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A socio-economic impact assessment of the European launcher sector

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A B S T R A C T

In a context where the economic strains are challenging European policies as well as the very fabric of governmental contributions to public life, innovation and efficacy of public policy in research are called upon to support growth in Europe and to sustain employment and entrepreneurial capacities. Governments need evidence that the investments in space, while providing strategic tools to implement sovereign policies, create jobs and build the competitive European economy of the future. This is particularly true when the decisions at stake have a potential bearing on the future of the European space sector for at least the next 30 years, as it has been the case for the ESA Council at ministerial level meeting in December 2014. On that occasion, Ministers took the decision to start the development of a new Ariane 6 launcher and Vega evolutions having a critical bearing on the Member States' strategic industrial capabilities and on the sustainability of the European guaranteed access to space. Given the importance of the subject, and following similar studies undertaken in the past for e.g. the Ariane 1–4 programme, the Agency has requested an independent consulting team to perform a dedicated study to assess ex-post the direct, indirect and induced socio-economic impacts of the Ariane 5 programme (mid-term evaluation) and of the Vega programme (early evaluation) globally, at European level, and within the economies and industries of each ESA Member State. This paper presents the assessment of the socio-economic impacts allowing the evaluation of the return on public investments in launchers through ESA in a wider perspective, going beyond the purely economic terms. The scope of the assessment covered in total approximately 25 ESA programmatic and activity lines and 30,000 commitments from 1986 to end 2012. In the framework of the study, the economic impact of the European launcher programmes is measured through a GDP impact defined as the straight economic activity deriving from the injection of Participating States funding channelled through ESA into the space upstream (manufacturing) industry, and through a cumulative assessment of the enabled revenues (catalytic impacts) arising from Ariane 5 and Vega operations.

1. Introduction

The ESA Council meeting at ministerial level in December 2014 had to take decisions on a number of fundamental questions critical for the future of the European space sector. Among these issues, Ariane developments and Vega evolutions had a specific bearing on the Member States' strategic industrial capabilities and on the sustainability of the European guaranteed access to space. Given the importance of the subject, and following similar approaches undertaken in the past for e.g. the Ariane 1–4 programme,[1] with the objective of providing the Ministers with solid background elements in view of their discussions and decisions, the Agency requested an independent consulting team[2] to perform a dedicated study to assess ex-post the direct, indirect and induced socio-economic impacts of the Ariane 5 programme (mid-term evaluation) and of the Vega programme (early evaluation) globally, at European level, and within the economies and industries of each ESA Member State. The assessment of the socio-economic impacts allowed the evaluation of the return on public investments in launchers through ESA in a wider perspective, going beyond the purely economic terms. The scope of the assessment covered in total approximately 25 ESA programmatic and activity lines and 30,000 commitments from 1986 to the end of 2012. In the framework of the study, the economic impact of the European launcher programmes was measured along its entire value chain, including the totality of the satellite service industries and the related enabled terrestrial services representing its downstream sector.

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[1] Bramshill Consultancy Ltd. Study on the economic effects of the Ariane 1–4 programmes. Prepared under ESA Contract Number 11606/96/F/TB CCN Number 01 (2001)

[2] Socio-Economic Impact Assessment of Access to Space in Europe: an Ex-Post Analysis of the Ariane 5 and Vega Programmes. Prepared under ESA contract Number 4000110988-14-F-MOS (2014) by PricewaterhouseCoopers – Strategy &, Cambridge Econometrics.

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2. Methodology

In line with their strategic importance, ESA investments in space launch capabilities brought upon a plethora of socio-economic benefits on European society. Such benefits include immediate economic impact (on Gross Domestic Product, GDP impact) materializing right after the institutional spending; medium and long term catalytic effects (space launch revenues and downstream sector revenues, in both satellite services and enabled non-space industries and services), as well as non-quantifiable wider social and environmental benefits.

The assessment included the following:

1. *A GDP impact assessment:* In the space sector, spending injected in the upstream industry leads to a cascade of spending and economic activity down the supply chain. The space industry spends a portion of this funding through its suppliers (e.g. for components or subsystems), which in turn spend a portion further down the supply chain (e.g. for raw materials); and so on. Furthermore, all companies within the supply chain pay their employee's salaries that in turn provide consumer spending in the larger economy. The compounding effect of all the spending originated from the initial upstream funding injection constitutes the 'GDP impact' from the initial investment. The GDP impact assessment includes an assessment of the *Employment impact* (i.e. the employment supported by the gross domestic product generated by those programmes) and of the *Government revenues* (tax and social security revenues associated with the wide GDP impact of the programmes).
2. An assessment of the *enabled revenues* associated with Ariane 5, and of the projected enabled revenues for Vega: Enabled revenues are represented by sales within industries and services that are enabled by Ariane 5 and Vega launches. These include downstream satellite industries as well as non-space industries and services that leverage satellite services and capabilities. The concept of enabled revenues reflects the creation of larger economic effects down the line over time and over the enabled value chain, less straightforward than GDP impact, still demonstrating the effectiveness of access to space as an enabling factor for a rich downstream economy.
3. An assessment of *qualitative impacts*: Those include several non-quantifiable, yet significant, effects in different areas: technology development, workforce skills, outreach, strategic capabilities, and national prestige.
4. A scenario analysis: a 'what if' analysis aimed at understanding what would have been the space launch market evolution in the absence of Ariane 5, and what would have been Europe's position in such a case.
5. A case study on French Guiana: a GDP impact assessment of the space launch activities on French Guiana local economy.

The funding data were used at the end of the GDP impact assessment analysis to relate the GDP impact to the initial funding for each of the involved countries, while the rest of the data fed the various analyses. While the available payments data from ESA is comprehensive, no contracting relationship data is available or can be derived from the data set. With the difficulty in understanding the contractual relationships between companies in the list of suppliers, and with the sheer scale of the supply chain (counting several hundred companies) the rebuilding of the supply chain original structure (as envisaged in the original methodology) was based on a modelling approach involving the following 3 steps:

1. Classification of companies involved in the programmes into related groups.
2. Single tier supply chain modelling.
3. Input interface harmonisation into the so-called input/output sectoral E3ME model.[3]

Such a modelling involved an initial classification stage where all companies were analysed and classified as:

1. Aerospace companies/plants.
2. Non-Aerospace companies/plants.

The classification was carried out on the basis of the nature of the companies' prevailing area of business, defined in terms of relative volume of revenues for the company or plant in the specific country under analysis.

Aerospace companies were further classified into the following sub-categories of economic activity:

1. Space system integration.
2. Space system propulsion.
3. Chemical.
4. Mechanical / Structure.
5. Electronics/Avionics.
6. Ground Software.
7. Space Agency.
8. Research Centre.

For each of those categories, estimation was carried out for the typical cost-structure in terms of:

1. Labour: direct labour working on launchers' activities: this labour is typically identified in contracts as direct labour involved in launcher projects.
2. Processes, capturing all insourced or outsourced activity, which may include for instance test centre support activities, also general administration, further broken down into indirect labour and spending into other sector including utilities.
3. Raw materials: purchases of raw materials not tracked by ESA, typically procured with purchase orders.
4. Profit: the part of economic activity retained by the company or used to remunerate its shareholders.

The estimation was conducted through primary research (direct consultation and data retrieval with selected high earners for each of the categories above). The non-aerospace companies, on the other hand, were classified along a pre-identified list of industrial sectors that are modelled in the E3ME (i.e. sectors following the NACE convention for which statistical spending ratios are available across Europe and for a wide time period). The above modelling of the launcher supply chain resulted into a detailed cost breakdown of all economic activities carried out by companies involved in the ESA launcher programmes, as well as the cost break down of non-aerospace activities into sectorial buckets, whether directly performed under ESA contract by non-aerospace companies, or procured by aerospace companies from other sectors. This resulted in a detailed allocation by country, by sector, by aerospace activity type, by year, which was used to feed the E3ME input/output modelling. The results included:

1. Spending in aerospace, used then in E3ME to calculate the GDP direct impact.
2. Spending in labour in aerospace, used (as part of the input) to

[3] The E3ME input-output software tool developed by Cambridge Econometrics was employed for this analysis. It is a computer-based model of the world's economic and energy systems and the environment. It was originally developed by Cambridge Econometrics for the European Commission's research framework programmes and is now widely used in Europe and beyond for policy assessment, for forecasting and for research purposes. In this study, the model has been applied for investigating supply change, multipliers and labour market impacts.

calculate the GDP induced impact.
3. Cumulative spending in other industrial sectors (E3ME sectors), used to calculate in the E3ME model the GDP indirect impact, as well as the induced impact.

3. Data collection

The study relied on an extensive stakeholder consultation carried out through face to face interviews, phone interviews and via an online questionnaire with the main companies involved in the programme. The objective of the stakeholder consultation was to retrieve:

1. Data on the spending of space companies into non-space industrial sectors, to be later on consolidated in order to produce the cost structure profiles required for the GDP impact assessment modelling.
2. Data on spin-offs/spillovers originated from R & D carried out through ESA contracts in the Ariane 5 and Vega programmes, to be used in the assessment of the qualitative and wider impacts.

The consultation targeted a pool of companies selected in order to cover contract value (i.e. main ESA contract receivers) and geographies (in order to ensure appropriate coverage in each country.

4. GDP impact of the Ariane 5 and Vega programmes: general considerations

The GDP impact represents the transactional impact of the institutional spending into the space upstream in the wider economy. It is measured by estimating the total Gross Value Added (GVA)[4] originating from the initial spending. The GDP impact is composed of:

1. **Direct impact:** the gross value added (GVA) in the space upstream. This is represented by the value added of the part of the activities carried out by the space upstream industry.
2. **Indirect impact:** the gross value added from suppliers down the value chain, that are outside of the space sector.
3. **Induced impact:** the consumer spending into the general economy supported by the salaries to employees working for the upstream producers and suppliers.

The GDP impact is expressed through multiplier which relates the total GVA to the initial spending, defined as Type II GDP multiplier:

$$TypeIIGDPMultiplier = \frac{(DirectImpact + IndirectImpact + InducedImpact)}{InitialESAspendinginthespaceupstream}$$

This GDP multiplier defines the expected immediate impact (in time) of spending into a sector: it accounts for the additional GVA created in the economy in the very short term.

The spending injected in the upstream industry leads to a cascade of spending and economic activity down the supply chain, through components and subsystems suppliers, raw materials suppliers and employee's consumer spending in the larger economy.

Fig. 1 and Fig. 2 below, respectively for the Ariane 5 and Vega programme cases, show on the left the breakdown of spending between aerospace and non-aerospace companies based on the commitments towards suppliers tracked within the frame of ESA programmes. The breakdown on the right takes into account purchases made by aerospace companies into other sectors on the basis of spending ratios.

The above figures show that while, as expected, the spending share in aerospace companies is predominant, a detectable share of the cumulative total is actually directly contracted to companies belonging to different industrial sectors.

Even before going into the detailed GDP impact assessment (i.e. even before considering the trickle down spending into the wider economy and the consumer spending impacts – the indirect and the induced impacts respectively), the above analysis paints for the space launchers supply chain a varied picture that cross-cuts several industrial sectors, extending the reach of the economic stimulus and of the technology development spending far beyond the space sector. Expectedly, in the case of Ariane 5 for instance, considering the amount of design and engineering work that went into development, the higher share of the spending across the programme went to Computer Programming and Information Services, which includes, among other things, technical consulting and associated engineering work. Other major spending areas are represented by Construction, Machinery & Equipment, Electrical Equipment, which is consistent with the need to build up infrastructure and operations & production facilities within the programme. Finally, the raw materials Metals, Fabricated Metal Products and Rubber & Plastic product are in line with the large use of metals and composites (carbon fiber reinforced plastics, reinforced rubber, and other polymers) in both infrastructures and actual launcher manufacturing. While the above analysis represents only the first step in the GDP impact assessment, it provides an initial picture on the way the initial ESA spending is redistributed into the economy.

5. Ariane 5 GDP impact assessment

In the case of the Ariane 5 development programme, the estimated total value added (direct + indirect + induced) over the entire 1988–2012 period leads to a **Type II multiplier of 2.2** for ESA Member States as a whole.

For most individual countries the GVA multipliers range among 1.6–3.5, a good indication of the immediate positive effect of space spending. Among the major participating ESA members, the GVA multipliers for France, Italy and Spain are broadly in line with the average across all ESA members. Countries that pay little or no ESA contribution still benefit from trade and higher economic activity in Europe area. If a multiplier is calculated for these countries, its value is high (a small benefit divided by a very small value for direct funding), but clearly this should not be compared with the multipliers in the countries in which the direct ESA spending occurs.

GDP employment impact is calculated as the increase in employment deriving from the increased economic activity (GVA) associated with the direct, indirect and induced economic impacts of the Ariane-5 programme. The supported Space employment (associated with direct impact), the additional employment (i.e. the one supported by indirect and induced impacts) and the total employment were assessed, leading to the calculation of an employment multiplier defined as:

$$EmploymentMultiplier = \frac{TotalSupp.\ \ Employ.\ \ (direct + indirect + inducedemployment)}{SupportedEmploymentinthespacesector\ \ (directemployment)}$$

The assessment led to a total ESA Members' employment multiplier average of 2.0, meaning that for each new job supported in the space industry 1 additional job is supported into the wider economy.

The assessment also showed that employment in the space sector was higher in the initial development phase (103,000 person years) than in the complementary developments/exploitation phase (78,000 person years): this reflects the fact that in the exploitation stage more of the work was undertaken by firms in sectors outside space and is also explained considering that the work undertaken in the space sector is less labour intensive in the exploitation phase compared to the primary development stage.

[4] GVA measures the contribution to the economy of each individual producer, industry or sector. It is used in GDP calculations.

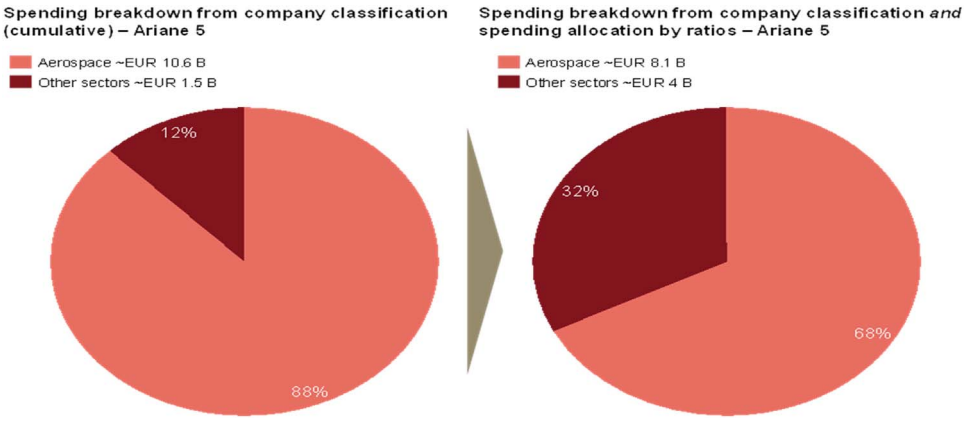

Fig. 1. Cumulative spending breakdown in aerospace and in other industrial sector (Ariane 5 – 1988–2012).

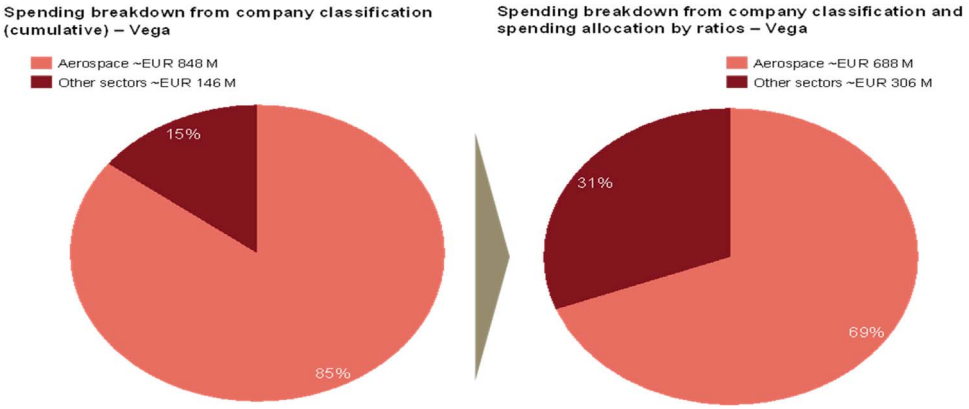

Fig. 2. Cumulative spending breakdown in aerospace and in other industrial sector (Vega – 1998–2013).

The indirect employment generated was 114,000 person years for 1986–1995, 49,000 person years for 1996–2002 and 82,000 person years for 2003–2012, again, showing the higher impact coming from development activities over the exploitation period, because of the more labour intensive nature of the development activities.

5.1. Arianespace exploitation

For Arianespace exploitation phase, the study focussed on the spending activity generated by Arianespace sales onto the launcher manufacturing industry. This led to the definition of the Type II GDP multiplier as follows:

$$TypeIIGDPMultiplier_{\substack{Ariane-5\\Exploitation}} = \frac{(DirectImpact + IndirectImpact + InducedImpact)}{Arianespacespendingintheupstream}$$

The exploitation activities under Arianespace spending lead to a Type II GDP impact multiplier for the total ESA member states of 1.6. The multipliers for exploitation are generally lower than for development, reflecting the fact that a higher proportion of the spending is devoted to material inputs which either directly or indirectly have a higher import content (to Europe) than is the case for development.

5.2. Ariane 5 programme return multiplier

A return-oriented approach would lead to the view that the commercial exploitation was made possible by the investments made on the programmes, and thus associate the value added generated during commercial exploitation to the initiating ESA spending: put another way, Arianespace's revenues during exploitation, and their wider GDP impact, are in fact 'levered in' by the development funding.[5] This approach leads to the definition of an ad-hoc GVA Return Multiplier on ESA spending (on the launcher programmes), that relates the sum of the total GVA resulting from ESA programmes and the Total GVA resulting from commercial Arianespace operations to ESA initial spending into the programmes. This leads to a higher multiplier of 3.2, meaning that overall, each euro spent in the Ariane-5 launcher programmes by ESA produces a total of 3.2 euro of value added in the economy.

5.3. Government revenues

The government revenues arising from the programme GDP impact include Income tax, Taxes on products (including Value Added Tax[6]), Employers' social security contribution and Employees' social security contribution.

A special analysis was carried out to capture the effect of the VAT exemption for ESA-funded activities. It's important to stress here that government revenues are not a part of the total value added: they represent the total spending that goes back to the government, i.e. which goes out of the macroeconomic flow.[7]

Ariane 5 activities benefitted also government revenues in non-ESA states: the economic activity connected to Ariane 5 has knock-on effects in all of Europe, and this brings tax revenues also to non-ESA member

[5] It should be noted that in addition to ESA investment, separate national investments have also contributed to establishing the Ariane-5 capabilities.

[6] The production of goods and services for ESA-funded programmes is exempt from VAT

[7] Given the relatively small size of the ESA launcher activities – as well as Arianespace activities – compared to the overall European economy, the values are not normalized on the countries' GDP.

states.[8] Also, government revenues realized from Ariane 5 programme are significant for ESA member states: it's important to stress here that these revenues do not come just from the input (i.e. the initial ESA spending), but from taxation on all the extended transactional money flow linked to the GDP impact.

These revenues however should not be entirely considered as a net benefit to governments since in return to social contributions, which represent 40% of these revenues, governments provide a social benefit back to employees. Taxes and VAT represent 60% of the Ariane-5 programmes government revenues. Since ESA is exempt from VAT, most of this VAT arise from the wider economy, i.e. indirect and induced effects. Similarly, the taxes and VAT represent about 60% of the government revenues stemming from Arianespace exploitation.

6. Vega GDP impact assessment

The Vega programme Type II GDP multiplier for total ESA member states was calculated as 1.4 using the same multiplier definition as for Ariane 5. The multiplier is lower for the Vega programme than it was for Ariane 5 because the structure of purchases has a higher indirect import content. The multipliers for most ESA member States range from 1.5 to 3, with a few outliers characterized by higher multipliers for the same reasons discussed in the Ariane 5 section (those are the countries with very low ESA contributions in the first place, and very low total GDP impacts).

The space and total employment supported under Vega development amount to 13,000 and 16,000 person-years respectively across the whole programme period, resulting into an ESA employment multiplier of 1.2, meaning that for each new job supported in the space industry 0.2 additional jobs are supported into the wider economy.

Employment directly supported by the Vega development programme is very large, with limited additional employment outside the space sector. This is mainly due to the lower scope of the Vega programme as a whole. The increases in employment reflect increases activity, with, broadly speaking, the largest gains in employment during the Vega development programme coming in the sectors that experience the largest increases in GVA and/or net exports. Fig. 3.

The Government revenues, constituted of Income direct tax, Indirect tax (Value Added Tax), and employers' social security contribution, taking into account the VAT exemption status of ESA, amount to EUR 446M. Taxes and VAT represent roughly 60% of these EUR 446M, i.e. EUR 267M.

Contrary to Ariane 5, Vega activities did not produce government revenues in non-ESA states. This is explained by the smaller geographical footprint of the Vega supply chain, which did not produce significant knock-on transactional activity in non-ESA member states.

7. Alternative scenarios on launcher market and development

Across the scale of the wider socio-economic impacts, the GDP impact is the one characterized by the strongest relationship of causality with respect to the initial institutional spending, being a transactional impact linked to the flow of spending in the value chain. When considering wider impacts of Ariane 5 and Vega (e.g. enabled revenues and launcher market evolution) the "opportunity cost" linked to those programmes had to be investigated, in order to be able to segregate the actual incremental benefits arising from the investment over a situation of do-nothing. Within this study, this was achieved through a scenario analysis, carried out to understand how the European Launcher Enabled Space Industry (ELESI) and Non-Space Industry (ENSI) might have evolved if the Ariane 5 and Vega programmes had not been pursued.

The analysis postulated that the absence of Ariane 5 and Vega launchers would have had global repercussions on the launch and downstream industry: the severe launcher supply problem resulting from A5 absence would have driven global launch prices higher, extending the economic viability of A4 for a few of more years. Ariane 4 would have transitioned to single-payload dedicated launches and possibly ceased operations completely by 2009. With substantial public funding offsetting fixed costs, the Ariane 4 might have been able to operate through 2014, in any case recapturing no more than 50% of the actual Ariane 5 payloads. With no Ariane 4 replacement, the financial viability of Arianespace as an operator would have been unlikely.

Ariane 5 development and operations represented a significant endeavour by all the European constituencies involved (ESA, CNES, Arianespace, and the European space manufacturing industry). In the absence of such development, key industrial player within the European space industry such as Airbus DS (France, Germany, Spain), RUAG Space (Switzerland), Snecma (France), MT Aerospace (Germany), Avio (Italy), SABCA (Belgium) and Dutch Space (Netherlands), as well as their subcontractors within and outside the space sector, would have lost an opportunity to advance in technological development and to push forward skills and competences. Key launcher design know-how base would have been progressively depleted, rendering Europe ill-positioned to develop a competitive launcher in the future, as well as cutting Europe out of any other future opportunity where launcher technologies would be required, like exploration and exploitation of space beyond GEO. Non-space industries would not have benefited from technology spin-off and support work: indeed, the majority of the benefits provided by healthy operation of the European launch industry involve trickle-down funds for infrastructure, support services, transport, and other companies that don't provide services exclusively to the space industry. ESA would have experienced setbacks in its ability to maintain participation to key programmes: without the Ariane 5 to deliver the five ATV supply craft, the already heavy financial burden of ISS participation would possibly be too great. Ultimately, Europe would see its non-dependency in access to space capabilities at risk: European countries would be dependent on foreign government to deliver large satellites beyond the capabilities of Ariane 4, with negative impact from the European economy and potential security concerns for payloads with classified payloads. With significant additional funding required to maintain the viability of Ariane 4, governments would have possibly questioned the viability and actual benefits of maintaining an independent access to space capability.

For Vega, in case of decline by ESA to adopt the programme as per Italian proposal, the Italian Space Agency would have possibly dropped the development, with negative repercussions on the ELESI in terms of skills and capability developments at European level. Prospectively, the lack of a small launcher like the Vega would result in institutions continuing to use foreign small launchers.

The hypothetical absence of the Ariane 5 and Vega Launchers would have global repercussions on the launch industry and its clients. The competition to Ariane-4 would have included: Sea Launch / Proton (ILS was already operating Proton at the maximum launch rate); United Launch Alliance (particularly with Atlas V), China Great Wall Industry Corp (CGWIC), despite ITAR restrictions; JAXA HII launcher (while expensive, it may have generated commercial interest as well). SpaceX's Falcon line of launchers, despite being developed at a rapid rate, was unlikely to be developed any faster as a result of prolonged exploitation of Ariane-4.

With the available launch capacity ensured by the global launch

[8] VAT resulting from Arianespace exploitation of Ariane-5 arises from indirect and induced activities only since Arianespace launch activities are considered as export and are assumed here not to be subject to VAT. Indeed, 'Octroi de Mer', a tax applied in French Guiana on all activities as well as VAT are not applied to Arianespace' launch activities due to exemptions motivated by the 1967 international treaty on space and France's decision to consider delivery to space as an export .

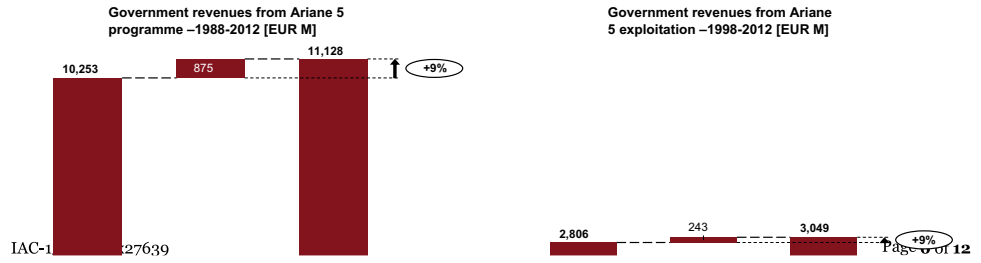

Fig. 3. ESA Members and rest of EU 27 government revenues (Ariane 5 programme and Ariane 5 exploitation by Arianespace, Cumulative, EUR M).

market competition, it can be assumed that the commercial satellite industry would not have been significantly affected by the lack of the bigger, more efficient Ariane 5 launcher: however, a high percentage of global commercial payload (> 50%) would have been likely launched on a non-European launcher. The average household would have been mildly impacted: most of the commercial payloads would have suffered only a delay, and potentially a higher cost. This would have slowed satellite deployment, adoption by media companies and growth of the DTH services in Europe, including service to cable heads. Essential civil services such as weather monitoring and forecasts would still exist and would have been serviced with the Ariane 4.

A detailed global commercial payload re-allocation exercise[9] was carried out in the scenario analysis: the exercise aimed at identifying the payloads launched using Ariane 5 that could not have been launched by Arianespace without Ariane 5 being operational. This speculative exercise had the purpose of feeding the calculation of directly enabled revenues (i.e. revenues associated to the operations of satellites only possible with the availability of Ariane 5). as presented in the next section.

8. Catalytic impacts

8.1. Enabled revenues from satellites launches

Enabled revenues are represented by sales within industries and services that are enabled by Ariane 5 and Vega launches. These include downstream satellite industries as well as non-space industries and services that leverage satellite services and capabilities.

Up to the end of 2012, Ariane-5 launched 67 times from Europe's Spaceport in French Guiana– with 63 successes – placing into orbit 133 payloads of which the vast majority (102, i.e. 77%) were Satellite Communication (Satcom) payloads. Among Satcom payloads, 41 were European (40%) vs 61 non-European satellites (60%). The 8 Earth Observation payloads are from European institutions, illustrating the role of Ariane-5, along Vega, to serve European institutional needs.

Enabled revenues from satellite launches comprise the following revenues:

1. **Launcher manufacturing Industry:** 63 payload launches gave rise to payments to Arianespace and subsequently the launcher industry.
2. **European satellite manufacturing industry:** 57% of the satellites launched by Ariane-5 until 2012 were manufactured in Europe (46% for Satcom satellites only). The satellite telecommunication industry is, by far, the most important space sector for the European satellite manufacturing industry - 60% of all European satellite manufacturing activities. In addition, the investments made by Member States into government programmes such as Herschel/Planck, Envisat, Rosetta, etc. led to revenues for the satellite manufacturing industry. Also, it is likely that Ariane-5 helps European satellite manufacturers capture additional sales from non-European operators.
3. **European Satellite operators:** The majority of revenues were in Ku-band, predominantly used for Direct To Home TV in Europe, and for communications in emerging regions, and in C-band, largely used in equatorial regions.
4. **Downstream markets:** these are estimated over the Ariane-5 exploitation period until 2012 and stem in great part from DTH and communications. Fig. 4.

Not all these enabled revenues are strictly related to Ariane-5, as some of these revenues would have arisen anyway had some of the payloads been launched on other launchers. As mentioned in the scenario analysis section, if Ariane 5 was not developed, Arianespace would have still been able to retain a quota of its launch manifest by operating the less efficient Ariane 4 launcher. In our estimation, we took the results of the scenario analysis to estimate, together with the cumulative enabled revenues, also the portion of ***directly*** **enabled revenues**: this was done by estimating the number of satellites that would not have flown on Ariane-4 – therefore directly enabled by Ariane-5 – making the assumption that operators would have been willing to pay up to 10% more to support an older generation European launcher.[10]

The exercise led to estimating for the Ariane 5 programmes Enabled Revenues over the period 2000–2012 amounting to EUR 110.4 B while Directly Enabled revenues are in the range of EUR 51.5 B. This figure drops to EUR 35.6 B in the worst case scenario of lower price sensitivity from operators.

A sale multiplier was calculated as the size (revenues) of the enabled market divided by initial spending injection, i.e. the ESA funding.

$$SalesMultiplier = (Enabledlauncherservices + Enabledsat\ manufacturing + Enabledoperatorrevenues + Enableddownstreamrevenues)/(ESASpending)$$

For Ariane 5, this lead to the results shown in the following Table 1.

For Vega, an assessment of actual enabled revenues was not achievable, since so far, only three launches of Vega have been performed, placing into low orbit a variety of small demo satellites, one science satellite and two earth observation satellites. Therefore the assessment for Vega was conducted as an Ex-Ante exercise. Enabled and related revenues could amount to more than **EUR 9 B** over 20 years, and much more if the future Copernicus downstream services

[9] The reallocation was conducted by taking into account a number of criteria (global competition, payload mass/volume, launch costs, legal constraints etc.)

[10] The less price sensitive operators would be, the less justification would there be for a programme that helps reducing launch costs, leading to lower directly enabled revenues.

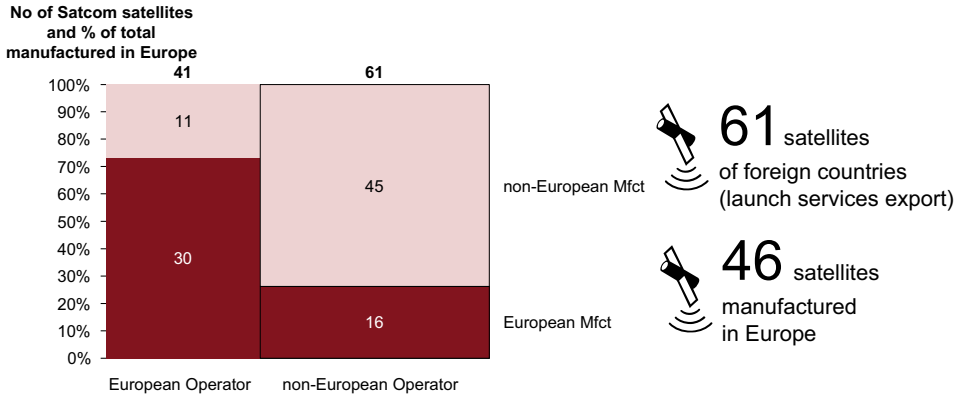

Fig. 4. Ariane-5 clients' manufacturing source: European vs non-European manufacturer 2000–2012 – (satellite units).

Table 1
Ariane 5 revenues and sales multipliers.

Ariane-5	Enabled revenues	Directly enabled revenues under probable (left) and less likely (right) assumptions	
Enabled revenues	110.4 B	EUR 51.5 B	EUR 35.6 B
Sales multiplier	**8.7**	**4.1**	**2.8**

were taken into account. This rough approximation shows that **Vega could have a sales multiplier of about 9**, similar to Ariane-5.

While sales multipliers paint a strong picture about the effects of investment in space launchers, it is important to stress that the further downstream the enabled revenues are accrued, the less direct the relationship between cause and effect becomes. However, the high multipliers highlight the strong impact of those ESA programmes on the wider European markets.

9. Qualitative impacts

Qualitative impacts from investments in space activities typically involve technological advancements and capabilities improvement leading to the creation of new assets (physical, process, or human capital), and their subsequent exploitation in other market environments. Other qualitative benefits include organizational management improvements, infrastructures enhancements, outreach effects on the general public and national prestige.

Other impacts usually included in qualitative assessments are effects that, while not strictly qualitative in nature, are inherently difficult to quantify in relation to the original spending in the space programme. These include, for example, investments in infrastructure, patent development and exploitation, and workforce increase as a result of the participation to the programme.

The assessment of the qualitative benefits associated with the Ariane 5 and Vega development programme, carried out through primary research on industry and academia, and complemented with desk research, allows to conclude that the participation to these programmes brought upon a number of substantial benefits across all involved constituencies in all the areas listed above.

The impacts observed indicate that the funding of these programmes by ESA has led to many new technology and process improvements, new IPR, has resulted in the establishment of differentiating facilities and infrastructures for launcher development and production, and is leading to increased business opportunities for all companies involved. The data collected points towards the conclusion that this funding is indirectly used by industry to effectively pursue the greater space market outside of Europe and also non-space markets as well.

Moreover, Launchers, as production-line items develop a pedigree for reliability and performance over time that also enhances the business reputation of companies connected to their production. Similarly, a university involved in the Ariane 5 and/or Vega programmes benefits from a more popular and higher profile image resulting from its contributions to these programmes.

All this comes on top of the fundamental impact, which is securing Europe's independent access to space, and the benefits that it generates at a macro level. Together, these two launcher programmes serve an invaluable role in Europe's successful space sector endeavours.

10. Case study: impact of space activities on French Guiana

A dedicated case study was carried also out on the impact of the Centre Spatial Guyanais (CSG, or Guiana Space Centre), including ESA space activities. This follows previous investigations on the subject carried out by the French National Statistics Institute, INSEE.

French Guiana shows many of the characteristics of a developing country. Its GDP per capita was about half the level of metropolitan France in 2013. Population growth is much faster in Guiana than in metropolitan France (3.1% vs. 0.6% per annum over the past decade) and consequently has a much higher proportion of its population under 20 (43% vs 25%). The key issue of low educational attainment, in the context of a rapidly-growing child population, is evident in the statistic that the proportion of the population aged 15+ with no qualification was 53% in 2007, compared with about 40% in Guadalupe / Martinique and 19% in metropolitan France.

Given this disparity, CSG provides an exceptional level of high-technology activity and jobs, together with investment in the wider infrastructure of the region, incomes generated by purchases from the wider Guiana economy (by the activities at CSG and by the workers employed there and those who visit), and support for some economic development projects.

It was assumed that output of maintenance activities was fairly stable regardless of the number of launches, and estimated that output of maintenance activities accounted for 45% of gross output over 2000-12, with launch activities accounting for the rest.

In delivering these services and outputs, it was estimated that CSG bought in around EUR 13 B of goods and services inputs over 2000-12. Approximately two-fifths were bought in to support maintenance activities with the remainder being used to support launch activities. Overall, CSG generated EUR 1 B of value added over 2000-12.

Employment at the CSG base has grown by 26% between 2005 and 2013, with little impact from the global downturn. This is of interest because employment in the broad transport sector did fall around the recession and has only grown modestly since.

The estimated direct number employed is an average of 1384 per year over 2000-12. The estimated total impact of 6450 compares with

the estimates made in INSEE (2008)[11] of a total impact of 4970 jobs in 2002 and 4964 in 2003 (some 11½% of the French Guiana total).

The impact of CSG contributed to around 46% of import duty revenues over 2000-07.

Value added generated by CSG directly contributed to 2.8% of GDP over 2000-12. This figure rises to 17.7% when accounting for indirect and induced impacts on the wider economy. Similarly, the impact of CSG on total employment in Guiana was around 13% when including indirect and induced effects. For the taxes identified here, CSG activity contributed (when accounting for indirect and induces impacts) 30.1% of total revenues raised in Guiana.

CSG expenditure over 2000–2012 on maintenance activities and launches has generated an estimated **EUR 11.3 B** in gross output in domestic sectors outside of the space sector. The bulk of purchases associated with launch activity are capital and intermediate goods, which are largely imported. However, there is still a positive impact on the sectors domestically (in particular capital goods and intermediate goods experience). Maintenance activities of the base rely more heavily on domestic suppliers. Business services, which has a low import content, provides a lot of the inputs and so this domestic sector benefits greatly: for every one euro spent on maintenance activities the domestic business services sector sees a **0.76 increase in gross output.**

11. Conclusions

The assessments performed in this study reveal a significant direct spending from ESA payments flowing to non-core aerospace companies, outlining the transversal reach of space activities, and the high potential for wider impacts of these economic stimuli injected into the space sector.

GDP impact of Ariane 5 programmes is significant for all Member States, with several countries exhibiting a total GVA exceeding 200% of their original ESA spending. The associated Type II multipliers for each ESA Member States are in line with high technology sector multipliers:

1. For Ariane 5 development programmes, most countries fall into the **1.6 to 3 range**, and a ESA participating Member States **total multiplier of 2.2.**
2. Exploitation by Arianespace shows a Type II GDP multiplier of **1.6** for all ESA member states.
3. Whereas Vega development led to a Type II GDP multiplier of **1.4** for all ESA member states.

Each job supported by a launcher space programme within Europe would support 1 additional job in the rest of the economy, or an **employment multiplier of 2.**

The GVA Return multiplier i.e. the total GVA achieved in the European economy through Ariane 5 and Ariane 5 exploitation to the original ESA spending is 3.2.

Overall, each euro spent in the Ariane-5 launcher programmes by ESA produces a total of 3.2 euro of value added in the economy.

Arianespace exports 60% of its services to non-European customers, leading to a positive impact on the trade balance – although modest in absolute terms –, especially in a context where Europe is experiencing persistently anaemic growth and unemployment.

Ariane-5 programme truly enabled EUR 51.5 B of revenues in the space and non-space industry. Revenues associated with Ariane-5 amount to EUR 110.4 B over 2000–2012.

The truly enabled revenues provide a good indication of the sales multiplier at European level: 4.1 when strictly considering the opportunity cost, and 8.7 when considering all related activities that Ariane-5 directly relates to.

Concerning the impact of space activities onto the Guianese economy, the value added generated by CSG directly contributed to 2.8% of GDP over 2000-12. This figure rises to 17.7% of GDP when accounting for indirect and induced impacts on the wider economy. Similarly, the impact of CSG on total employment in Guiana was around 13% when including indirect and induced effects.

CSG expenditure over 2000–2012 generated an estimated EUR 11.3 B in gross output in domestic sectors outside of the space sector. For every one euro spent on maintenance activities the domestic business services sector sees a 0.76 increase in gross output.

The assessment of the qualitative benefits associated with the Ariane 5 and Vega development programmes show that the participation to these programmes brought upon a number of substantial benefits across:

1. Technological advancements and capabilities improvement leading to the creation of new assets (physical, process, or human capital), and their subsequent exploitation in other market environments.
2. Organizational management improvements.
3. Infrastructures enhancements.
4. Outreach effects (positive business externalities) on the general public and national prestige.

The impacts observed indicate that the funding of these programmes by ESA has led to many new technology and process improvements, new IPR, has resulted in the establishment of differentiating facilities and infrastructures for launcher development and production, and is leading to increased business opportunities for all companies involved.

The ESA funding is indirectly used by industry to effectively pursue the greater space market outside of Europe and also non-space markets as well.

[11] INSEE (2008) page 11.