized in Figure 1. More details on the rationale behind each score can be read in the full report of this market consultation (available in Dutch only).

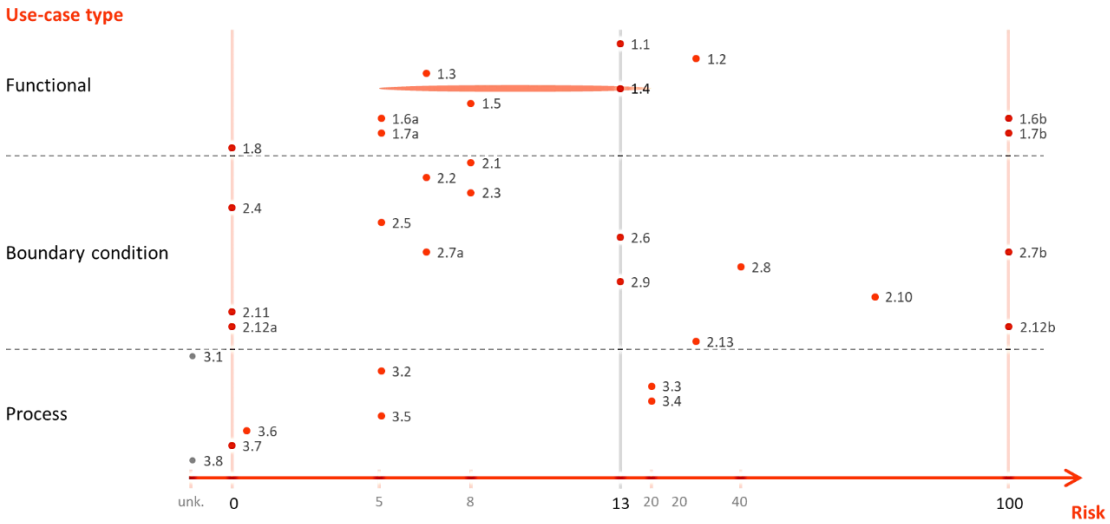

Figure 1: Overview of the risk scores of the use cases from the market consultation. (Use case 1.4 has received a final score of the experts with a spread of 5 to 20)