



Small launchers services for agility in space

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Abstract

NewSpace is turning to be a new era for the Space Market as actors are initiating new projects and innovations to democratise access to space. It is driving for more affordable and agile approach to develop space systems and services : Solutions must be found to foster the growth of NewSpace's activities while proposing sustainable and affordable services. To address the needs of the evolving space market, it is crucial to redefine transportation and launch systems with agile and reusable launchers but also to think of initiating a full range of services and additional systems to support the development of small launchers. NewSpace is also changing the space sector by fostering global cooperation with space and especially non-space industries, so it can be highly beneficial to aim for new partnerships and activities.

Regarding the space market, small launchers are perfectly addressing the evolving needs of satellite's constructors and operators : To launch multiple payloads quickly and at low-cost. Indeed, small launchers are faster to produce, easier to transport and more affordable to launch with. One of the main advantages of small launchers could be the opportunity to launch from multiple launching sites depending on mission's profiles : It could be launching from a classic pad like Kourou in French Guiana but also on offshore platforms or northern sites for better SSO performances for example. With a greater production capacity, it is also possible to aim for higher launch rate than heavier launchers like Ariane 5 and to target up to 10 launches per year. The development of a launcher's family could also be highly beneficial with lower development and production costs : By considering a simple launcher as a base, it is possible to upgrade it with additional standard boosters to propose more powerful versions and a greater variety of mission's profiles. Developing additional launchers would allow to address a wider share of the market and propose various services as dedicated, piggyback or rideshare launches for the most powerful versions of the launcher's family. To guarantee multiple mission's profiles as those, it is recommended to provide multiple fairings shape, adaptors, dispensers and even kick-stages to propose various services depending on the client's needs. Furthermore, to support a more sustainable access to space, it is highly recommended to aim for 100% reusable launchers to minimise space pollution and avoid collision risks in orbit. The development of a standard reuse system for various small launchers could foster cooperation between space actors and be the opportunity to aim for 100% recovery at a global scale for small launchers.

With NewSpace's evolution, sustainability and affordability have become crucial for the development of solutions and services to access space. Commercialising various and agile services could be the opportunity to foster the development of reusable small launchers at a global scale. At Sirius Space Services, the project development is inherent to the space market evolution and requirements : The company is focusing on commercialising affordable and agile services to access space by developing a family of launchers, high part systems and a standard reuse kit for small launchers recovery. The presentation will be about determining the challenges of developing new systems and services and identifying solutions to address a large variety of actors.

1. Introduction

With the NewSpace evolution, space actors are supporting the development of small private and low-cost entrepreneurial projects to develop innovations and easy access to space. Regarding NewSpace launchers activities, it is now crucial to consider sustainable and reusable architectures to provide for tailored and dedicated rides.

Today there is a need to support NewSpace activities and define with space actors a new way of considering space missions. To that end, in this paper it will be presented the advantages of developing a family of modular reusable rockets. With a wide range of capabilities, it is possible to target payload capacity up to 800kg on a Sun-Synchronous Orbit of 700km, with the ambition to provide for competitive, sustainable and agile access to space. To do so, it is recommended to develop simple products, using low-cost and COTS systems to guarantee affordable services. There is also a need to work with experienced space companies, to adapt the launchers to the market's evolution: simple and flight proven technologies combined with new space innovations. The objective would be to reuse 100% of the launchers on the long term while developing innovative systems for recovery and reusability purpose. In this article, it will be shown that flexibility is mandatory for future space program and crucial to support agility in space missions. There will be also a proposition of recovery system will also be presented here to address the reusable market needs, including upper stages, fairing and booster recovery.



Figure 1 : Sirius launchers @Sirius Space Services

Regarding the space development, it is also crucial to consider the life cycle of the product to make launchers more sustainable. Recovery of small rockets should be supported, as it guarantees low carbon footprint emissions to drive a new model of production and consumption of space products. This article is dealing with sustainable and new space innovations to support low environmental impact for space missions. There are propositions of space product management to support agility for space access and lower the carbon footprint of NewSpace activities.

2. Small satellites market's needs

In the document published by the Air and Space Academy in 2021 [1], it has been shown that the number of satellites available on the market from 2024 to 2028 should be significant and shows that the range of 800kg capacity is consistent with the needs for launch services, as shown in the next figure.

In the figure below, the number of satellites between 51 and 250kg will grow in the next years which is perfectly addressing the needs of agile and affordable rides to space. There is also an important volume of heavier satellites, almost 200 satellites of 251 to 500kg, which is perfectly matching the capability of larger launchers with a payload capacity up to 800kg and a significant development for new constellations that requires to launch multiple medium satellites through batches. Constellations like those are the perfect opportunity to address the space market and aim for long-term agreements.

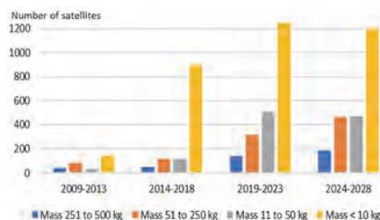


Figure 2 : Number of small satellites (excluding broadband connectivity) @AAE

Today, what is important for satellites manufacturers is to get tailored launch services at low-cost and high flexibility options. Launch plannings are expected to be shorter and satellites can be sent all over the world depending on the mission needs and operations requirements so one of the main objectives would be to launch from multiple launch sites as it will be explained later. To that end, it is necessary to support for agility and flexibility considering launch services requirements and a family of small reusable launchers is perfectly addressing the needs of the market.

For launcher manufacturers, there is a need to anticipate the evolution of future space market and to target a commercial development logic, which implies to adapt to the evolution of the NewSpace activities. Small launchers development should be agile and constantly evolving with the market needs to guarantee that it is providing one of the best services to target space.

3. Modular launchers and simple architecture

There are more advantages to develop a family of launchers than considering the market's evolution, including cost optimisation and simpler development phases. Developing a family of launchers guarantees an agile and innovative development organisation and requires determining new technologies and manufacturing processes to optimise the design, production and test phases.

3.1. Modular launchers

For launcher manufacturers, it should be supported to develop highly modular and adaptable launchers, in order to easily adapt and reconvert some parts for one launcher to another. For example, the first stage of one launcher could mean to be easily adapted as a booster for a heavier version. Doing so, and by using the same architecture, propulsive and fluidic systems, it will be significantly easier to lower costs and development phase duration. To optimise the production of the cryogenic stages, it could also be considered manufacturing same tanks structures for propellants to lower the costs and production times. The fairings should also be adaptable and suitable for each launcher, depending on the mission needs and capabilities. Three versions could be available considering at least one larger expended version for constellations rides or institutional and heavier satellites launches. As for the adaptors and dispensers, it is necessary to design and develop various and modular systems to be suitable for multiple mission's variations such as constellation rides, rideshares, piggyback and dedicated launches. Using flexible platforms and configuration is one way to optimise the number of satellites and cost of launches.

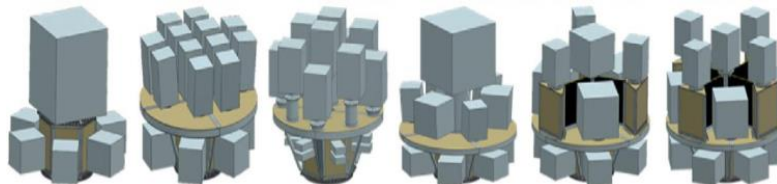


Figure 3 : SAB aerospace dispensers @S.A.B. Aerospace

Using modular and adaptable systems for a launcher's family is the opportunity to provide for tailored services and simplified operations : Combined with a standard price for all of the launchers, this is the opportunity to target for more flexibility in filling launchers with satellites dedicated to the same orbit and having the same launch date target. Inspired for the highly modular launcher Ariane 4, a range of small adaptable launchers would be providing for a wide range of mission capacities using an adaptable number of boosters. The main objective is to optimise the satellites launch flexibility and filling configuration under the fairing to optimise cost and operations. Promoting modular systems and simple architecture is the opportunity to optimise the development, qualification and production processes of the launchers.

3.2. COTS components

To optimise and target a competitive launch price, launcher manufacturers could aim to use as much as possible space and non-space COTS components. There is a need to support collaboration opportunities and to work with numerous partners with various backgrounds to support the project's development.

To guarantee affordable launch services, launchers providers should be aiming to use as much as possible COTS and generic components, which can be adapted or integrated on other systems. For example, separation systems for the inter-stage and fairing separation phases could be using the same technology to guarantee lower development and production costs. It should not be limited to consider only space systems, as there is today great collaboration opportunities for non-space companies to provide for new innovations and possibly affordable systems. To reduce the qualification times and increase chances of success, it is also necessary to select components and systems that have already a high maturity level considering a minimum TRL of 6 or 7. Some systems can have a lower TRL, but it will require a particular integration to ensure qualification of those systems.

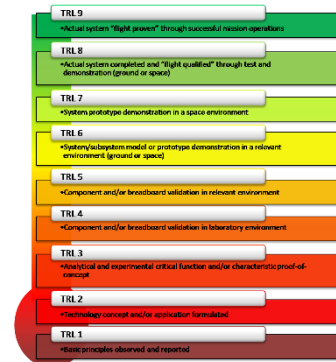


Figure 4 : TRL scale @NASA

Some innovative processes can also be highly supported, for example metal additive manufacturing is a new manufacturing process that most of launcher manufacturers are developing and integrating within their teams to support new technologies.

3.3 Metal additive manufacturing

Regarding micro-launchers development, there is a need to promote reliable and simple architecture for small launchers, and a new manufacturing process is highly recommended for fasten production processes : In-house metal additive manufacturing.

This innovative and challenging technology is the opportunity to lower the production cost while maintaining great performances and guarantee reliability for space systems. Considering for example to use the same engine for the first stage, second stage and additional boosters, it is crucial to develop metal additive manufacturing in-house to optimise development cost and duration. The main advantage for this manufacturing process is to promote rapid prototyping, with a time of production that is easy to estimate. Also, the additive manufacturing process allows complex geometries to save mass while maintaining good mechanical properties, so it is possible to design infinite geometry and shapes. Considering that small launchers usually promote higher launch rate, it is critical to integrate manufacturing processes to support production planning. Metal additive manufacturing is one of the most adequate solutions as it would allow to manufacture every day and night, in-house with the right equipment. Indeed, using traditional methods, manufacturing engines would not be suitable to produce up to 300 engines a year for small launchers. Additive manufacturing is also a manufacturing process that can be easily integrated in-house, with training of dedicated teams and quality control to ensure that the pieces are compliant for launch.



Figure 5 : Star1 engine made by metal additive manufacturing process @Sirius Space Services

Additive manufacturing is also an innovative process that guarantees a lower environmental impact while reducing the waste production and transportation needs to have at least identical or even better thermo-mechanical properties than traditional manufactured pieces.

4. Launch capacity and reusability for small launchers

Today, there is a huge opportunity considering reusability for small launchers to target modularity and agility in space. Recovering small launcher parts can provide for shorter and diversified operations configuration to access space in a more agile way.

4.1 Diversification of launch sites

Considering flexibility of small launchers, there is an opportunity to consider launching from multiple launch sites all over the world. This can be the opportunity to provide for highly agile launch services and tailored missions for small satellites.

Today small launchers can be launched everywhere thanks to the development of many launch centre projects all over the world. More than 20 different countries are currently planning or developing launch sites for micro-launchers, considering more than 50 launch pads under development. The opportunity to launch from many different spaceports could lead to various mission profiles, organisation and more flexibility for launch services. It is also a powerful commercial asset to launch satellites on their territory, having to bring the launcher to the launch pad.

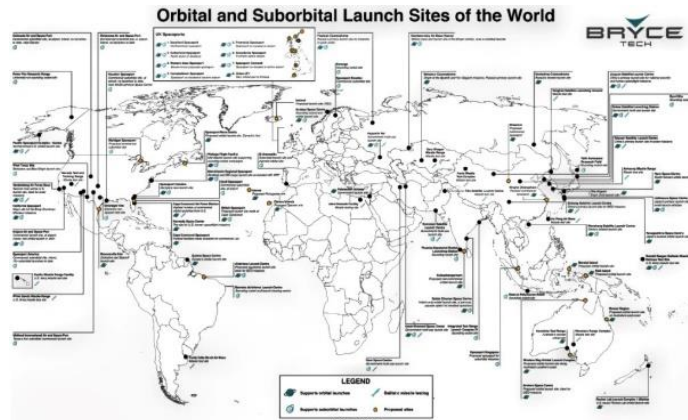


Figure 6 : Launch sites in the world @Bryce Tech

One of the main advantages to small launchers is the possibility to launch using a truck to carry the rockets and organise the launch sequence with a minimum of additional ground systems needed. This is the possibility to launch from multiple sites in the world thanks to the great adaptability of small launchers to ground system facilities.

4.2 Reusability for small launchers

Developing small reusable rockets is the opportunity to catch up launcher parts and to brought them back to technical facilities for maintenance. There are multiple solutions to study in order to recover elements depending on the size of the launchers.

To accommodate with small launchers and systems, the recovery system could provide at least a parachute reuse kit to aim at first for small launcher part's recovery. Indeed, the development of a parachute reuse system should be significantly more affordable than other systems as it is simpler to design and to aim for using COTS and non-space systems with high maturity products. This solution would be combined with the use of a helicopter to hook in mid-air the line between the pilot parachute and the main parachute. After this operation, the launcher's elements are brought on a boat to return to the spaceport. Considering the performances of the helicopter, this solution only applies to pieces with a mass of less than 2 tons.

For heavier launchers, parachute might not be suitable and reverse thrust combined with intelligent recovery system could be considered. The development of a versatile drone ship should be highly recommended, as it would allow to recover parts of the launchers together to be shipped to the nearest harbour for recovery and qualifications. The drone ship system could be easily combined with the use of reverse thrust to catch the stages of the reusable launchers and is compliant with the use of multiple spaceports.

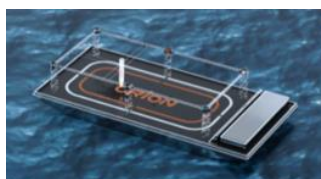
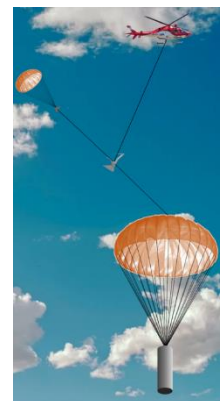


Figure 7 : Sirius recovery solutions developed in partnership with @ Orion Space System

Recovery systems and reusable launchers are part of a strong initiative to support the development of sustainable space activities. It is possible to provide for solutions to lower the environmental impact of space missions and to minimise the amount of debris into orbits.

5. Conclusion

The growth of NewSpace has led to a diversification of actors and activities all over the world. As of today, there is a need to make space more accessible and agile to lighten processes as the requirements for launch are now affordability and sustainability meeting with flexibility. To comply with the evolution of launch services, it is crucial to support the development of small launchers that can be easily integrated on various spaceports all over the five continents, also considering simplicity in design and architecture alongside recovery and reusability solutions.

Developing a family of small reusable launchers with a wide range of payload capabilities is perfectly addressing the needs of the space market. It is possible to adapt launchers to the mission profiles and requirements to minimise planning for launch operations and optimise filling the launchers. This is one solution that we are supporting at Sirius Space Services to address the market and democratise access to space.

References

- [1] J. Ackermann, C. Bonnal, G. Bréard et al. 2021., SMALL LAUNCHERS : A European perspective. AAE file 52/DGLR file 2021-01.