DOI: 10.2478/ie-2025-0018

sciendo

*Intereconomics*, 2025, 60(2), 88-95

JEL: F01, O33, O38

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# The Missing Rocket: An Economic and Engineering Analysis of the Reusability Dilemma in the European Space Sector

In 2023, SpaceX's Falcon 9 completed 138 orbital flights, up from 96 in 2022 (Foust, 2025). In contrast, Ariane 6, Europe's long-awaited successor to Ariane 5, launched only once – for its inaugural flight. This stark contrast has sparked debate, with many advocating for Europe to develop its own reusable rocket, following SpaceX's model. The idea is that investing in reusability could boost Europe's competitiveness in the global market.

Europe and the US took extremely divergent paths between 2000 and 2014. The decision was not purely technical but driven by economic, political and strategic factors. While SpaceX's reusability model has reshaped the industry, its sustainability relies heavily on Starlink and the Low Earth Orbit (LEO) satellite market – a self-created internal demand that requires frequent, low-cost launches. Without a comparable market, Europe would need significant institutional investment and long-term political commitment to develop reusability, radically reshaping its rocket industry.

The current debate is often shaped by the dominance of SpaceX and frustrations over the delays of Ariane 6, rather than a more comprehensive European economic strategy. Blindly adopting the American approach may not be the best way for Europe to protect its sovereignty in space. Instead, Europe might be better served by carving out a distinct strategy for long-term growth and independence within the global space economy.

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Open Access funding provided by ZBW – Leibniz Information Centre for Economics.

* This article has greatly benefited from extensive interviews with Pierre Lionnet (rocket economy), Peter B. de Selding (US economy and SpaceX evolution), Slava Turyshev (SpaceX and NASA rocket engineering), Axel Ronneke (European space strategies) and Marcello Spagnulo (European space politics). The authors sincerely thank them for their invaluable insights, which helped refine and shape some of the theories presented in this article.

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This article examines overlooked data in the reusability debate, retraces key moments in American and European space policy and explores alternative strategies that align with Europe's strengths and interests. The article raises important questions: is reusability truly worth it? Why did the US invest in reusability while Europe did not? What alternative investments could Europe pursue? The answer depends on whether the market can support such an industry. With SpaceX's success tied to Starlink's demand, and the European market lacking high-frequency launches, Europe's decision is more complex than simply following SpaceX's lead.

Ultimately, the focus should shift from reusability versus expendability to a broader, strategic vision for Europe, leveraging space technology to achieve long-term goals.

## Is reusability worth it?

The fundamental question in any exploratory endeavour, whether on Earth or in space, is: how do you get there, and at what cost? Rockets are the key to making space more accessible. Expendable rockets are costly to build, and unlike reusable ones, they can only be used once. This drives up launch costs, keeping space an exclusive domain for select institutional and private actors. Lowering rocket costs is essential for accessibility, and reusability has long been explored as the solution.

However, reusability is not inherently cheap. It requires a technological overhaul, heavy R&D investment and – most critically – a market with high demand to offset the costs. A reusable rocket that flies only three or four times a year is far from being more sustainable than an expendable one from an industrial policy standpoint. Additionally, reusability is only viable for "low-energy" spaceflights, hence for LEO and Geostationary Orbit (GEO) missions mainly. Indeed, the reusable propulsion stage, like the first stage of Falcon 9, requires fuel for return, limiting its capability to carry mass to orbit beyond Earth ("high-energy" spaceflights). To compensate, the launcher needs to increase in size, requiring more fuel: Starship, the fully reusable super heavy-lift launch vehicle currently in development, is nothing more than a large-scale application of Tsiolkovsky's equation.

This places reusability in a double dilemma: it is technologically sustainable for LEO missions and economi-

cally sustainable only with high-frequency LEO missions. Therefore, the question is not simply whether reusability is worth it, but rather in which context(s) reusability is worth it.

## The engineering of reusability: A beyond-earth perspective

Is Europe truly facing a launch crisis, or is the issue one of competitiveness rather than capability? A genuine "launch problem" would imply a lack of technological expertise and infrastructure to develop, produce and operate space systems. That is not Europe's situation.

When it comes to competitiveness, several factors determine a launch system's edge. The foremost is payload capacity: the greater the payload a rocket can deliver to orbit, the stronger its market position. However, payload capacity must always be analysed in relation to mission type and target orbit. For example, SpaceX's Falcon 9 can lift nearly 23 tonnes to LEO in its expendable configuration and up to 18 tonnes when partially reusable. To GEO, Falcon 9 can carry a maximum of 8.5 tonnes.

Europe's heavy-lift launcher, Ariane 6, in its four-booster configuration (Ariane 64), has a lift capacity of about 22 tonnes to LEO and 11.5 tonnes to GEO. By these numbers, Ariane 6 is comparable to Falcon 9 in LEO and even superior in GEO. The reason for this design choice lies in Europe's historical strength in GEO missions, sensibly facilitated by its Kourou launch site in French Guiana. Located near the equator, Kourou enables launches that require minimal plane change manoeuvers to launchers, translating into fuel savings and increased European launchers' payload capacity. This strategic advantage allowed Europe, through Arianespace, to dominate up to 60% of the commercial geostationary launch market from the 1980s to the early 2010s (Arianespace, 2014).

However, this dominance has significantly eroded since 2015 due to SpaceX's introduction of reusable launchers, drastically lowering launch costs. While reusability has revolutionised LEO and GEO missions, its benefits for deep space exploration remain debatable.

### The geographical challenge of Moon missions

Launch competitiveness varies with mission objectives. For Moon missions, the equation changes. The Kennedy Space Center, located at 28 degrees latitude, aligns well with the Moon's maximum orbital inclination, enabling US launchers to access the Moon with minimal fuel-intensive plane change manoeuvers. In contrast, Ariane 6 launches from Kourou at almost five degrees latitude. Consequently, to avoid the need for launchers to execute severe plane change manoeuvers (over 20 degrees), Europe must wait for the Moon to pass near the equator, limiting the lunar launch windows to every two weeks.

Despite this constraint, Ariane 6 demonstrates solid payload capabilities for Moon missions, rivalling Falcon 9 and other US rockets. Consequently, the efficiency and the competitiveness of a launcher cannot be reduced to a simple "mass-to-orbit" versus "cost" equation. The GEO and lunar mission examples illustrate how launchers with comparable LEO performance diverge in competitiveness when mission targets shift.

### Reusability: A game changer or a limitation?

The ability of SpaceX to recover up to 75% of Falcon 9 – including the first stage and fairing – drastically lowers launch costs and increases flight frequency. This model works exceptionally well for LEO and, more recently, GEO missions, where relatively low energy is required to reach orbit.

However, for high-energy missions to the Moon, Mars or beyond, reusability introduces significant design challenges. A reusable propulsion stage must reserve fuel for its return journey, reducing payload capacity. To compensate, a larger rocket is needed, which in turn demands more fuel to stabilise during re-entry. This is why SpaceX frequently opts for expendable Falcon 9 versions for interplanetary missions and relies on the expendable Falcon Heavy when additional mass is required.

Recent US Moon missions under NASA's Commercial Lunar Payload Services (CLPS) programme, launched on reusable Falcon 9 rockets, have demonstrated limited payload capacities. While this constraint is currently masked by the small size of modern lunar landers (having a payload mass capability in the order of maximum 150 kg), the Artemis programme's needs extend far beyond, requiring payloads in the range of several tonnes. China's Chang'e missions already showcase superior capabilities in lunar logistics.

This limitation presents a challenge for commercialising lunar activities. Unlike LEO, where affordability drives demand, the lunar economy requires both cost-effectiveness and high payload capacity – something Falcon 9 cannot yet guarantee. This is why SpaceX is developing Starship.

### Starship: The heavy-lift solution?

Deep space missions demand enormous fuel consumption because of the high energy levels that characterise such trajectory mission profiles. NASA's Space Launch

System (SLS), for example, burns over 720 tonnes of propellant – at a rate of six tonnes per second for 120 seconds – to place the 26.5-tonne Orion spacecraft on a direct lunar transfer trajectory.

Starship aims to scale up reusability for space exploration, promising over 100 tonnes of cargo delivery to the Moon and up to 150 tonnes to LEO (SpaceX, 2020). While this is revolutionary for LEO, deep-space missions remain unproven. A lunar Starship mission must:

- reach LEO
- execute a Lunar Transfer Injection (LTI) manoeuver
- perform multiple Trajectory Control Manoeuvers (TCMs)
- conduct a Moon orbit insertion (MOI) burn
- dock with the Gateway station
- land astronauts on the Moon's south pole
- ascend back to orbit
- return to Earth while surviving atmospheric re-entry.

A major challenge is refuelling: Starship requires approximately 5,500 tonnes of propellant, transferred in microgravity. Even assuming success, Starship would need multiple refuelling missions – possibly involving additional Starships – raising logistical concerns.

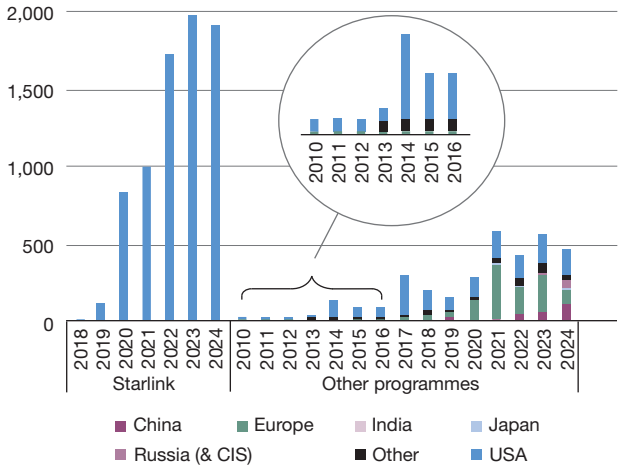
This underscores the paradox of reusability: while it simplifies architecture by consolidating functions into a single vehicle, it also introduces operational complexities. The Artemis programme, which currently lacks a reliable lunar lander solution beyond Starship, faces uncertainties. Can a Starship mission ultimately cost less than an expendable SLS mission? That remains to be seen.

## The economics of reusability: A LEO perspective

For beyond-orbit missions focused on scientific discovery and planetary exploration, reusability often seems impractical and physically limiting. However, the equation changes when considering near-Earth objectives with a commercial purpose. In this dimension, cutting costs and achieving industrial-scale rocket production offers a clear advantage: large-scale manufacturing can reduce expenses enough to enable private customers to participate, fostering a broader economic system beyond institutional flights. However, even in this case, reusability has its limitations.

Reusability can cut costs only in the long run and if sufficient demand exists to sustain frequent launches. The key question from an economic perspective is: which markets can generate this demand. Do they already exist, or do they need to be created? And how large must demand be to make reusability financially viable?

Figure 1
**Number of commercial spacecraft launched by customer region (Starlink shown separately)**




Note: Disregarding Starlink, global space activity growth remains moderate.

Source: Eurospace LEAT database (2024).

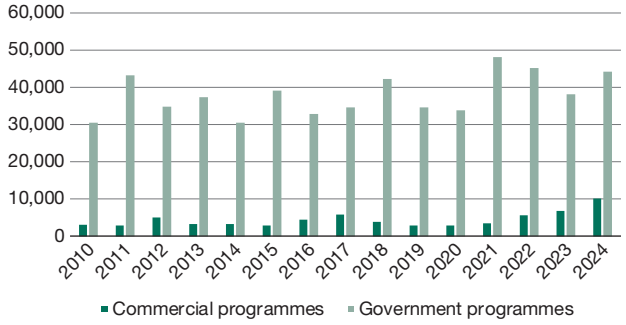
As of 2025, independent data remains scarce on whether reusability is definitively cost-effective. A study by Lionnet and Cuellar (2021) analysed the economics of Falcon 9 launch, revealing that profitability strongly correlates with launch frequency. The study concluded that a reusable rocket is economically viable only if it achieves at least six to nine launches per year, with contract prices ranging from US $50 million to US $110 million, depending on the customer.

The question of whether reusability is worth it therefore depends on a market demand that requires frequent, cost-effective launches to surpass the break-even threshold. Which market can create such demand?

In 2023, there were 212 successful orbital launches globally. The US led with 114, while Europe conducted only three (ESA, 2024). SpaceX accounted for 96 of the US launches – over 80%. However, 67 were for expanding its Starlink constellation, meaning 69% of SpaceX's missions were self-provisioned. Without Starlink, SpaceX conducted 30 launches – still far more than Europe's three but highlighting a crucial trend: SpaceX's high launch rate is driven primarily by Starlink, not overall commercial demand for LEO, Medium Earth Orbit or GEO launches (see Figure 1). In fact, a Eurospace (2024) study showed that in 2024, spacecraft market value was still dominated by governmental programmes (see Figure 2).

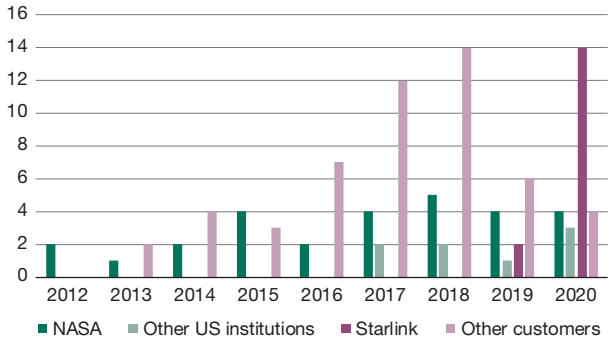
However, Lionnet and Cuellar (2021) demonstrated that even US governmental programmes – despite demand

Figure 2
**Spacecraft market value**
in million US dollars by market segment




Source: Data from Eurospace LEAT database (2024).

Figure 3
**Falcon launches by main customer**




Source: Data from Pierre and Cuellar (2021).

being higher than in Europe – are still insufficient to make reusability profitable in the long run. For example, in 2020, NASA provided stable launch opportunities for SpaceX, averaging four launches per year (Figure 3). Other US customers, mainly military and intelligence agencies, added two to four more. Yet, with only six to eight annual launches, reusability barely broke even. To sustain a reusable rocket production line, a much larger, consistent demand was needed. The only market capable of supporting such a cadence was that of LEO mega-constellations – a market that did not yet exist. So, SpaceX deliberately created it to serve its own economic goals.

### The game-changing creation of Starlink

Reusability alone was not enough – SpaceX needed frequent launches to make Falcon 9 economically viable. As mentioned above, estimates suggest that reusability only becomes cost-effective after six to nine launches per year (Lionnet & Cuellar, 2021). In 2011-2012, Falcon 9 v1.1 had a lift capacity of 16 tonnes to LEO (Space Launch Report, 2017). Therefore, to sustain operations, SpaceX required at least 96 tonnes of annual payload (16 tonnes multiplied by a minimum of six launches), which was not covered by NASA and other US institutional operations until 2017 (Figure 3). The commercial sector lacked sufficient demand, forcing SpaceX to find new customers – or become its own.

In early 2014, Elon Musk and Greg Wyler explored launching a 640-satellite constellation called WorldVu (now Eutelsat OneWeb). Assuming the 16-tonne LEO capacity of Falcon 9, this could have secured six launches for SpaceX – helpful, but not financially sustainable. When discussions collapsed, SpaceX pivoted, filing an International Telecommunications Union (ITU) application through the Norwegian Communications Authority under the name STEAM. By 2016, it formally applied to the Federal Communications Commission (FCC) for what would become Starlink.

Since its first launch in 2019, SpaceX has deployed nearly 7,000 Starlink satellites, including 4,216 Gen1 units, and is now seeking approval for over 30,000 Gen2 satellites (Rainbow, 2024). SpaceX's industrial-scale launch and satellite production has dramatically cut costs. Each Starlink satellite costs approximately US $2,500/kg to produce, with data pricing below US $100/Mbps, compared to OneWeb's US $14,000/kg and US $200/Mbps (see Figure 4).

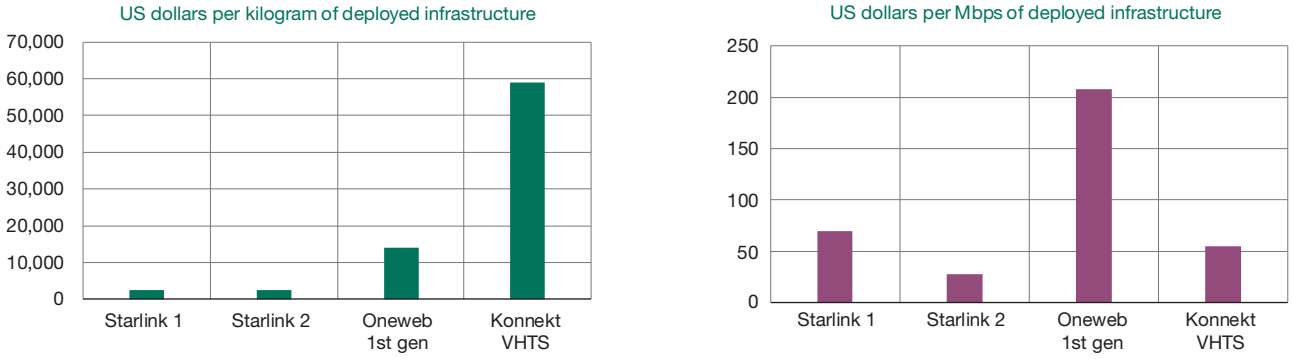
This vertically integrated approach – combining launch and satellite production – was a game-changer. While Teledesic and Iridium attempted similar models in the 1990s (Mellow, 2004; Polyakov, 2023), SpaceX was the first to successfully control both demand and supply, leveraging a reusable launch system and a mass-produced satellite constellation under one corporate umbrella.

Ultimately, Starlink and reusability became interdependent: reusability required high launch volumes, while satellite constellations provided the necessary demand. By solving this equation, SpaceX created a self-sustaining business model that no European competitor could replicate, as the European market followed a different, more fragmented trajectory.

## The European trajectory: Why did Europe not go reusable?

Culturally, the commercialisation of space activities is a new concept within Europe's traditional space vision. Europe has historically seen major space activities driven by the European Space Agency (ESA), with public-private

Figure 4
**Investment costs across companies**




Notes: Broadband costs reflect bandwidth commercialisation potential. For example, Konnekt VHTS, a GEO satellite constellation operated by Eutelsat, costs more per kg than Starlink but lasts 3-4 times longer (15-20 years vs. 4-5 for Starlink) and commercialises 85% of available bandwidth (only 15% for Starlink), making cost per Mbps competitive.

Source: Data from Lionnet (2024).

partnerships emerging but still under significant government oversight. To understand Europe's approach, it is essential to go back to the 1990s when Europe made early attempts at reusability, forecasting what would later be realised by companies like SpaceX.

### Early European efforts in reusability: The 1990s initiatives

From January 1988 to February 1994, ESA conducted the "Winged Launcher Configuration Study" (WLS), assessing seven reusable launch vehicle proposals. Among these, Vehicles 5a, 5b and 6a were considered viable for operation from the Kourou launch site. However, the outcome of the WLS was to choose to investigate only one solution, the one that best aligned with Europe's overall mission and operational needs. The technical feasibility of these proposals is detailed in Berry and Grallert (1996).

In 1994, ESA's Future European Space Transportation Investigations Programme (FESTIP) picked up from the WLS study, aiming to develop the next-generation launcher beyond Ariane 5. The primary goal was to dramatically reduce the cost of accessing space – what we now define as reusability. A 1995 ESA report highlighted the need to lower access costs to open new markets, and reusable launchers were identified as a key solution. However, reusability posed significant challenges in technology fields like materials, propulsion, avionics and aerothermodynamics. As a result, ESA projected that reusability would not be feasible until at least 2005, a timeline needed to develop such required technologies.

The FESTIP programme concluded in 1998, identifying the most promising reusable launch vehicle concepts but recognising that more technological advancements were necessary before reusability could become viable (Dujaric, 1999). This led to the creation of the Future Launchers Technologies Programme (FLTP) in May 1999. The FLTP aimed to assess partial or full reusability in launch systems, with a target of developing critical technologies by 2007. Unfortunately, the programme was put on hold due to disagreements over resource distribution among member states (Ackermann et al., 2005), highlighting how national interests played a role in Europe's hesitance towards reusability (in the past like at the present time).

Europe, however, was aware of the risks posed by not investing in reusability. As Caporicci (2000) noted, Europe risked losing its market share if a technological breakthrough occurred elsewhere, especially in the US. This is why in 2003, the FLTP evolved into the Future Launchers Preparatory Program (FLPP), which officially started in February 2004. The FLPP shifted focus to refining Europe's position in the global launcher sector, taking into account both technological and strategic factors. In 2006, FLPP Period-1 concluded successfully, while Period-2, though intended to conclude by 2015, lacked a clear finish date. The programme worked to define, design, analyse and test multiple reusable launcher concepts, with one notable success being the Intermediate eXperimental Vehicle (IXV), which successfully flew in space. The SpaceRider project, a modern evolution of IXV, illustrates Europe's ability to combine innovative technology with practical applications aimed at meeting future market demands.

### The 2000s diverging strategies: Europe vs the US

Between 1998 and 2004, Europe conducted four major studies on reusable launchers but never reached a defini-

tive decision. This indecision stands in stark contrast to US developments during the same period.

In the early 1990s, NASA initiated programmes such as the Delta Clipper Experimental (DC-X), a prototype for single-stage reusable launch vehicles. By 2000, the US already had a strong internal demand for launch services – 16 launches that year, with 13 serving NASA, the Department of Defense, the National Reconnaissance Office and other government agencies. This demand provided a stable baseline for investing in a private sector-driven space economy.

As the "President's Commission on Implementation of United States Space Exploration Policy" outlined in 2004, the US vision was a space industry that would "contribute to national economic growth, produce new products and lead the world in invention and innovation" (Aldridge, 2004). Government contracts alone were not enough to revolutionise the industry, so the US actively fostered a private space economy built on reusable technology.

Europe, on the other hand, lacked similar demand. In 2000, Ariane 4 launched four times, and Ariane 5 only once. Arianespace studies in the early 2000s suggested that Europe would need only nine half-capacity Ariane 5 launches per year for a second-generation satellite constellation (Caporicci, 2000), and later studies projected that by 2025, European institutional needs would have been around 25 tonnes per year, requiring roughly 11 launches annually from Vega-C and Ariane 6 combined (Lionnet & Cuellar, 2021). Given these numbers, developing a reusable market from scratch made little sense for Europe. The ESA Space Economy Report (2024) reinforced this, noting that Europe nowadays still lacks the domestic demand base enjoyed by the US, China and Russia.

With limited institutional demand and no immediate commercial market, Europe opted to refine its existing expendable system rather than pioneer reusability. This reflects a fundamental difference in approach: the US saw reusability as a means to create new markets, while Europe focused on optimising known solutions.

### The consequences of Europe's strategy

While Europe did not neglect space investment, its focus was directed elsewhere. The 1990s saw the foundation of Copernicus and Galileo, flagship satellite constellations that today provide extensive Earth observation and navigation capabilities. In the early 2000s, Ariane 5 was a competitive rocket dominating the commercial satellite market.

However, Europe's reluctance to invest in reusable launchers had long-term consequences. Between 2006 and 2015, Europe accounted for 10% of global launches, while China claimed 17.5% (Aliberti & Tugnoli, 2016). By 2023, the gap widened significantly: China launched 67 rockets, while Europe managed just three (ESA, 2024).

Europe's decision-making reflected budget constraints, technological risk aversion and national political interests. Unlike the US, which treated space as a disruptive economic sector, Europe approached it as a stable government-led industry. As a result, while other nations pursued growth, Europe maintained the status quo.

### The US private sector boost: International Space Station as a critical factor

The US also had additional incentives to invest in private launch companies. Following the retirement of the Space Shuttle, the US faced a strategic dilemma: relying on Russian Soyuz rockets for International Space Station (ISS) access was politically and economically untenable. NASA, constrained by high costs, recognised that supporting private-sector development was the fastest and most cost-effective way to fill the gap. In 2005, NASA launched the Commercial Orbital Transportation Services (COTS) programme, a mix of government and private funds to develop space transport capabilities, and in 2010 it allocated US $50 million in stimulus funds under the Commercial Crew Development (CCDev) initiative to advance private crewed spaceflight to and from the ISS (NASA, 2010).

These programmes enabled companies like SpaceX to develop enough funding to invest in reusable rockets – though reusability itself was not initially a requirement. The first Falcon 1 and Falcon 9 iterations were expendable, proving that the shift to reusability was driven by private initiative rather than government mandates.

Europe, with no equivalent crisis or immediate demand, never faced similar pressures. Without urgent necessity or political will, the shift to reusability remained an unresolved debate.

### The role of the European private sector

A notable exception in Europe's largely government-driven approach emerged in the early 2000s with the industry consortium "New Generation Launcher Prime Company" (NGL), formed by EADS (now Airbus) and Finmeccanica (now Leonardo). The NGL set out to design and develop a reusable launch vehicle and proposed a roadmap that began with on-ground demonstrations of critical technolo-

gies – especially in structure and propulsion – with the aim of progressing to in-flight tests. The underlying idea was that only a reusable launch vehicle could ultimately offer substantial long-term cost reductions beyond the incremental improvements achievable with traditional expendable launch vehicles like Ariane 5 evolving into Ariane 6.

The NGL marked the first time a private European consortium proposed a "private launcher" outside the direct control of national space agencies. The question remains: if the NGL had operated under an American model, might the outcome have been different? Europe's space sector has long been shaped by an ideological framework in which significant governmental oversight prevails, a stance that has often slowed technological advancement compared to the competitive, entrepreneurial spirit found in the US.

## Today's condition: Ariane 6

By 2014, after 15 years of research, reports and studies, Europe made its decision: it would stick with expendability and proceed with the Ariane 5 successor, the Ariane 6 modular launcher. But is Europe trapped in a cycle with Ariane 6, or is it making genuine progress?

Ariane 6 was initially scheduled to replace Ariane 5 by 2020. However, a combination of global challenges – including the pandemic, geopolitical tensions, economic inflation and strategic planning issues – resulted in significant delays. These setbacks have hindered ESA's competitiveness, particularly for GEO missions, where Europe once led the world. Ariane 5, while proven, was technologically outdated and unable to meet ESA's ambitious goal of doubling its annual launch capacity from six to twelve.

Ariane 6 is not a radical departure from its predecessor. It features two main propulsion stages, with an increase in height of about 11 meters, but it retains the same width of 5.4 metres as Ariane 5. The first stage is powered by an updated version of the Vulcan engine used in Ariane 5, while the second stage is equipped with a new, single-engine system called "Vinci", replacing the dual-engine configuration of Ariane 5.

### The Vinci engine

The Vinci engine was designed for greater flexibility, as it can perform multiple burns in space – enabling multiple satellite insertions into different orbits with a single launch. This was considered the key innovation for Ariane 6, enhancing mission flexibility and opening the door to servicing multiple customers at once. However, during its maiden flight, the Vinci engine failed on its second ignition, undermining its primary feature and leaving behind dangerous debris. The second burn in fact was meant to safely deorbit the second stage, but instead, it remains in LEO as debris.

This highlights a critical issue with Ariane 6: the launcher, while technically advanced, does not represent a significant departure from the past. Its two solid boosters configuration mirrors that of Ariane 5, with the only notable new feature being the Vinci engine. The payload capacity remains largely unchanged: about 22 tonnes to LEO, a slight improvement over 20 tonnes of Ariane 5, and similar for GEO missions. Ariane 6 has restored Europe's sovereign capability to access space autonomously, but in terms of pushing industry growth or introducing disruptive technology, it has not marked a breakthrough.

### Ariane 6 cost efficiency and timing issues

From an economic standpoint, Ariane 6 introduces a more cost-effective approach. With a simplified manufacturing process, fewer components and a more efficient assembly line, it aims to cut costs by nearly 50% compared to Ariane 5. A new procurement model encourages competition among suppliers, further driving down costs. However, despite these advancements, the first flight of Ariane 6 occurred four years later than initially planned. Originally set for 2020, its maiden flight took place in July 2024 – one year after the retirement of Ariane 5. This delay, coupled with the loss of the Soyuz rocket due to the Russian invasion of Ukraine and the grounding of Vega C after a failed 2022 launch, left Europe without independent access to space for a year – a paradox considering the extensive ESA studies aimed at preventing such a scenario.

### A future reusable rocket industry?

Amid what ESA's Director General Josef Aschbacher has called a "launcher crisis" in 2023, Europe feels the growing pressure to catch up with SpaceX's immense success. After 25 years of research, Europe is now eyeing a reusable rocket industry. However, creating such an industry requires specific market conditions – conditions that have not been nurtured in Europe. With SpaceX's Starlink already dominating the civilian satellite sector, it may now be too late for Europe to build a competitive reusable launcher infrastructure, especially in the absence of a strong commercial space market.

Several initiatives are underway to address this gap. The European Launcher Challenge, approved in 2023, aims to study the future of European space transportation.

Meanwhile, private efforts like Maya-Space, a spin-off of ArianeGroup, are also making strides. Maya-Space's development draws from ESA's Themis programme, which is focused on reusable technologies, specifically the vertical landing and reuse of first-stage boosters.

Yet, is this the right path for Europe? When we look at global trends, the US and China are the only two major powers investing heavily in reusable rockets – primarily because their large-scale demand justifies the R&D costs. In contrast, medium powers have chosen a different route.

### The Japan case study: A strategic alternative

Japan presents a compelling example. Despite its prestigious space history, it has opted for expendable launchers for its future, as seen with the H3 rocket – a modular, expendable design similar to Ariane 6. Japan's strategic choice is based on its specific goals and resource constraints, distinguishing its approach from that of the US and China. Similarly, South Korea's KARI is developing its first fully expendable domestic launcher.

This comparison offers valuable insights for Europe. Like Japan and South Korea, Europe's strategic needs are different than those of the US or China. Medium powers with limited budgets can achieve significant progress with a focused, forward-thinking space strategy. The key is aligning technological development with clear, achievable goals, rather than chasing disruptive innovations simply for the sake of competition.

## The path ahead

Europe's space strategy has been marked by technical excellence but lacks a disruptive vision. While ESA recognised the potential of reusability decades ago, limited institutional demand, political constraints and risk aversion led Europe to prioritise expendable launchers. By contrast, the US leveraged government demand to drive private investment, creating a thriving commercial space sector. Europe's decision to maintain the status quo worked for a time, but as global competition intensified, the consequences became clear. Now, with China and the US leading in reusable spaceflight, Europe faces a significant challenge in regaining its competitiveness in the launch market.

Although Europe has made strides in Earth Observation and navigation systems, such as Galileo and Copernicus, its approach to launchers has been more cautious. Europe's decision not to prioritise reusability stemmed from the correct assessment that such technology needs a robust LEO market, which it lacked. The US, recognising the same, chose to invest in developing that market, underscoring contrasting risk cultures between the two powers.

The real difference was not in developing reusable prototypes, but in the US's forward-thinking strategy, backed by a well-established institutional market. In contrast, Europe lacked both the market and the appetite for the long-term investments required for reusability. National political interests further shaped Europe's conservative approach.

Now, Europe faces a pivotal decision: in which infrastructures should it invest to compete globally? Countries like Japan and South Korea have chosen not to heavily invest in reusable infrastructure, aligning with their capabilities and ambitions. Europe's future in space depends on whether it chooses to redefine its ambitions, take risks and solidify its global position. Its next steps will determine whether Europe rises to the challenges ahead or remains constrained by its current trajectory.

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