ACADEMIE DE L'AIR ET DE L'ESPACE
AAE
AIR AND SPACE ACADEMY

The Opinions

Opinion of AAE on the

Future of European Launchers

ISBN 978-2-913331-79-2
ISSN 2426 3931

2019 Opinion No. 9 € 10

TABLE OF CONTENTS

INTRODUCTION

Almost twenty years after the first flight of Ariane 5, which still guarantees European independent access to space today, and has long supported the position of Arianespace as world leader in the realm of commercial launches, the decision was taken in 2014 to develop a new generation of launchers: Ariane 6. Since then, however, there has been an increase in commercial, financial and technological pressures from new operators such as SpaceX, whose successful start owed much to NASA's need to regain US access to the International Space Station. The reusable first stage of the launcher is one of the most visible aspects of this competition. Projections for Ariane 6 are down as a result, particularly commercially speaking, not least due to the current collapse of the market following a drastic reduction in the need for geostationary satellites, as well as doubts surrounding the potential market for constellations. Given this situation, the Air and Space Academy (AAE) considered it timely to examine this topic and its general context.

While underlining that this is a global problem, this Opinion focuses more particularly on this question of the future of Ariane, because of its relative urgency. However, Vega has also become an important launcher for European access to space in a range of smaller satellites, and the future of this launcher class also needs to be carefully considered. In addition, the emergence of launchers tailored to micro and nano-satellites, not studied in this report, will also undoubtedly contribute to shaping the future landscape of access to space; several projects exist in Europe in this category.

The following text, aimed to be concise, sets out five recommendations which, on different levels, all express an acute concern for Europe's strategic independence and unity as well as a renewed technological ambition:

RECOMMENDATION 1:

Endow Europe once again with an ambitious Space Vision, transcending purely economic motivations, in which a key element is sovereign access to space and space exploration.

RECOMMENDATION 2:

Recreate a genuine European strategic alliance in the area of launchers between France, Germany and Italy, as well as other EU members and ESA, integrating the European preference requirement.

RECOMMENDATION 3:

Reach a consensus at the highest political level as to the urgent need for a European strategy for access to space capable of matching scenarios of disruptive innovation pioneered by SpaceX and Blue Origin in particular.

RECOMMENDATION 4:

Achieve an in-depth understanding of how SpaceX reached this level of technical and economic performance, in order to draw lessons for European launchers within their own context. Proceed likewise with Blue Origin and other programmes as soon as possible. Establish a permanent entity for fact gathering.

RECOMMENDATION 5:

Begin immediate, determined funding for the preparation of a successor to Ariane 6, inspired by the principle of disruptive innovation, which should deliver long-term competitiveness and flexibility.

1. NEWSPACE COMBINED WITH POLITICAL WILL TO RENEW AND RELAUNCH THE SPACE ADVENTURE

The future of launchers can only be conceived within a comprehensive European space strategy. Currently the United States (the government but also the private sector, which is a radical innovation), China (which in 2018 became the leading power in terms of numbers of launches) and soon India (which is stepping up initiatives) are redefining and re-developing genuinely ambitious visions for their space future, indicating their desire for power and/or to invest in technological revolutions.

Whether it is a question of mega-constellations to support the Internet, renewed plans for an inhabited lunar base followed by travel to Mars, exploiting asteroids or protecting the Earth against dangerous NEOs – to cite just a few examples – a whole new "space world" is emerging, of which launchers are an integral part.

Europe, though, the world's second largest economic power, which some 30 years ago was capable of promoting – and largely carrying through – a coherent, very ambitious range of programmes, seems to have run out of steam. It is lacking both impetus and momentum. And yet a grand plan for space could, more than ever, release immense economic, technological, scientific, military and strategic potential; not only would it have the capability of unifying and strengthening the European ideal, but also a virtually unrivalled capacity to stimulate interest in science and technology which is currently on the decline in European youth.

The future of Europe in the great space adventure, which cannot be limited to cherry-picked applications, is consequently in danger of being subservient to American and – soon to Chinese – ambitions, through cooperative projects in which Europe would take only a back seat. This is true, for example, of space exploration and exploitation and manned

flight projects where, despite its excellence in the sciences of the Universe, Europe has for some time had no perceivable strategy (other than sectoral). Elsewhere, on the other hand, the combination of "NewSpace" initiatives and political will are giving a new impetus to these very subjects.

It is vital we rediscover the energy of the early days in 1975, then of Ariane 5, Hermes, Columbus, Envisat, Horizon 2000, etc., in 1985. This can only be achieved at the highest political level, that is to say at the level of heads of State and government, where it would be advisable to bring together the EU bodies and ESA council. This vision should be comprehensive, avoiding the kind of haggling between states which tends to deliver a hotchpotch of more or less disparate programmes. It should also aim to encourage equally ambitious, diversified private initiatives in a broader, more methodical way.

It is within the framework of this rediscovered vision that access to space must be redefined as an essential requisite of **sovereignty**. With the present push to construct a European Defence and an expansion in space applications and services, independent access to space is essential. The commercial successes of Arianespace with Ariane 1 to 5 may have overshadowed this fundamental objective, giving the impression of it being an "added extra" when it is in fact the key argument justifying the continued existence of independent European launch systems. In order to be efficient and applicable, a European space strategy should include an ambitious model for European launch services at global scale.

RECOMMENDATION 1:

Endow Europe once again with an ambitious Space Vision, transcending purely economic motivations, in which a key element is sovereign access to space and to space exploration.

Let us now turn to the question of launchers.

2. EUROPE LACKS A SHARED APPROACH BETWEEN THE MAIN PLAYERS

The evolutions of Vega (Vega E, which still needs to be specified), the discussions around the P120 common to Ariane 6 and Vega and the announced arrival of a Lox-LCH4 engine to replace the AVUM (Vega's top-stage engine, of Ukrainian origin) all hold the risk of growing friction between the worlds of Ariane (A62) and Vega, in particular concerning European institutional launches. For while the guaranteed minimum number of institutional launches constitutes a fundamental basis for the economic viability of both launchers, the corresponding requirements are in fact likely to be at the bottom of the Ariane 6 payload range, while the specifications of the future Vega E could approach those of Ariane 62.

Even though the two launchers are linked by the use of the solid A6 boosters, which also constitute the first stage of Vega, current relations between the two "systems" are not satisfactory, either between the companies or the agencies involved.

Although Italy has become a major player in the launcher industry (or perhaps for that very reason), there is no shared long-term vision, but rather a type of separation Europe cannot afford (except possibly at the R&T stage for sound competitive reasons). Italy must be part of European leadership on access to space, alongside Germany and France, and must therefore be fully integrated into the different stakes.

State and industrial players – the EU, ESA, the national agencies (CNES in France, DLR in Germany and ASI in Italy) and the industrial prime contractors of Ariane and Vega, ArianeGroup and Avio – must work together in the face of the obvious desire on the part of the other powers to limit Europe's role, and converge towards a common vision of their future.

Ariane 62 – Vega C

Figure 1: The Ariane 6 powder accelerators and the Vega C first stage use the same solid-fuel engine (P120).

The European institutional satellites (Copernicus, Metop, Meteosat, military observation, ...) of the 1.5t / 2t category are aimed at Vega C or Soyuz, or even the lower performance range of Ariane 62. Their launch rates are low.

	Launcher height	Take-off weight	Payload performance sun-synchronous orbit 700 km	Geostationary transfer orbit GTO capacity	Price estimation
Vega C	35 m	210 tonnes	2,200 kg	NA	€35 M (rate of 3 per year)
Ariane 62	63 m	530 tonnes	7,000 kg	5,000 kg	€70 M (rate of 11 per year)

Moreover, it has been emphasised over and over again in all its different bodies – the EU, ESA, Eumetsat, each member state – that Europe must at last guarantee a European preference for use of its launch vehicles, provided that certain conditions of availability and pre-established prices are respected; this is far from having been the case in the past (although the EU policy for launching Galileo via Arianespace must be underlined). There is no need to go into this at greater length here: it is a matter of common sense, politically and strategically, and obtaining such a commitment is a prerequisite for a successful, sustainable European space vision.

RECOMMENDATION 2:

Recreate a genuine European strategic alliance in the area of launchers between France, Germany and Italy, as well as other EU members and ESA, integrating the European preference requirement.

3. SPACE-X AND BLUE ORIGIN DRAMATICALLY CHANGE THE SITUATION

The formidable nature of the SpaceX challenge to Europe has been clear since the early days of Ariane 6 development: it was even an essential element in the political decision behind the Ariane 6 programme. But, four years later, it is clear that SpaceX, with the help of American institutions, has progressed both further and faster than anticipated at the time.

Based on the Falcon 9, SpaceX has instigated a scenario of disruptive innovation characterised by immense ambition and innovative technical choices in terms of propulsion, lighter structures and in particular a reusable first stage (a technical success which will undoubtedly deliver economic benefits although it remains to be formally demonstrated). Although it has benefited from *considerable* indirect support from the American government through institutional orders (at almost double the commercial price…), the success of SpaceX is also due to the fact that, after a process of continuous evolution, Falcon 9 offers a remarkable cost/performance ratio. In addition, beyond its concrete successes, SpaceX helps give real meaning to the space adventure : whatever one might think of the realism of the manned Mars exploration project as put forward by Elon Musk, it possesses a remarkable entrepreneurial and technical dynamic. At the same time, Jeff Bezos, with considerably greater financial means, is pursuing the development of Blue Origin discreetly but apparently very efficiently – once again with a stated goal of reusability. Other initiatives exist too (such as Virgin Galactic). These "NewSpace" billionaires from the digital economy are creating completely new conditions and revolutionising the commercial launch market (although not necessarily their main target) in which Ariane has been the undisputed champion for three decades.

As a result, the situation for European launchers is not only unprecedented but critical. The official price tag for Ariane 64

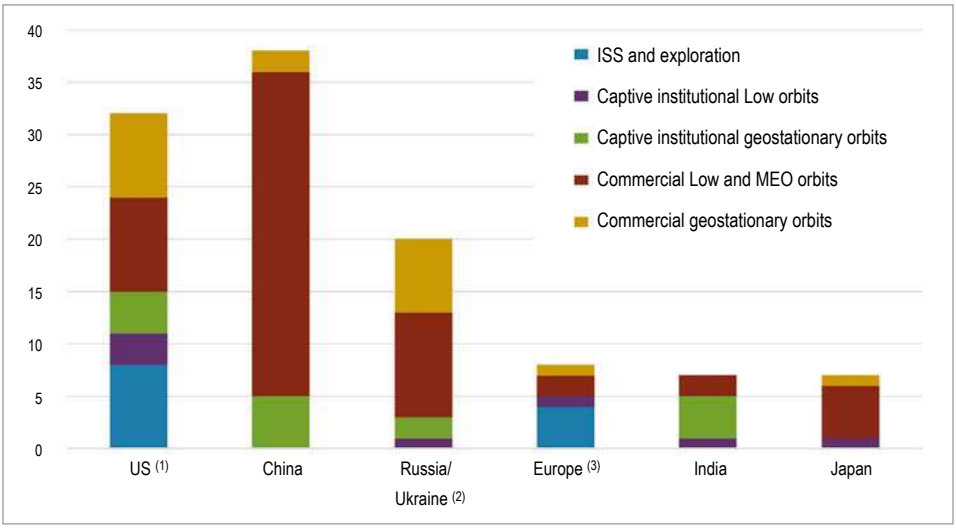

Figure 2: Some launches involve multiple deployments (dual or cluster launches):

(1) including 21 for SpaceX (out of 32) with 8 GTO commercial telecom payloads

(2) including 15 Soyuz for 20 launches

(3) including 6 Ariane 5 (4 ECA dual launches for 8 GTO commercial telecom, 1 ECA Bepi Colombo, 1 ES for 4 Galileo) + 2 Vega.

112 launches worldwide placed 452 payloads.

Geostationary orbits are mainly dedicated to commercial telecom satellites. The lower orbits (LEO, SSO, MEO) are more oriented towards institutional needs (navigation, observation, military, weather, ...).

of $130 M (about $65 M per payload in a shared launch mode) is already highly challenged by an aggressive pricing strategy on the part of SpaceX ($50-62M on the commercial market and often over $100 M for services to US institutions) and most likely also from Blue Origin. Both, as we know, are supported by numerous orders from the captive US institutional market and could still in all likelihood make further price cuts when re-use is fully operational and optimised.

It should also be noted that Vega's situation is not free from worrying international competition, such as the Indian PSLV launcher, which benefits from low labour costs.

While Arianespace should be expected to pursue an innovative and astute commercial policy on the world market, only a proactive political leap as part of a global vision, as mentioned above, can restore a situation acceptable to European launchers: this would be based, on the one

hand, on a detailed understanding of the SpaceX and other systems, and on the other (and above all), on implementation of a European strategy by all those involved to improve competitiveness in its launcher development.

This strategy should also include innovative thinking on financial instruments to complement the necessary public funding for development.

RECOMMENDATION 3:

Reach a consensus at the highest political level as to the urgent need for a European strategy for access to space capable of matching scenarios of disruptive innovation introduced by SpaceX and Blue Origin in particular.

4. PROFOUND INNOVATION IN THE DESIGN AND PRODUCTION OF COMPETING LAUNCHERS

Technical and economic "reconstitution" of competing products (here, launchers) is, or should be, a basic practice absolutely essential to any new project. Detailed understanding of what is being achieved elsewhere, going far beyond natural curiosity, is indispensable at all times and in all cases.

Existing publications are already very instructive. Partial reconstitution of Falcon 9 has been undertaken (notably by CNES and ArianeGroup), but more needs to be done and the exercise should be completed by setting up a permanent observatory for such activities.

Three major axes need to be explored and analysed in depth: project management, design criteria and selected technologies and (in line with the above, although more tricky) production and operating costs.

a) Management approach and processes

The organisation of SpaceX is characterised by strong horizontality (a consequence of a very personal leadership of Elon Musk) and great reactivity, reflecting the start-up that it was until recently. It accepts and even encourages risk-taking at a higher level than the culture in Europe is usually prepared to tolerate (acceptance of failure). The definition of the launcher evolves continuously, so as to introduce any possible improvements as soon as possible. From 2010 to 2018, SpaceX produced 10 successive upgrades of the Falcon 9, including its propulsion, thereby doubling its launch capacity without increasing the launch price! Management approach and processes must be adapted on the one hand to renewed, refined risk management, and on the other, to modern information technology capabilities.

b) Design criteria and technology

The constructive indices (ratio of structural mass to total mass) displayed by the structural and propulsive elements of the launcher are exceptional: roughly half of what Europeans can achieve with their current technologies and sizing rules. This opens up the possibility of a two-stage architecture, a prerequisite for useful recovery of the first stage. We need to understand the reasons behind this level of performance in all areas.

The Falcon launcher design uses a number of technologies different to those used on Ariane 6; some of them are known and available in Europe. A detailed, expert review of these technologies is essential (materials, propellant management, propulsion, etc.)

c) Costs

The Falcon 9 production and operation process is fairly well known; it is a highly integrated process using often very advanced technologies. It would however be rather hasty and superficial to consider that centralising production of all elements by integrating them into a single factory is by definition the optimal solution (this is far from being the case in the aeronautical industry, for instance). The processes of Blue Origin, on the other hand, remain obscure.

Certain analytical models tend to show a coherence between the price and analysed costs of the Falcon 9. However, to obtain a sufficiently robust result, several models and sources of expertise should be compared in order to establish a solid knowledge base of the cost of the competition on the market. This is a critical, urgent task requiring the creation of a high quality information gathering and analysis entity.

RECOMMENDATION 4:

Achieve in-depth understanding on how SpaceX reached this level of technical and economic performance, in order to draw lessons for European launchers in their own context. Proceed likewise with Blue Origin and other programmes as soon as possible. Establish a permanent entity for fact gathering.

5. EVOLUTION AND POST-ARIANE 6, NOW

In the first place, despite a very difficult commercial situation in an uncertain market, **it is necessary to complete development of Ariane 6** – whose versatility is an asset – and to ensure a successful production ramp-up, but this only makes sense if, at the same time and as a matter of urgency, the entire medium- and long-term vision is taken into account and given sufficient funding. Without this, the future of the launcher industry in Europe would be in jeopardy. This vision must also include preparation of the next generation within the operating life of the launcher, a strategy that has been tried and tested for decades which is more essential than ever.

It might be tempting to limit the use of Ariane solely to European institutional needs, arguing that Ariane 6 at least reduces unit production costs as compared with Ariane 5 ; it will also be noted that Vega C, and later on E, are equally part of the available panoply. The commercial market would then be left to others, under the domination of SpaceX and, at a later stage, Blue Origin, to name but these two. This would be a fundamental error, in contradiction with the philosophy underpinning Ariane from the very outset. Only a strong presence in the commercial market can keep production rates high enough to guarantee quality and reliability, and ensure recurring cost levels that are acceptable to all. It has already not been possible to obtain a European preference guarantee (see above) with prices based on a commercial model including a high proportion of commercial launches: what would be the case with costs distributed only over institutional launches, known to be endemically insufficient in Europe?

The uncertainty of the commercial market and the fact that the development of new launchers will take longer than that of their payloads imposes great flexibility in the architecture of future launchers.

Indeed, the difficult but perhaps promising gestation of mega-constellations gives rise to a wait-and-see attitude on the part of classical (geostationary) systems developers. No one can possibly claim to know today how tomorrow's satellite systems will pan out: how many constellations, how many geostationary satellites, etc.

Let us look at two horizons, both of which must be prepared now:

- For the 2023 timeline: at the beginning of its life cycle, Ariane 6 presents opportunities for incremental improvements that will enhance its competitiveness in the short term while reducing costs and improving its performance. These evolutions will have to be supported whenever possible by evolving management principles and processes, thereby also enabling validation of the latter.

- At the same time, technological and architectural work, especially on propulsion, must be pushed through rapidly with the aim of identifying new avenues for significant cost reductions, until it is possible to **define a new launcher to follow on from Ariane 6 by the end of the next decade**. First stage reusability is potentially a key to this competitiveness, provided that it is justified by the operational profile of the European launcher: **there is an optimal launch**

Reuse is not an end in itself, it is one of the possible contributors to a reduction in launch service costs which must be considered in its entirety, taking into account, in the context of operational use of European launchers, the unavoidable loss in performance, operational complexity and collateral effects on the industrial tool by the impact on the production rate.

SpaceX and Blue Origin demonstrate the effectiveness of the "Toss-back" concept for the first stage (return using main propulsion and vertical landing). This concept, indeed all possible reuse concepts, imposes a specific design on the launcher, different in nature from that of Ariane 6.

It is desirable to learn the lessons of these architectures, including all necessary technological developments (propulsion, etc.), which will anyway contribute to enhancing performance and cost considerations; in the long run, if called for by market developments and justified by an increase in launch rates, effective introduction of reusability features will thus be facilitated.

rate below which the ratio of fixed costs to variable costs does not justify reuse. Moreover, there is no point in "copying" the Falcon 9 launcher of today for a post-A6 launcher that would be available in ten years' time, ten years being roughly what separates current European technology from that demonstrated by SpaceX. We must find ways to push forward, to go "one better" by reducing launch costs and/or differentiating ourselves in the service offer (for example: possible separation of low orbit launch from transfer orbit and launch to service orbit).

Studies currently underway are perfectly justified: the Prometheus LOx-methane engine demonstrator, some of whose technologies may also have short-term benefits, the Callisto precursor of reusable technologies and the Themis reusable stage demonstrator.

However the volume and rhythm of this research is far too modest, due to the lack of any budget to commence development of a new launch vehicle around 2023. And the studies themselves are not ambitious enough. It is vital to begin architecture studies for the future launcher to guide technological developments.

All areas must therefore be re-analysed in depth and without preconceptions in terms of governance, project management, architectures and sizing, technologies, operations and implementation .... Europe has 40 years of know-how which must be exploited.

RECOMMENDATION 5:

Begin immediate, determined funding for the preparation of a successor to Ariane 6, inspired by the principle of disruptive innovation, which should deliver long-term competitiveness and flexibility.

Preparation for the ESA Council at ministerial level, at the end of 2019, should determine the best solutions to the challenges facing the European launcher industry, while placing them in the very broad strategic context of tomorrow's space activities as a whole. Through this Opinion and its recommendations, the Air and Space Academy has no other purpose than to make a constructive contribution to this crucial debate.

Legal deposit May 2019

ACADÉMIE DE L'AIR ET DE L'ESPACE
Ancien observatoire de Jolimont
1 avenue Camille Flammarion
31500 Toulouse – France
contact@academie-air-espace.com
Tel : +33 (0)5 34 25 03 80
www.academieairespace.com

Printed by:
Equinox imprimerie – Z. I. de Gabor – 81370 Saint-Sulpice

ISBN 978-2-913331-79-2
ISSN 2426 3931

Photo credits: ESA