BEST PRACTICABLE ENVIRONMENTAL OPTION

SR75

Version 1.*0*

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Name	**Company**
HyImpulse Technologies GmbH	Marine Scotland
HyImpulse UK Ltd	Saxa Vord Spaceport

ISSUE RECORD

VERSION #	REVISION DATE	AUTHOR	MODIFIED SECTIONS	DESCRIPTION OF CHANGES
1.0	06/09/2022	D. Corbo P. Breda	All	Initial draft
2.0	17/07/2023		Table 1 Figure 1	Update due to new splashdown zone

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1 INTRODUCTION

Under the provisions of the Marine (Scotland) Act 2010, (M(S)A), a licence issued by Marine Scotland is required for the deposit of substances or articles within waters adjacent to Scotland, or that originated in Scotland. Applications for a M(S)A licence require supporting information, including a Best Practicable Environmental Option (BPEO) assessment, demonstrating that alternatives to sea disposal have been investigated and that sea disposal does not pose an unacceptable risk to the marine environmental and other legitimate users. This report was prepared in support of an application to Marine Scotland for disposal of rocket parts at sea under M(S)A. To do this, the document provides an overview on the debris foreseen during the launch of a sub-orbital rocket by HyImpulse Technologies (HIT), called the SR75. Section 3 contains a list of the debris, with their size, mass, specifications, and a justification for each one of them. The adherence to policies laid out in Scotland's National Marine Plan [AD-01] is discussed in detail in Section 4.

Further information on the planned launch of the SR75 can be found in the associated Marine Licence Application documentation.

2 APPLICABLE DOCUMENTS

[AD-01] Scotland National Marine Plan

3 METHODOLOGY

The methodology associated with this BPEO will differ significantly from other BPEOs, primarily because the activities associated with it are concerned with a sub-orbital launch, rather than dredging. A flight safety analysis is conducted to understand where the launch vehicle is expected to land and how it will perform. The various elements (debris) of the launch vehicle are catalogued below, and it is the recovery (or not) of these items which this BPEO is concerned with:

- Nose Cone
- Booster
- Drogue Parachute
- Manacle Ring
- Hatch

Understanding the material construction of these elements then drives the production of the debris catalogue and with understanding the potential to recover them. A 'do nothing' option is also considered.

Having assessed the feasibility of recovering the debris items, due consideration is then given to the General Policies within Scotland's National Marine Plan.

4 DEBRIS CATALOGUE AND JUSTIFICATION

Table 1 provides the debris catalogue for SR75 including specifications whether the item will be recovered or not, its weight and dimensions, as well as a description of the assessment conducted by HyImpulse. Figure 1 supports the description provided in Table 1.

Table 1: Debris catalogue and justification

Item	Specifications	Details
Nose Cone Not Recovered	Length 1.5 m Ø 0.64 m 140 kg	Hollow ogive (1.3 m) with a small cylindrical section at the base (0.2 m, 1.5 m total). The body is hollow and contains a metal bar with ballast weights mounted on top. The total weight of the structures and ballast weight is around 140 kg. The body will tumble down and hit the water at around 220 m/s: water is expected to fill the body almost immediately after impact, with consequent sinking of the entire nose cone.
Booster Recovered	Length 9.7 m Ø 0.64 m 800 kg	The booster (800 kg dry mass) will be slowed down with a drogue parachute first, then a main parachute, and it will land around 54 km downrange together with the main chute. Water is expected to enter the engine block from the nozzle section and fill it completely. The booster will likely assume a highly tilted/vertical position due to the higher mass of the engine section and relatively low center of gravity of the empty booster without the nose cone. The engine and the next component, the liquid oxygen tank, are connected exclusively by the injectors and feed lines. The first interface is characterized by capillary holes and small pipes, so that water will hardly be able to penetrate the LOX tank, or at least with a slow mass flow rate. If the LOX tank will start to fill, the process is expected to require hours. The recovery ship will be located outside of the 20km dropzone that will exist around the nominal impact area and the booster will have a locator beam. This time should be sufficient to successfully locate and recover the booster before the LOX tank is completely filled with water. In this worst-case scenario, the next component in the line is the helium tank. The only interface between LOX and Helium tanks is again the feed line. In this case though, a pressure regulator (spring mechanism) is present and should be able to completely isolate the tank and stop the water from flowing in. The Helium tank is expected to remain isolated and water-free.
Drogue parachute Recovered	Ø 2.8 m 4.8 kg Chute	The drogue parachute will slow down the booster and kill the lateral component of the velocity. It will be cut when the main parachute opens. In a no-wind ideal condition, the drop area will be the same of the booster. During the launch, the effect of the wind on drogue and main parachute (booster) will be simulated (with real wind data), in order to estimate the

Item	Specifications	Details
		impact areas with higher accuracy. The drogue will be located and recovered.
Manacle Ring Not Recovered	Ø 0.64 m 1.5 kg	Booster and nose cone are linked together using a manacle ring that will be cut to separate the nose cone from the booster. The manacle ring is a thin steel band with several rectangular steel inserts (small blocks) along its length. The manacle is expected to directly sink to the seabed.
Hatch Not Recovered	Length 20 cm Width 60 cm 1.5 kg	The parachute module's hatch is a thin plate, expected to land in the drogue's chute area, shortly uprange of it. It is expected to sink immediately.

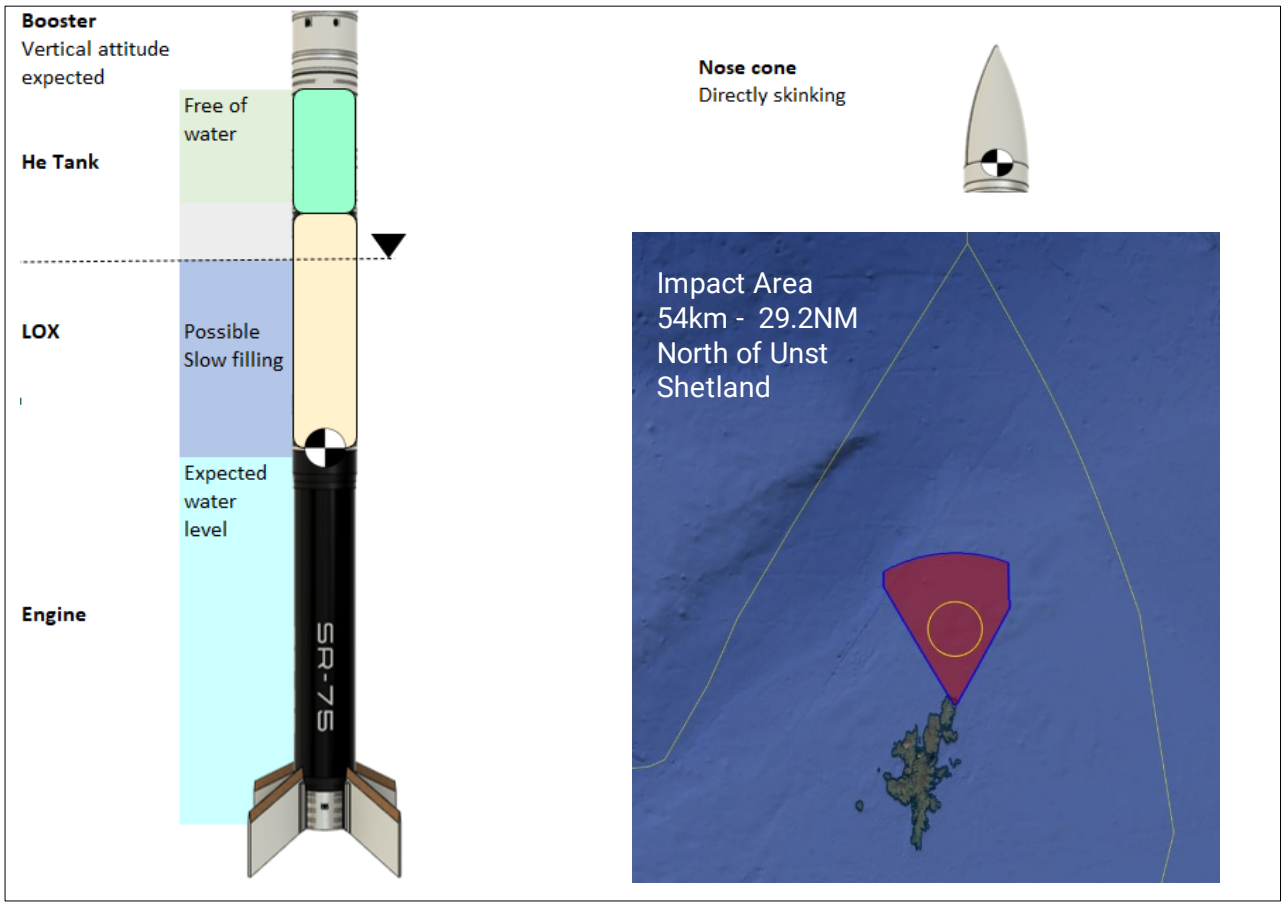

Figure 1: Main debris and impact area

A 'Do Nothing' approach is now considered. Put simply, should this launch not take place (as will be the case for all other launches of this nature from SaxaVord Spaceport) then the launch operator will cease to have a business. This launch will be the first launch of this vehicle and it is designed to not only prove its effectiveness, but also provide the data necessary to make any required improvements for future launches. These early test launches will form the basis for future, payload carrying, launches for which HIT propose to do.

5 COMPLIANCE TO EXISTING POLICIES

This paragraph comments on the general policies provided by the Scotland's National Marine Plan and shows how the debris of SR75 can comply to such policies. Note that not all the policies apply to this case.

Table 2: [AD-01] Scotland's National Marine Plan – Chapter 4. General Policies

Policies		Details
GEN 1	**General planning principle** "There is a presumption in favor of sustainable development and use of the marine environment when consistent with the policies and objectives of this Plan"	HyImpulse is recovering all items which could pose a concern for the safety of the marine environment if the launch frequency of SR75 was to be increased. HyImpulse is ensuring that non-recoverable items do not pose a threat for maritime navigation by sinking into the seabed and not keeping afloat.
GEN 2	**Economic Benefit** "Sustainable development and use which provides economic benefit to Scottish communities is encouraged when consistent with the objectives and policies of this Plan"	This activity will be the first launch of SR75 from the Shetlands and will form the cornerstone for future launch activity from SaxaVord Spaceport. It will require coordination with multiple agencies (maritime and land-based). This launch will validate the procedures of SaxaVord Spaceport for the next upcoming launch of ABL Space Systems in the framework of the project UK Pathfinder Launch. The Pathfinder Launch will herald a new age of space related activity within Scotland. Sounding rocket and space launches will enable science and commercial activities, boosting the economy on the island in Scotland.
GEN 3	**Social Benefit** "Sustainable development and use which provides social benefits is encouraged when consistent with the objectives and policies of this Plan"	As SaxaVord Spaceport will increase its commercial activities, so will the number of high value jobs and enhanced opportunities for the population of the Shetlands targeted to a competitive industry like space. Together with the activities directly related to the Spaceport, an increase of tourist activities is expected in the area.
GEN 4	**Co-Existence** "Proposals which enable coexistence with other development sectors and activities within the Scottish marine area are encouraged in planning and decision	SaxaVord Spaceport cannot operate in isolation from other activities and is reliant on other actors within the maritime sector to achieve its goals.

	making processes, when consistent with policies and objectives of this Plan”	
GEN 5	**Climate change** “Marine planners and decision makers must act in the way best calculated to mitigate, and adapt to, climate change”	This is a single launch and uses a hybrid technology as propulsion system, which is rated as green technology compared to conventional liquid engines based on hydrocarbon fuels. Lower CO and CO2 emissions are foreseen. This single launch will not cause accumulated effects which will negatively contribute to the climate change.
GEN 6	**Historic Environment** “Development and use of the marine environment should protect and, where appropriate, enhance heritage assets in a manner proportionate to their significance”	No impact on historic environment.
GEN 7	**Landscape/Seascape** “Marine planners and decision makers should ensure that development and use of the marine environment take seascape, landscape and visual impacts into account”	No impact expected on landscape and seascape. Non-recovered items will sink to the seabed and will not pose a threat to the maritime navigation.
GEN 8	**Coastal process and flooding** “Developments and activities in the marine environment should be resilient to coastal change and flooding, and not have unacceptable adverse impact on coastal processes or contribute to coastal flooding”	No impact on coastal process and flooding.
GEN 9	**Natural heritage** “Development and use of the marine environment must: (a) Comply with legal requirements for protected areas and protected species. (b) Not result in significant impact on the national status of Priority Marine Features. (c) Protect and, where appropriate, enhance the health of the marine area”	No impact on natural heritage.

GEN 10	**Invasive non-native species** "Opportunities to reduce the introduction of invasive non-native species to a minimum or proactively improve the practice of existing activity should be taken when decisions are being made."	No introduction of invasive non-native species.
GEN 11	**Marine litter** "Developers, users and those accessing the marine environment must take measures to address marine litter where appropriate. Reduction of litter must be taken into account by decision makers"	No marine litters. Major debris will be recovered, while minor debris will sink to seabed.
GEN 12	**Water quality and resource** "Developments and activities should not result in a deterioration of the quality of waters to which the Water Framework Directive, Marine Strategy Framework Directive or other related Directives apply"	The debris will not affect the quality of waters. The assessment is provided as required material for the licence application of SR75. The fuel residuals in the engine, if present, are made of solid paraffine. Under nominal conditions the fuel grain is entirely consumed. No spillage of liquids and contaminants are expected.
GEN 13	**Noise** "Development and use in the marine environment should avoid significant adverse effects of man-made noise and vibration, especially on species sensitive to such effects"	The noise and vibration impact due to the rocket launch had been assessed as negligible for the maritime environment. The assessment is provided as required material for the licence application of SR75. The highest predicted level occurs on land at the closest receptor with a predicted level of 102 dBLAmax. The predicted noise level reduces below 60 dB after approximately 80 seconds. No likely significant effects from vibrations associated to launch events. No effects on fish and birds are expected uprange (marine environment).
GEN 14	**Air quality** "Development and use of the marine environment should not result in the deterioration of air quality and should not breach any statutory air quality limits"	Impact on the air quality due to the single launch of SR75 has been assessed as negligible. The assessment is provided as required material for the licence application of SR75. The maximum predicted dose at the closest receptor to SaxaVord is 44.2 mg/m3 CO over 30 seconds, which is below the statutory air quality limits.
GEN 15	**Planning alignment A**	An extensive stakeholder engagement with wide coordination was carried out and it

	"Marine and terrestrial plans should align to support marine and land-based components required by development and seek to facilitate appropriate access to the shore and sea"	involved stakeholders for terrestrial, maritime and airspace uses.
GEN 16	**Planning alignment B** "Marine plans should align and comply where possible with other statutory plans and should consider objectives and policies of relevant non-statutory plans where appropriate to do so" **<applies to inshore waters only>**	Not applicable.
GEN 17	**Fairness** "All marine interests will be treated with fairness and in a transparent manner when decisions are being made in the marine environment"	The recovery operations require full cooperation with Marine and Maritime authorities and the SaxaVord spaceport.
GEN 18	**Engagement** "Early and effective engagement should be undertaken with the general public, and all interested stakeholders to facilitate planning and consenting processes"	An extensive stakeholder engagement was carried out and involved stakeholders for terrestrial, maritime and airspace uses.
GEN 19	**Sound evidence** "Decision making in the marine environment will be based on sound scientific and socio–economic evidence"	Not applicable.
GEN 20	**Adaptive management** "Adaptive management practices should take account of new data and information in decision making, informing future decisions and future iterations of policy"	The lessons learned from this first launch campaign will enable improvement on future decisions and optimization of the recovery procedures.
GEN 21	**Cumulative impacts** "Cumulative impacts affecting the ecosystem of the marine plan area should be addressed in decision making and plan implementation"	Cumulative impacts were assessed to support the licence application for SR75. No significant cumulative effects on the environment are foreseen for the two suborbital launches planned for SR75 from the SaxaVord Spaceport.