The European Offhsore Spaceport for Microlaunchers - GOSA

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Abstract

The New Space industry is growing in Europe, an increasing number of startups and small and medium-sized companies offering space infrastructure and space-based services from or in Europe. With HyImpulse, ISAR Aerospace, Orbex, PLD Space, Rocket Factory Augsburg, Skyrora, Maïa Space, Latitude, HyPrSpace among a few others, several promising companies developing microlaunchers are located in Europe and a high demand of launch infrastructures is expected in the short and mid-term for operating these new vehicles.

Aside the current European spaceport projects, an offshore spaceport connected to a suitable European on-shore site enabling launches of small satellites to Polar or Sun Synchronous Low Earth Orbits will increase possible launch capacities to existing spaceports and offer new flexible, agile and safe launch opportunities due to its mobile maritime launch infrastructure.

In 2020, the companies Tractebel DOC Offshore, MediaMobil, OHB and Harren&Partner joined their forces in the German Offshore Spaceport Alliance on the basis of their unique competencies in their respective fields of activity in maritime offshore and space projects. The concept foresees a preparation area in Bremerhaven, Germany, and a mobile launch and control infrastructure on two vessels deployed in the offshore German exclusive economic zone (EEZ) where the fully integrated launcher is transported, erected and prepared for launch. Other possible European locations for the on-shore and offshore operations have also been identified (Kourou, Andøya, Saxavord, Azores), taking advantage of existing on-shore infrastructures and favourable launch locations. The foreseen infrastructure and operational concept are kept flexible and agile to be able to serve different type of launchers and to offer rapid turnaround between two launches.

In September 2021, the German Offshore Spaceport Alliance GOSA signed MoUs with Skyrora, Rocket Factory Augsburg, T-Minus and HyImpulse. The project is currently undergoing a concept development phase in view of offering in the coming years efficient service to launch service providers to serve the worldwide growing small satellite market. This paper will give an overview on the currently infrastructure and the operational concept of the European Offshore Spaceport. It will cover topics on airspace and maritime safety and will show the recent progress in the development of the operational concept.

Keywords: Launch, Safety, Offshore Spaceport, Maritime, Microlauncher, Europe

Acronyms/Abbreviations

BDI	Bund der Deutschen Industrie
BSI	Bundesamt für Sicherheit in der Informationstechnik
CIR	Committed Information Rates
CO2	Carbon Dioxide

C-STS	Commercial Space Transportation Services and Support
EEZ	Exclusive Economic Zone
ESA	European Space Agency
EU	European Union
GOSA	German Offshore Spaceport Alliance
ICBM	Inter-Continental Ballistic Missile
IEC	International Electrotechnical Commision
IMCDG	International Maritime Code for Dangerous Goods
LEO	Low Earth Orbit
LTAN	Local Time of Ascending Node
LV	Launch Vehicle
NASA	National Aeronautics and Space Administration
NOTAM	Notice to Airmen
NOTMAR	Notice to Mariners
RFA	Rocket Factory Augsburg
SSO	Sun Synchronous Orbit
SWOT	Strengths, Weaknesses, Opportunities and Threats
QoS	Quality-of-Service
VSAT	Very Small Aperture Terminal

1. Introduction

1.1 The Need for Launch Sites in Europe

In 2022 more than 160 Micro- and Minilauncher projects have been identified worldwide with different level of maturity [1]. In Europe, the space start-up scene has recently been the focus of attention, not only with new satellite providers and downstream application start-ups but also with new microlauncher companies, supported by private investments as well as European (ESA, EU) and national public funds.

The initiative for the Commercial Space Transportation Services and Support (C-STS) launcher program of the European Space Agency (ESA) has clearly shown that the governments are adopting a dual and market-oriented approach in setting its priorities. Especially the German funds subscribed in the program converted directly into start-up orders, which replace the prize money for microlauncher in a German competition. Germany has thus created a competition to promote three competing companies in Germany and at the same time is setting a pioneering brand towards more competition in the overall ESA system. The support for microlaunchers has been confirmed in the ESA ministerial conference in November 2022 and the institutional European market is opening for microlaunchers more and more.

A high demand for launch site infrastructures in Europe is therefore expected at short and medium terms: while not less than seven microlauncher companies have been pre-selected by CNES for operating from the future microlaunchers launch area (ELM) at the Guiana Space Center (Kourou) [2], Isar Aerospace, RFA and Orbex are currently building their respective dedicated launch pad infrastructure in Andøya (Norway) [3], in the Shetland [4], and at Sutherland [5] (Scotland). Considering that each pad is implemented to serve a specific microlauncher, whereas these sites have specific operational restrictions such as seasonal weather conditions, launch azimuth range or the requirement of previous Launch Vehicles (LV) flight heritage [6], it is expected that these European on-shore launch facilities will not be able to serve the whole coming microlaunchers demand. In this context, a mobile offshore launch system operating from the European area is deemed to offer suitable additional flexible launch possibilities for European and international microlauncher companies.

1.2 Interest for Offshore Launches

The interest of an offshore launch base, also referred as maritime or sea launch, has been evaluated since several decades, and is now again, with the emergence of a new demand of flexible and responsive launch infrastructure for microlaunchers, considered as a promising concept [7],[8], [9].

Fig. 1. SWOT (Strengths, Weaknesses, Opportunities and Threats) assessment of ground-based and sea-based launch concepts [8]

Among the main advantages of an offshore launch, the flexibility for the definition of the launch location enables the optimization of the launch performance according to the targeted orbit (somehow similar to airborne launch, but without the same limits in terms of payload capacity), as well as the mitigation of the risk and constraints in terms of launch safety given the flight trajectory. This latter aspect might be considered as a significant advantage especially when considering the launch of new vehicles with no or limited flight heritage.

1.3 Offshore Launch Heritage and Projects

Several sea launch projects have been implemented over the past decades and operated from different locations around the world, showing various configurations and applications, based on different types of offshore infrastructures, serving various launch inclinations for various launchers of solid and liquid types, from microlaunchers to heavy lift launch vehicles. Future projects are even targeting the offshore launch of super-heavy launch vehicles. The following section is providing an outlook of the main sea launch projects actually implemented in the past, as well as a few concepts proposed for future projects.

1.3.1 San Marco Equatorial Range

The San Marco Equatorial Range, part of the Luigi Broglio Space Center implemented by the Italian Space Agency in the 60’s, was based on a jackup barge type launch platform (a former oil platform), set in the Indian ocean next to Kenyan’s coast at 2°56’ South from the equator, a few km from the sea shore near Malindi, supported with a secondary control platform, three logistics boats and one communications ground station on the mainland.

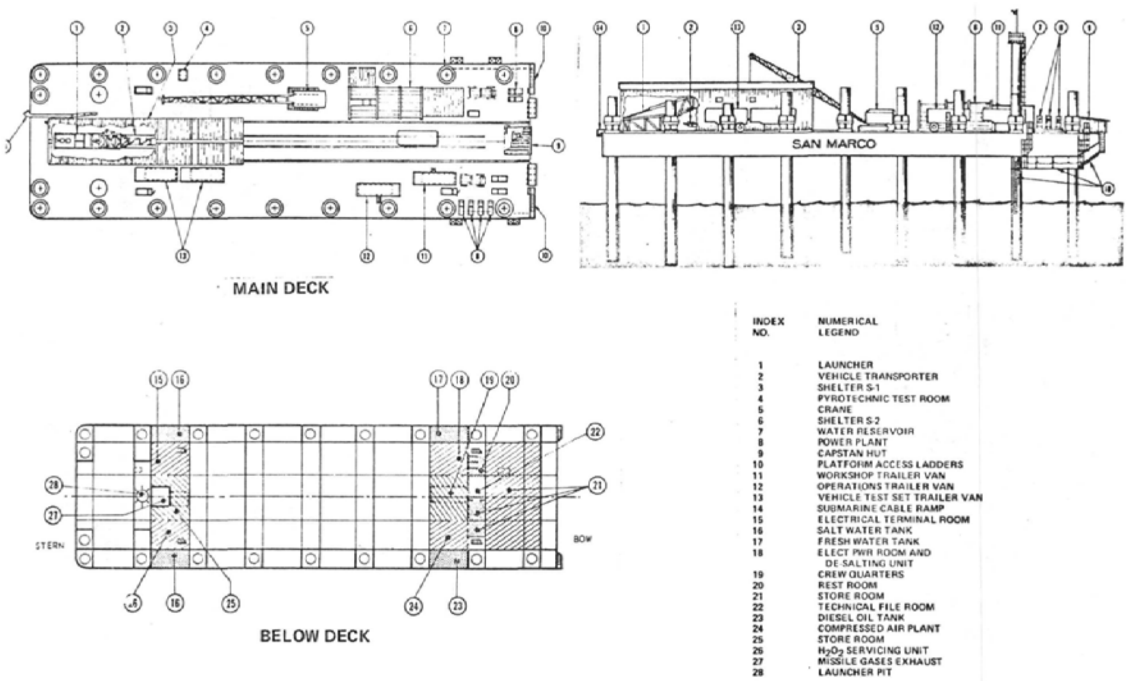

Fig. 2. The San Marco Launch Platform arrangement [14]

The launch configuration that was implemented actually used San Marco as launch platform and Santa Rita as control platform. The San Marco Equatorial Range was operated from 1967 up to 1988 and hosted in total 27 suborbital and orbital launches, including 9 orbital launches with the SCOUT rocket (solid fuel, 3-4 stages, 18-21 metric tons, 21-25 m length) in cooperation with NASA.

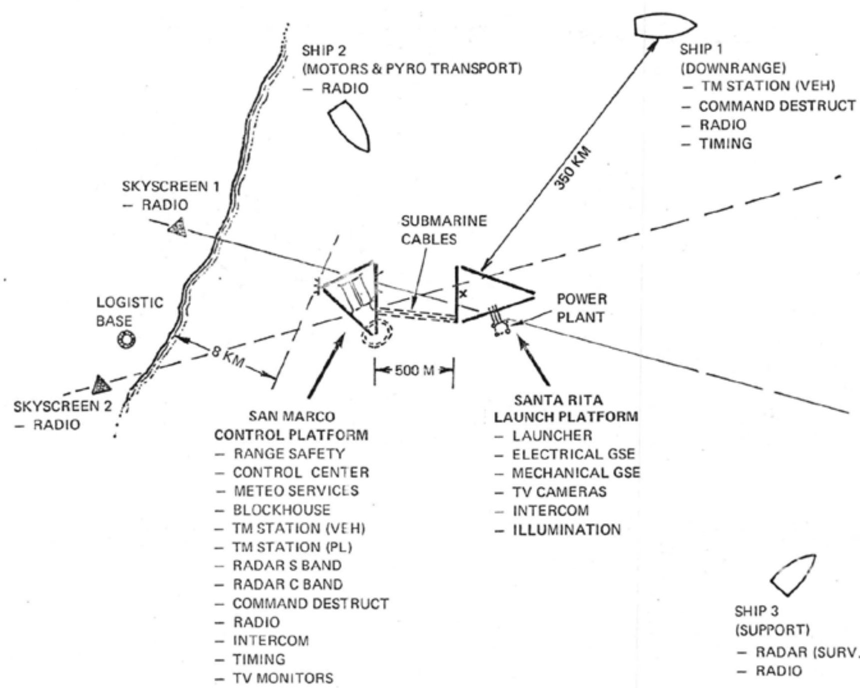

Fig. 3. San Marco Equatorial Range initial configuration concept [14]

17th International Conference on Space Operations, Dubai, United Arab Emirates, 6 - 10 March 2023.

1.3.2 Sea Launch

The Sea Launch system has been operated between 1999 and 2014 and hosted 36 orbital launches with the Zenit-3SL launch vehicle (LOX-Kerosene, 3 stages, 462 metric tons, 60 m length). It is based on self-propelled launch semi-submersible platform (named Odyssey), supported with an assembly and command ship, and was operated near the Kiribati island, 2200 km south of Hawaii and 5400 km far from its base port Long Beach (California).

Fig. 4. The Sea Launch Platform (left, [15]) and Assembly and Command ship & Launch Platform in launch preparation configuration (right, [16])

The LV was integrated and tested aboard the Assembly and Command vessel during the long cruise from the Long Beach to the launch area, then transferred offshore into the Launch Platform when arrived at the launch area.

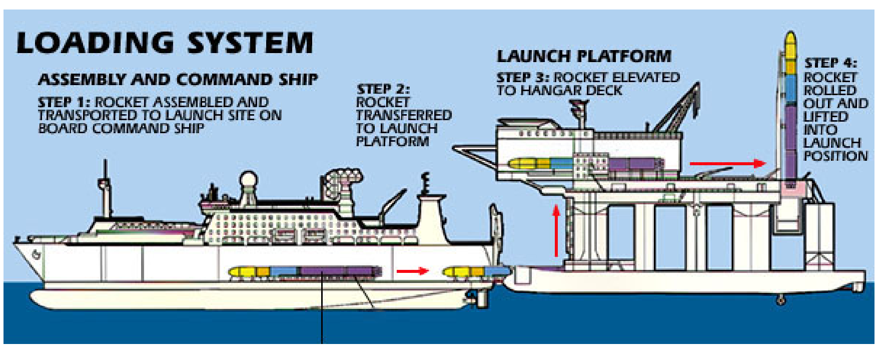

Fig. 5. The Sea Launch Concept of Operations for offshore LV loading aboard Launch Platform [8]

The Sea Launch operations have been interrupted in 2014 after some financial issues and in the context of political tensions between Russia and Ukraine which were both part of the consortium. In 2016, the offshore infrastructure composed of the launch platform and the assembly and command vessel have been bought by the S7 Russian company, and is maintained in the area of Vladivostok in view of launching the next Soyuz-5 launch vehicle generation. Discussions are currently ongoing with Roscosmos for a transfer of property of this infrastructure to the Russian government [17].

1.3.3 Offshore Launch Projects in China

A paper of a Chinese team published in 2020 [18] is providing an outlook of a concept very similar to the Sea Launch one, for the launch of liquid medium-lift launch vehicles. It shows a similar platform configuration as the Odyssey one, and provides details of the considered concept of operations.

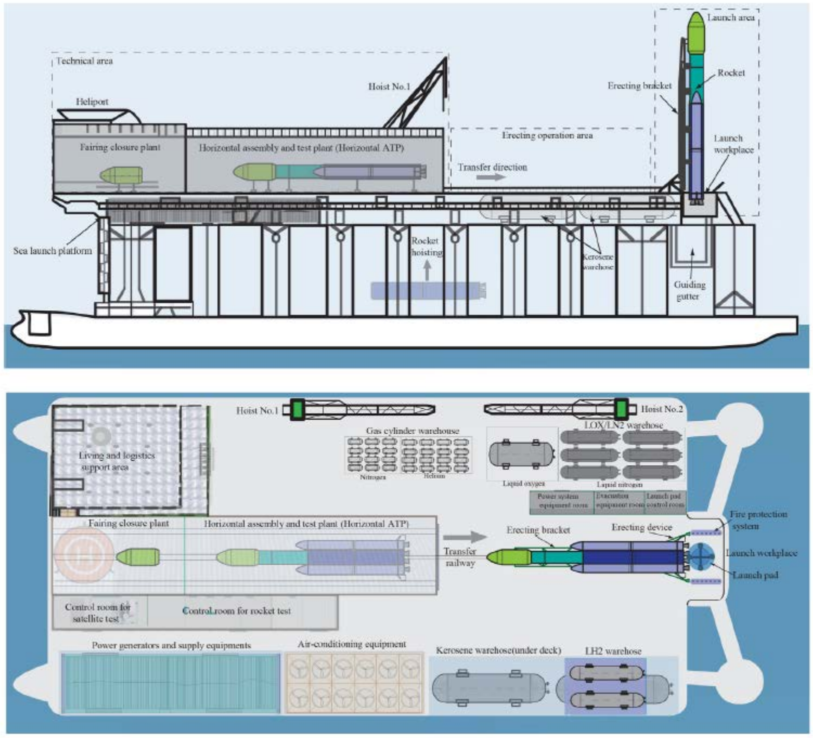

Fig. 6. Semi-submersible Launch Platform concept for liquid medium-lift launch vehicles [18]

The Long March 11 launch vehicle (LM11), a 4 stages solid launch vehicle (21 m length, 58 metric tons) has been launched already 4 times from the sea (East Chinese sea and Yellow sea, a few hundred km far from the Chinese coast) over the 2019-2022 period. Two of these 4 LM11 offshore launches were operated using a non-propelled flat deck barge (named Tairui), 110 m long and 80 m wide, with a load capacity of 22.200 metric tons, pulled to the launch area using a separate tug boat further used as command vessel, whereas the other two launches were operated using self-propelled deck barges (named Debo-3 and Defu-2), 160m long and 40 m wide, with a load capacity of 20.500 metric tons.

The LM11 launcher, also known as CZ11, was initially launched using a Transporter-Erector-Launch system in a silo launch configuration. The LM11 launches operated from mobile offshore platforms have also been performed using the original silo launch configuration. Mobile and containerized equipment is set onto the platform, completing and supporting the launch silo system itself. The LM11 homebase harbour infrastructure is very limited, composed of a few container-based building, a transporter and a container-based fairing/payload A/C facility.

Fig. 7. LM11 launch barge and homebase habor infrastructure

The LM11 homebase equipment include an interesting container-based fairing and payload processing facility concept, as shown in Fig. 8 below.

Fig. 8. LM11 launcher into its launch silo mated to the container-based fairing/payload processing facility set at homebase harbour (left,), and set onto its transporter for transfer onto launch barge (right)

The LM11 setup on the launch barge includes a fairing protection box and a silo erection system.


Fig. 9. LM11 erected into its silo onto the Tairui launch barge [19]

Fig. 10. LM11 erected in its silo aboard the Debo-3 self-propelled launch barge (left, [20]) and the non-propelled Tairui launch platform pulled to the launch point by a tug boat (right)

LM11 launcher is a solid LV which has been so far launched from sea only in silo configuration. An open launch pad option for sea launch is under development in order to lower the dynamic loads to the payload at lift-off.

Fig. 11. LM11 launch from silo launch system from non-propelled (left, [21]) and self-propelled (right, [22]) barges

1.3.4 SpaceX Maritime Launch

SpaceX is currently modifying 2 former deepwater oil plaftorms (named Deimos and Phobos) of the Ensco 8500 Series Semi Submersible type to support the launch and landing of its next super-heavy launch vehicle Starship.

Fig. 12. Artist view of the SpaceX Starship LV onto its offshore launch platform [23]

1.3.5 Black Arrow Space Technologies

The Black Arrow Space Technologies company (UK) proposes an offshore based launch service concept based on a self-propelled vessel, quite similar to the concept developed hereafter

Fig. 13. Artist view of the Black Arrow Space Technologies launch vessel concept (artist view) [24]

1.4 The European Offshore Spaceport Project (GOSA)

Considering the coming demand for new launch sites for European microlaunchers, the Federation of German Industries (BDI) asked the federal government in 2018 to check whether a launch site for small launch vehicles in Germany would be feasible. The idea of a mobile offshore launch platform, to be operated from the German Exclusive

Economic Zone (EEZ) in the North Sea and supported with ground infrastructures located at the Bremerhaven harbour was proposed and further investigated [9], [11]. In December 2020, the operator consortium German Offshore Spaceport Alliance (GOSA) based in Bremen was founded in order to follow up with the development of this concept and its implementation.

The industrial partners that joined their forces in the GOSA are Tractebel DOC Offshore, Media Mobil, OHB and Harren&Partner. Tractebel DOC Offshore offers a large expertise in the planning, implementation and operation of maritime offshore projects such as offshore wind parks or submarine energy cable connections. MediaMobil offers communication solution via satellite especially for maritime mobile systems. OHB is a space group with the knowledge of design, manufacturing and launching satellites as well as the development and manufacturing of ground systems for the space industry. Harren & Partner is a Bremen-based shipping group that has a fleet of 85 units and an expertise in conducting worldwide special (maritime) projects.

2. The European Offshore Spaceport: Targeted Market and Possible Offshore Launch Location

2.1 Microlaunchers for the launch of small satellites into dedicated orbits

Microlaunchers that are under development in Europe do have payload capacities up to ~1 ton and are usually interesting for customers with small satellites with a mass of less than 500 kilograms. The small satellites are often categorized in Mini-, Micro- and Cubesat. Different definitions do exist. The following table give one possible categorization, where the Microsatellites are dominated by Earth Observation and the Minisatellites are represented by SatCom applications.

Table 1. Small Satellite categorization

Category	Mass [kg]
Mini-Satellites II	300-500
Mini-Satellites I	140 - <300
Micro-Satellites II	60 - < 140
Micro-Satellites I	25 - <60
Cube-Satellites	< 25 kg

The number of small satellites that have been launched in recent years has increased steadily and recently by leaps and bounds. In 2020, despite the pandemic, over 1,200 satellites (including the Starlink satellite network) were launched worldwide, of which only 85 satellites had a mass of larger than 500 kilograms. In a study by Euroconsult [4], 12,510 satellites are expected to be launched in the 2020-2029 decade, around 90 percent will be small satellites and 27 percent will be microsatellites with a mass of less than 50 kilograms. The annual satellite launches are dominated by the commercial constellations in the near-earth orbits LEO, such as Starlink and OneWeb. Many of these constellation satellites will be transported to orbit with large launchers and are not easily accessible for microlaunchers. In the same time the number of satellites in the LEO that are not part of a mega-constellation is also increasing. So due to batch launches and regional restrictions the total number of satellites that can be accessible for launches by microlaunchers in Europe is expected to be that around 25 % of the total number satellites launched in this decade.

Many of the telecommunication constellations are launched in orbits with an inclination between 40 and 60 degrees in order to cover the mainly populated areas. Other constellations such as OneWeb and Iridium Next have a polar orbit with an inclination of almost 90 degrees. Earth Observation Satellites are usually launched into Polar or Sun Synchronous Orbits (SSO), i.e. also with inclinations close to 90°.

In order to serve the diversity of desired orbits and to support the required launch cadence, most microlauncher operators plan to launch not only from a single launch site but rather from several locations, in order to be able to offer a large range of launch opportunities to their customers. In this context, there is room and need in Europe for several launch site infrastructures for microlaunchers, serving complementary needs in terms of possible launch inclinations and launch capacity

2.2 The North Sea launch location

The northwest of the Dogger Bank in the North Sea, located in the German EEZ, was assessed to be a suitable launch location. The transfer of the mobile launch platform from Bremerhaven to the launch site takes about one day.

The preliminary assessment of the trajectories shows that both polar and sun-synchronous orbits can be reached from this launch location. Flight paths in an azimuth corridor of around 112° to 85° are possible without trajectories over an inhabited area. This suits ~65% of the small satellite customers

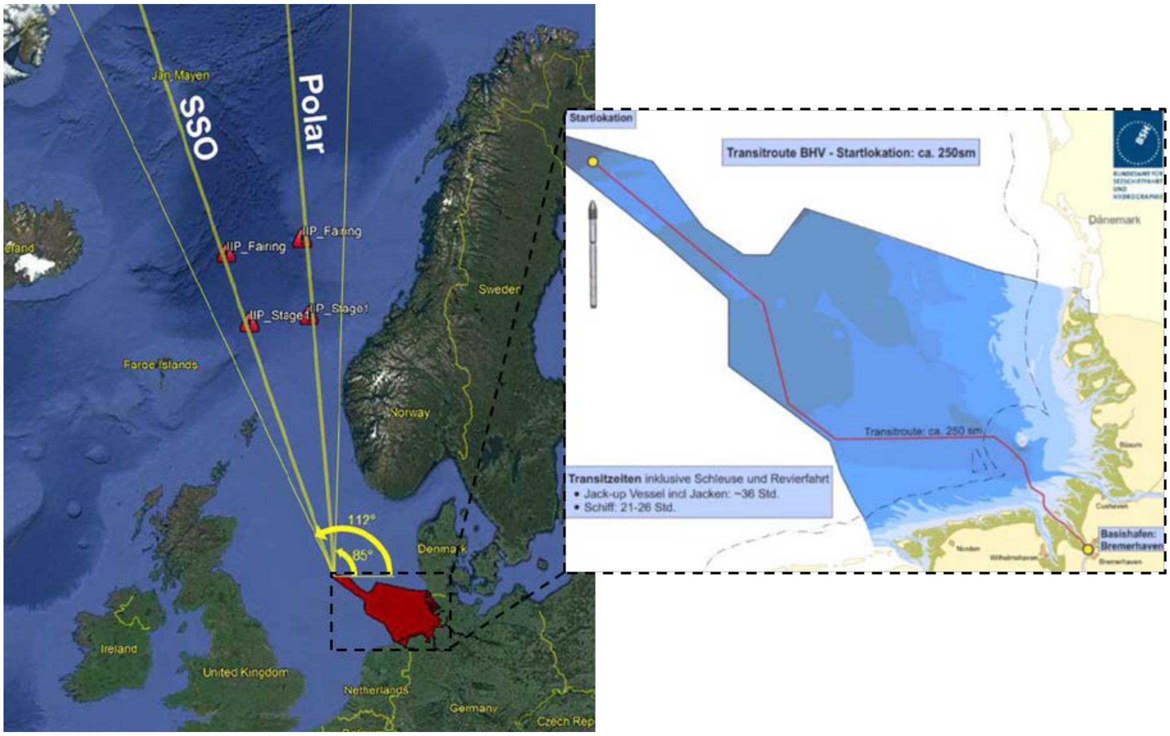

Fig. 14. (left) Typical trajectories and impact areas within the accessible launch corridor from the selected North Sea launch area, (right) sea transit within the German EEZ between Bremerhaven and the selected launch area

Other possible offshore launch locations of interest within the European area are those located in the vicinity of the existing spaceports, taking advantage of their existing on-shore infrastructures, established launch operating procedures and legal framework. Given the limited number of launch pad infrastructures, an offshore launch platform providing an additional and versatile launch pad area, operated in coordination with the existing spaceports, is a priori of interest in order to extend their capacity to serve several microlauncher operators simultaneously and extend the possible launch azimuths for serving a wider range of missions.

The following locations near existing European spaceports located close to the sea shore are currently considered for further assessment: Guiana Space Center (French Guiana, France), Andøya Spaceport (Norway) and Saxavord Spaceport (UK). In addition, the area of the Azores archipelago (Portugal) is also considered although there is no existing spaceport nor ongoing spaceport project at the moment, but a preliminary assessment of a potential spaceport has shown the interest of establishing a spaceport in this area using an offshore launch pad infrastructure, whereas the island of Santa Maria actually hosts a set of tracking antenna and radar equipment which could be used as part of the offshore spaceport ground infrastructure. The identified possible locations are depicted in Fig. 15. The actual feasibility and interest of the concerned spaceports will be further investigated in the current phase of the European Offshore Spaceport development.

Fig. 15. Launch locations of interest identified for the European Offshore Spaceport: (a) North Sea (Germany), (b) Andøya (Norway), (c) Shetland (UK), (d) Azores (Portugal), (e) Kourou (French Guiana)

3. The European Offshore Spaceport: overall Concept of Operations

The European Offshore Spaceport overall concept of operations is composed of the following steps:

- On-shore (typ. duration: 10 to 20 days, upon LV requirements):
  - Delivery of the LV elements (typ. pre-integrated stages) and Payload(s) to the Integration Facility
  - Integration of LV stages & Tests (in LV Integration hangar) in parallel to Payload Preparation & Tests (in Payload Preparation Facility, clean room environment)
  - Encapsulation of Payloads into Launcher Fairing ((in Payload Preparation Facility, clean room environment)
  - Mating of the Encapsulated Payload(s) to the LV and Tests (in LV Integration hangar)
  - Setup of the fully integrated LV (incl. encapsulated Payload(s)) into the Mobile Launch Box
  - Mobile Launch Box roll-in into Launch vessel
- Off-shore (typ. duration: 2 to 7 days upon weather conditions and LV requirements):
  - Launch vessel and Command vessel Transit from Base Port to Launch area
  - Launch preparation including setup and test of communications, LV erection etc. up to readiness to fuel
  - Evacuation of all staff from Launch Vessel into Command vessel
  - Command vessel positioning and preparation for final operations
  - LV fueling and final operations (remotely controlled from Command vessel)
  - Launch

- Launch vessel staff return onboard, post-launch checks
- Launch vessel and Command vessel return to home base harbour

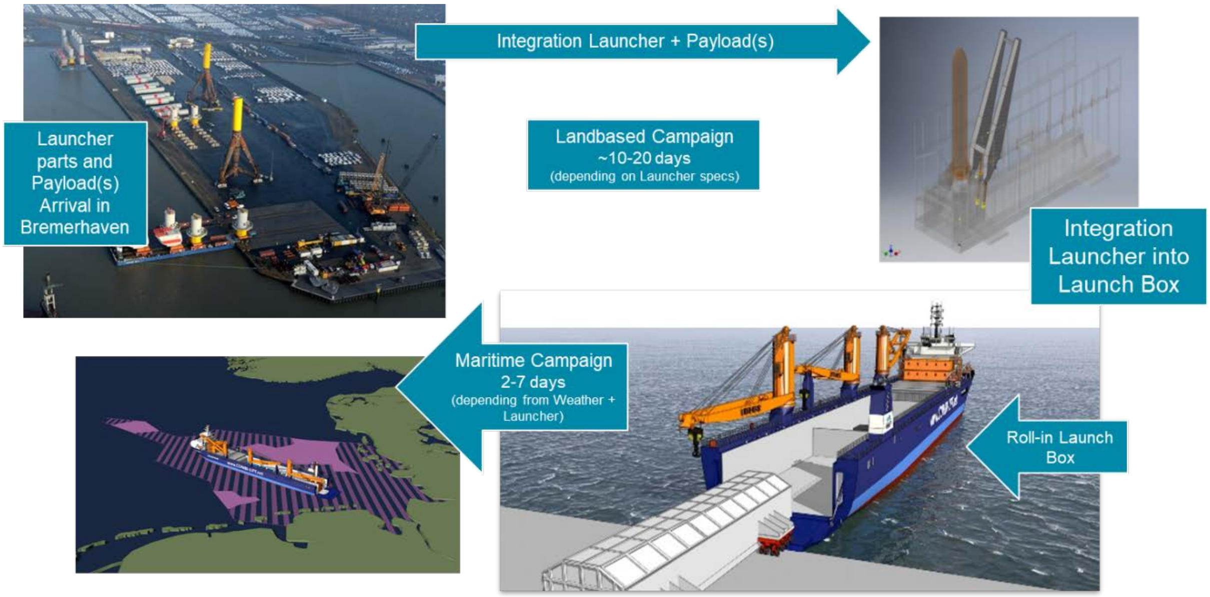

Fig. 16. European Offshore Spaceport Concept of Operations (on-shore part)

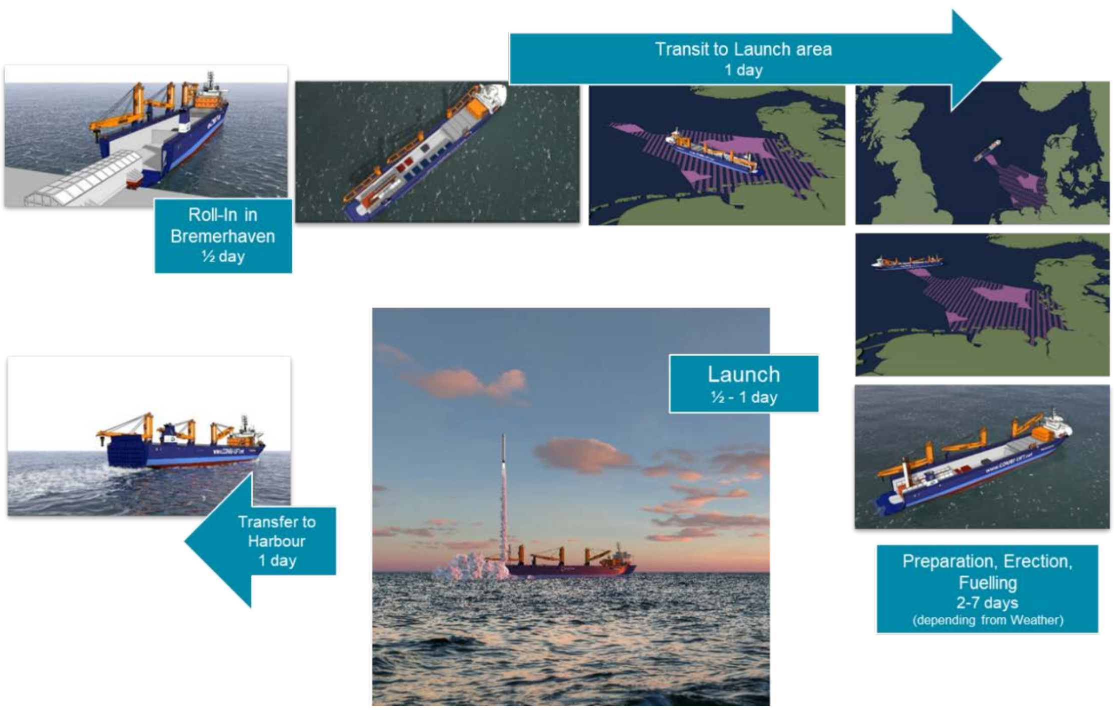

Fig. 17. European Offshore Spaceport Concept of Operations (off-shore part)

4. The European Offshore Spaceport Launch Vessel

A key element of the offshore spaceport is the launch vessel. It must meet the requirements of the various microlaunchers and provide the necessary security and stabilization systems.

The proposed solution is a versatile dock vessel equipped with a stern ramp for rolling cargo on and off the vessel and three heavy lift cranes with a combined lifting capacity of 700 tons. The vessel has a high level of stability and can travel with an open hold and an open stern ramp.

The selected transport and launch vessel for the European Offshore Spaceport project is the Combi Dock I vessel, part of the Harren&Partner fleet. It is the first in a series of four vessels that were built between 2008 and 2010 at the Lloyd shipyard in Bremerhaven, which is used for heavy duty transport operations, including in FloFlo mode (i.e. for shipping floating vessels) thanks to its semi-submersible ability.

Fig. 18. Combi Dock RoRo Vessel

The construction of the dock vessel allows heavy units up to a weight of several thousand tons to be rolled over the stern ramp onto the main deck instead of being lifted using heavy-duty cranes as is usual [28].

Table 2. Combi Dock Vessel Data

Item	Data
Stern Ramp for Rolling Cargo	
3 Heavy Lift Cranes, combined lifting capacity	700 metric tons
Vessel Length	170 m
Breadth	25 m
Cargo Width	18 m
Depth	16 m
Design Draught	5.6 m
Velocity	16 kn
Loading of heavy units of several 1000 tons over the stern ramp possible	
Load Capacity	10,500 metric tons

The vessel Combi Dock I is already equipped for the transport of dangerous cargo (International Maritime Code for Dangerous Goods, IMDG). It is also equipped with a recessed locking system able to secure the launch cargo in its intended stowage position

5. The European Offshore Spaceport Mobile Launch Box

The Mobile Launch Box is another key element of the European Offshore Spaceport concept. The Mobile Launch Box includes all mechanical, fluidic and electric interfaces to the integrated LV (including the Launch Mast), as well as the LV erection system. The inclusion of the Launch Table and Flame Deflector into the Mobile Launch Box is still under evaluation

The main functions of the Mobile Launch Box are to hoist and protect the fully integrated LV from leaving the Integration hangar up to the Launch, to enable the connection of the LV Umbilical lines to the required ground systems, and to perform the LV erection. Its ability to roll into the Launch vessel via the stern ramp and the fact that it includes the Launch Mast and the erection system are essential point of the implementation of the European Offshore Spaceport concept, as the ro-ro (roll on, roll off) procedure is much faster and safer for the launcher and its payload than a crane operation. Moreover, all ground-board connexions can be set and tested before leaving the Integration hangar, which is beneficial to smooth and safe operations, and minimize the operations to be done at later steps.

Fig. 19. Loading/Offloading of the Mobile Launch Box in Roll-in-Roll-Out Procedure

The Mobile Launch Box is seafastened and weather protected during transport by the side wall and the rear ramp. After final preparations and fuelling the roof of the Mobile Launch Box will be opened and the micro-launcher will be erected in launch position. Prior refuelling process, the launch team and the ship's crew will leave the Launch Vessel and the launch control is transferred to a nearby control vessel within a safe distance from which the launch procedure will be remotely continued.

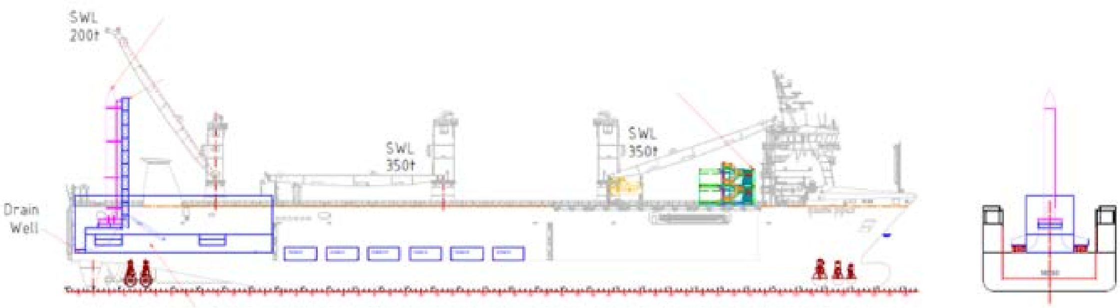

Fig. 20. Section View on Vessel and Launch Box during Launch Preparation

In order to keep the vessel in a defined position, it is equipped with a dynamic positioning system (DP2). High demands on exact positioning and minimized movement during the launch will require a remote control of the vessel in order to meet the requirements of a rocket launch (higher level of redundancy, i.e. higher security in the event of failure of subsystems). The DP2 system together with a remote control will ensure high demands on exact positioning and thus an angle of encounter with the prevailing waves in order to keep vessel movements, in particular pitching and rolling movements, as low as possible.

Before the rocket is launched, the stern ramp of the launch vessel will be opened so that the exhaust jet of the rocket, deflected by a deflector, can exit the vessel unhindered (comparable to the jet funnel on the launch pad).

Next to the launch and the control vessel which are mandatory for the safety of the marine and launch crew as well as for the control of the vessel and microlauncher during fuelling, launch and initial flight phase other supporting units may be required. Smaller guard vessel for the area safety at sea might be required as well as recovery units in case recovery of rocket parts like payload fairings and stages is mandatory. In addition, the offshore concept also offers a good starting point for future developments towards reusable rocket stages and parts that usually return above water for reasons of cost and safety.

The requirements for the various launcher types and its different types of fuel will be managed by interchangeable container tank elements. The fully integrated Mobile Launch Box containing the microlauncher is rolled onto the vessel and secured on deck for sea transport and the subsequent take-off. The vessel will transit approx. 1 day to the coordinates of the launch location in the outer north-western edge of the German EEZ

Fig.21. Launch from the Combi-Dock vessel (Artist view)

6. Flight Safety

Air & Sea Traffic is one of the important topics of the future for all European launch sites. With increasing launches worldwide initiatives worldwide want to optimize flight safety with respect safety and economic interests of ships and aircrafts.

In general, the coordination with sea and air traffic is mandatory like for rocket launches from onshore facilities. The advantages starting from the German EEZ is the avoidance from any inhabited area but still in a central position in Europe. Nevertheless, the launch location at the selected position within the north- west corner of German EEZ and launch direction to the north has the advantages of low traffic volume and low number of fixed sea and air traffic routes. Main sea routes between the European trade harbours are located east and further south of launch location. Same is applicable for the air routes connecting European most frequented airports.

A sea notification process (release of Notices to Mariners (NOTMAR)) will be followed to provide sufficient warnings to all seafarers as well as guard vessels will be used to ensure a minimum safety area at sea without any vessels disturbing the launch process.

Flight safety will need coordination and administration of launch permit for upper airspace supported by Eurocontrol. Eurocontrol is involved into the coordination of higher airspace operation and together with DLR participating and supporting the EU funded ECHO project, which has the ambitious goal to find a way for regulating the use of higher airspace and meet the requirements of all stakeholders of airspace operation in Europe. Eurocontrol is the first contact for the European Offshore Spaceport in order to receive the permission for launching rockets from North Sea spaceport and meanwhile Eurocontrol have gained experience with the coordination and support of horizontal start of air launch projects and coordination with national authorities in Europe for the coordination of the release of Notices to Airmen (NOTAM).

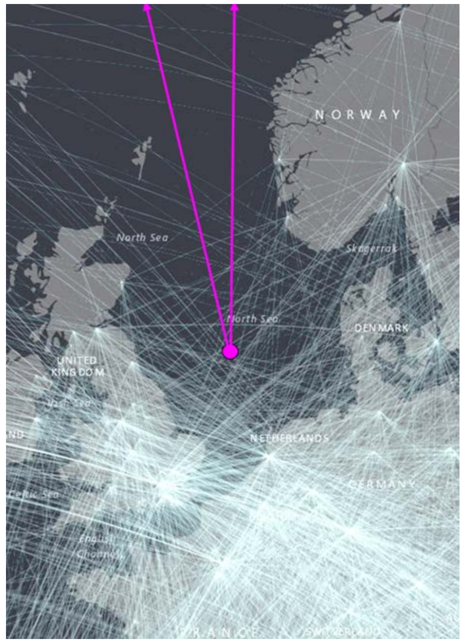

Fig. 22. Flight Trajectories and Airline Routes

7. The Communication Infrastructure

The information exchange and communications between the parties involved in the offshore launch activities require an advanced communications infrastructure. This applies to the onshore integration site, the offshore launch area as well as the transit route of the launch vessel and other supporting vessels.

The key requirements for the European Offshore Spaceport information exchange and communications are security, reliability and Quality-of-Service (QoS). Security implies that the users must be authenticated, any network connection must be protected against interception and the integrity of the information content must be ensured. Besides of applying the relevant Cyber Security standards like IEC 62443 and the BSI IT protection directives, network technologies with inherent security features have been selected at the core of the European Offshore Spaceport communications infrastructure. Reliability means that the communications must be always on with very high availability level, especially for the link to the launch vessel when the vessel is evacuated during the actual launch. The European Offshore Spaceport communications architecture is therefore based on a hybrid, fully redundant network concept. QoS flow control mechanisms will ensure that all information and sensor data is classified with different priorities and committed information rates (CIR) to minimize latency and to ensure the performance of the applications.

The network concept is based on the new 5G standard both for the onshore site and for the offshore launch area. The offshore 5G cell will be connected to the onshore network via satellite. Satellite connections will also be used as backup and during the transit of the vessels between the onshore and offshore working areas. Advanced 5G mechanisms like network slices, user authentication, encryption and traffic flow QoS control will be deployed to achieve the requirements described above. The overlay satellite network will be integrated with the 5G infrastructure and will be based on an advanced VSAT platform operated by the European Offshore Spaceport.

This is a highly innovative network design which will overcome the limitations of current satellite and cellular networks. It will ensure high performance seamless communications between all parties anywhere anytime during the launch activities.

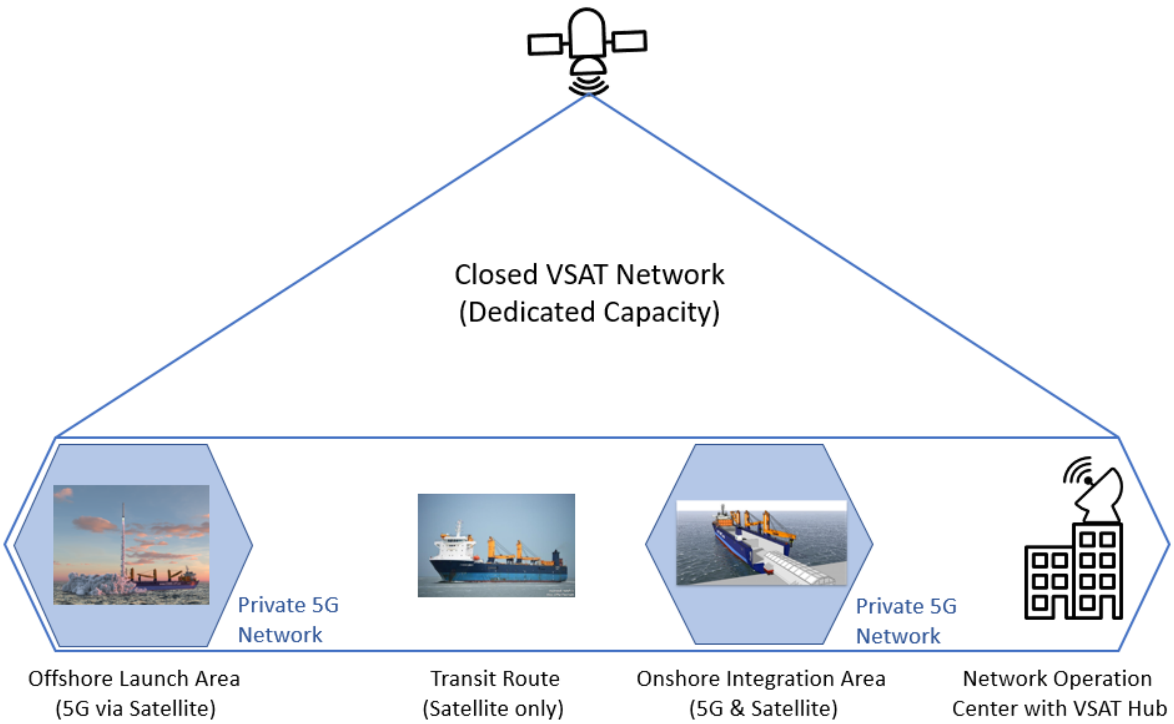

Fig. 23. European Offshore Spaceport Secure Communications Network Architecture

8. Conclusions

The European Offshore Spaceport aims to provide an agile and flexible launch solution for small launchers. In line with the new space mindset, the focus is on a low-cost and effective set-up and company structure. The concept benefits from combining existing know-how from different industries and thereby building on existing procedures and infrastructures. It is for instance not necessary to build a new ship. The core of this new approach is the individual, ship-independent "launch box concept". The possibility to access several ships that fulfil the requirements gives a high redundancy in the event of ship failure and also a high flexibility in order to increase the capacities when needed.

The offshore spaceport with Bremerhaven as selected baseline onshore base port for the on-shore activities is providing cost advantages mainly due to significant reduction of supply chain costs and higher degree of flexibility for direct support of the launch campaign. This leads automatically to the advantages of improved CO2 footprint.

Customers will benefit from positive influence on the entire CO2 footprint through shorter distances for transport and the reuse of existing infrastructure.

Due to the fact that the vessel does not have direct interaction with the seabed, the launch campaigns from vessel do not imply higher environmental risks than starting from shore.

Critical European payload characterized by export restrictions and national interest of European governments can be handled and launched avoiding excessive and restricted process of export control. Therefore, time consuming and costly export permission can be avoided which mitigates risk of significant delay within the project schedule.

The baseline launch site in the North Sea is ideal to serve the growing and urgent need for launch sites for the European institutional and international commercial payloads. An offshore spaceport in the European Union offers the launch from EU territory for its own space programs. In the same time it offers an agile and flexible launch possibility for European and international Microlaunchers.

End of 2021, GOSA has signed MoUs with launcher companies such as HyImpulse, Rocket Factory, Skyrora and T-Minus. In the moment GOSA partner companies work on a feasibility study to investigate technical, economical and approval-related topics in more detail. A customer and stakeholder workshop is planned for end of April 2023 to iterate the requirements of the launcher companies and support the concept development. The partner companies investigate the possibility of a suborbital launch, technical feasible in 2023, to support the approval and licencing process to be able to offer launch capacities to European and non-European launch providers from 2024 onwards.

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