# Comments on the CTAC(Sub) application for authorisation in public consultation

This comment has been prepared jointly in the framework of the Space Chromates Task Force ('STF') of the European space industry and covers certain applications of chromium trioxide (EC 215-607-8; CAS 1333-82-0) in the European space sector.

Industrial STF participants include the main actors from the European Space Industry including prime contractors and some of the most important subcontractors:

- AIRBUS DEFENCE AND SPACE
- AEROSPACE PROPULSION PRODUCTS
- AVIO
- EUROPROPULSION
- HERAKLES
- OHB SYSTEM AG
- RUAG SPACE
- THALES ALENIA SPACE

STF has been assisted by the European Space Agency (ESA) and Centre National d'Etudes Spatiales (CNES). The task force was initiated by the Materials and Processes Technology Board of the European Space Components Coordination (ESCC MPTB).[1]

ASD-EUROSPACE has been acting as coordinators and Secretariat to the STF and REACHLaw Ltd. as consultant.

The aim of this comment is to **support** the application for authorisation by the CTACSub consortium (consultation number: 0032-04 entitled: *"Surface treatment for applications in the aeronautics and aerospace industries, unrelated to Functional chrome plating or Functional chrome plating with decorative character"* and the associated consultation number 0032-01 entitled *"Formulation of mixtures"*) by elaborating further on the specific needs of the space industry and the absence of suitable alternative substances or technologies for the use applied for, by providing specific information on the space industry. The space industry's non-use scenario is described and the associated impacts are presented.

The use of chromium trioxide in the space industry subject to this comment is in chromic (or chemical) conversion coating (CCC) and the repair or maintenance of such coating on aluminium alloy parts used in launchers and space vehicles. This use is also covered in the aforementioned CTACSub applications.

[1] The MPTB operates under the rules and limitations of the ESCC system to enable all partners to co-operate and influence the formulation of a European strategy and work plan in the area of Materials and Processes for space applications. It is participated by industrial partners, national space agencies, and ESA, whereas a large part of resources are dedicated to obsolescence risk management in relation to REACH.

## 1. Space sector and supply chain

Eurospace recognises four main product segments: launcher systems, satellite applications, scientific systems, and ground systems/services. The three first product segments in the scope are flight products. The European launch service provider also offers launch services as well as some satellite operation services.

The space market can be divided into a local institutional market and commercial and exports market. The institutional market is made up of national (e.g. military, ministries of research or agriculture) or international bodies structured at European level (e.g. ESA, EUMETSAT, the EU). European public institutions play a key role in the space sector and their involvement is essential to sustain the space economy.

The commercial and exports market segment includes private customers, mostly satellite operators, inside Europe and worldwide, and public entities located outside Europe. The commercial market has traditionally been dominated by the geostationary satellites and associated telecommunications services; but recently the Low Earth Orbit (LEO) constellations have become the main growth segment for this market. The public/institutional vs. private/commercial market is described in Figure 1 in terms of sales breakdown.

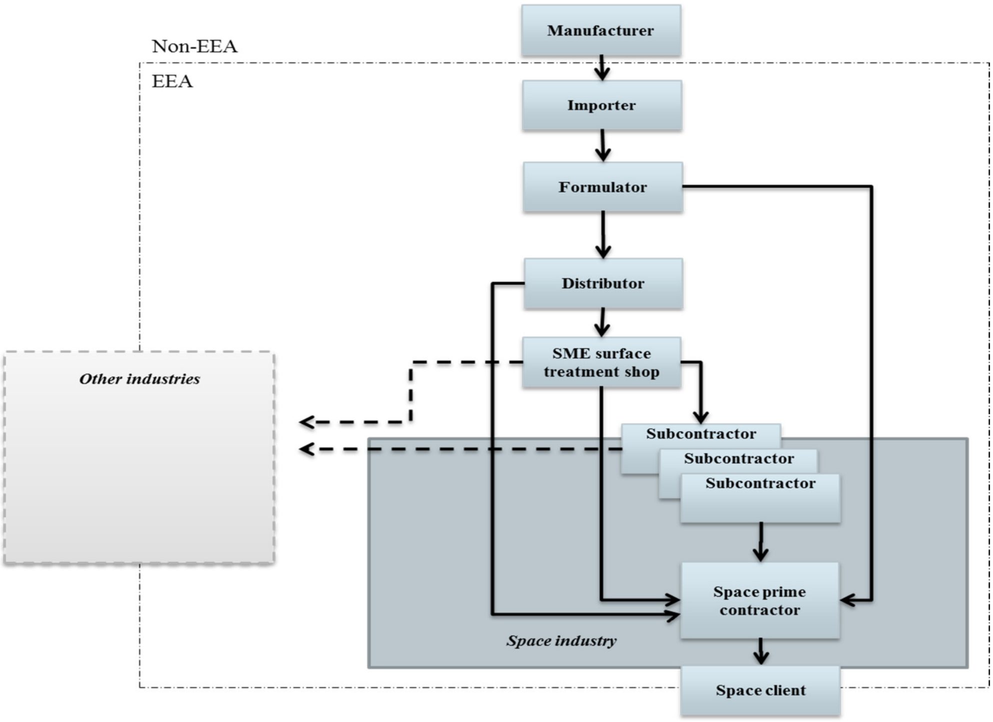
**FIGURE 1 SALES BREAKDOWN BY SEGMENTS (PUBLIC/INSTITUTIONAL AND PRIVATE/COMMERCIAL MARKET)[2]**

| | European customers | | Export customers | | TOTAL |
|---|---|---|---|---|---|
| Sales by segment M€ | Public | Private | Public | Private | |
| Launcher development programmes | 569 | | | | **569** |
| Operational launcher systems and parts | | 809 | 4 | 33 | **846** |
| Total Launcher systems | 569 | 809 | 4 | 33 | **1 415** |
| Telecommunication systems | 301 | 458 | 480 | 733 | **1 972** |
| Earth Observation systems | 822 | 14 | 171 | 46 | **1 053** |
| Navigation systems | 397 | 47 | 0 | 7 | **452** |
| Total satellite systems | 1 520 | 519 | 651 | 787 | **3 477** |
| Science systems | 724 | 27 | 89 | 26 | **865** |
| Human related Space infrastructure (ISS, ATV,…) | 328 | 1 | 0 | 28 | **358** |
| Microgravity products (racks, experiments) | 55 | 1 | 0 | 3 | **59** |
| Total scientific systems | 1 107 | 29 | 89 | 57 | **1 281** |
| EGSE, MGSE (test & support equipmt) | 34 | 13 | 6 | 18 | **70** |
| Ground stations (TT&C, UL/DL…) | 233 | 90 | 20 | 19 | **363** |
| Professional services (engineering, test, etc.) | 362 | 75 | 3 | 13 | **453** |
| Total ground systems and services | 629 | 177 | 30 | 51 | **886** |
| Other & unknown | 114 | 10 | 26 | 48 | **199** |
| **Total** | **3 939** | **1 544** | **800** | **976** | **7 258** |

The space sector has a complex contractual supply chain (Figure 2), where one prime contractor signs with a customer and then divides the work among itself and many subcontractors. The main actors in the space sector are often active along entire manufacturing value chains. In particular the space prime contractors are the assemblers of launcher systems and space vehicle systems, but they may also have in-house surface treatment units using the chromate conversion coating technology. The main prime contractors of the European space industry are members of the STF. The space manufacturing sector in Europe is at the same time very fragmented and very concentrated. The 30 largest space companies in Europe account for almost 80% of total employment in the sector. The remaining smaller players, of which there are hundreds, represent barely 20% of the total employment. The smaller players work almost exclusively as subcontractors to the larger players, except where they are involved in development activities and are directly contracted by space agencies, mostly ESA.

[2] ASD-EUROSPACE (2014)

**FIGURE 2 PRESENTATION OF CHROMIUM TRIOXIDE FLOW FOR THE SPACE INDUSTRY**




The space manufacturing companies, and their subcontractors, use chromium trioxide in mixtures containing a maximum concentration of up to 60 % $CrO_3$ in solid Bonderite M-CR 1200 and Bonderite M-CR 600 Aero, produced by Henkel AG and Co. KGaA. This solid is diluted to a concentration of ~0.8 % w/v in water before use.

Most of the big players in the European space sector have in-house surface treatment units using chromate conversion coating technology. In addition, their subcontractors, as well as specialized surface treatment processors (surface treatment shops), use chromate conversion coating surface treatment. These surface treatment processors are typically SMEs, serving many businesses, in several industries. This reflects the importance of the technology and the potential wider impacts.

## 2. Comments on the Analysis of Alternatives

### 2.1. Challenges faced by the Space sector for substitution

As explained in Chapter 5 of the Analysis of Alternatives in the CTACSub dossier (consultation number: 0032-04), technologies to be used in the space industry require maturity (Technology Readiness Level; TRL) before they can be implemented in space vehicles.

Additionally, a simplified explanation of the key steps required during implementation of new technologies to ensure that it is viable for space applications follows below, with a diagrammatic representation in Figure 3.

- Research & Development: The timeframe for Basic Technology Research levels is undefined, as it depends on alternative technologies being commercially available, such that they can be investigated for any potential viability, and also on commitments to fund a development programme by either institutions or industry. Experience to date with CCC replacements is that up to 10 years of development work has been completed with no viable alternative identified that can match the performance of mixtures based on $CrO_3$;

- Testing the alternatives by space companies against the functional requirements of the specific mission and testing of the alternatives: The performance of the alternatives is tested until key functions and/or the most critical requirements are met, for both the ground and space environments. In relation to $CrO_3$ in CCC treatments these requirements as defined in the MIL-DTL-81706, applicable to the space sector are:
  - Corrosion resistance;
  - Electrical conductivity to protect energetic materials (such as the propellant) of the Solid Rocket Motors (SRM) and pyrotechnic devices against electrostatic discharges which can potentially ignite it on launchers, as well as prevention of electrostatic charging on satellites in orbit;
  - Resistance to thermal cycling and prevention of particle generation for in-orbit performance.

  Development testing is an iterative and continuous process. Products and process improvements are tested until the requirements (technical but also industrial requirements) are met. There is also a requirement to qualify, for example, a new treatment procedure, as well as any redesigns resulting from a new technology.

  It should be noted that the current crop of potential alternative technologies for CCC are currently at low TRL for a significant share of space applications.

  Furthermore, once a product is at the operational stage, substitution of this technology may require re-design of the systems/subsystems involved and qualification of any new processes, bringing the technology back to the testing phase. This, in turn, requires additional time, resources and further TRL assessment to ensure compatibility with other systems, and requalification of any systems/subsystems integrated into the space vehicle.

- Qualification of sites and suppliers with final testing ideally being performed under industrial conditions (qualification of product, process and supplier with respect to the alternative solution) to ensure compliance.

- Industrialisation, including heritage considerations, makes it more difficult for both commercial and some institutional customers to accept new technologies and materials.

  Heritage involves using the experience of parts and technologies from previous missions to give credibility and confidence in the performance of this technology for future missions. It is one of the key drivers behind the continued use of Cr (VI) coating on aluminium alloys in launchers and space vehicles.

  Heritage can affect the length of the industrialisation phase, as the change cannot be applied simultaneously for all customers. An example of this is with the European Union’s Galileo satellite systems. This is a constellation of at least 30 satellites; the first satellites being launched in 2011 with CCC treated Al-alloys before the sunset date of $CrO_3$, and the final satellites will be placed into orbit in 2020, after the sunset date. As this is an example of a heritage system the systems, subsystems and components in each must be identical to ensure that the operation of the constellation as a whole will be assured.

  Industrialisation occurs through design and document changes, with process change definitions and serial production after the first article.

**FIGURE 3 KEY STEPS IN THE IMPLEMENTATION OF NEW TECHNOLOGIES IN THE SPACE SECTOR**

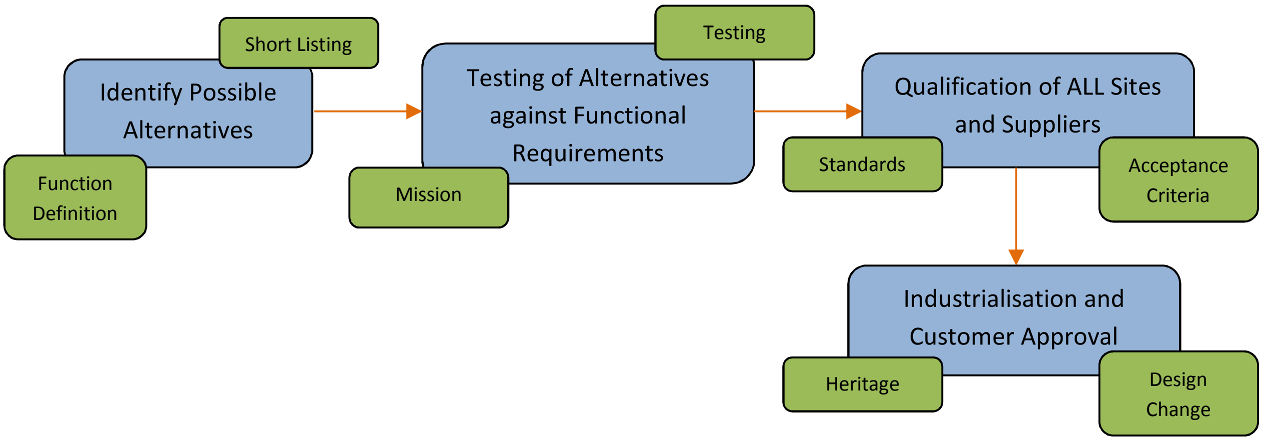



Figure 4 outlines a typical timeframe for the development of a technology and its projected usage. In the case of CCC, alternative technologies that exclude $CrO_3$ are currently at low TRL despite several years of investigations. This means they have not yet reached a sufficient technology maturity, and the processes involved in their application cannot be qualified for all Al-alloys due to the high requirements of the MIL-DTL 81706 (salt spray 168 h). Therefore they cannot be integrated into any systems or subsystems.

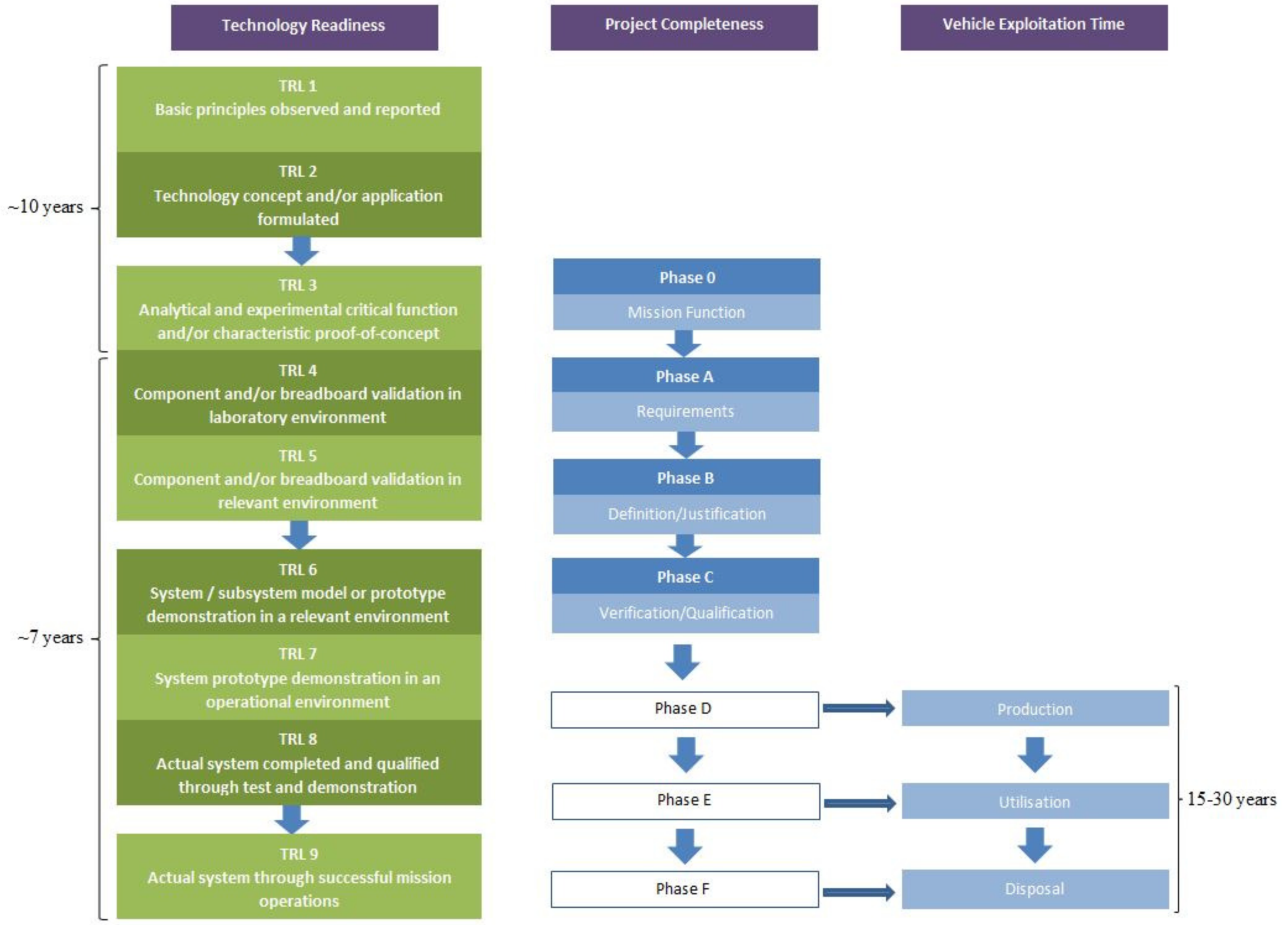
The figures for the production, utilization and disposal are taken from the utilization of Ariane 4 (15 years before replacement) and the projected replacement of Ariane 5 in the early to mid 2020's, which will be about 30 years since its first launch. This means that the overall lifecycle; from concept development, design, construction and exploitation of the vehicle for launchers is about 40 years. Additionally, for satellites, though the payload changes from mission to mission, the platform[3] design is generally standard. This ensures heritage of the key systems to customers. A platform design can be exploited from 15-20 years without significant modifications in its design, though market constraints and technology change are pushing manufacturers to shorten those cycles.

It is for this reason that heritage plays such an important role in the development of spacecraft. Technologies currently in use all have accepted TRL and so can be integrated into different systems without the need for lengthy and expensive development and qualification.

It should be noted that Figure 4 is a simplified diagram in order to describe the potential timeframe of technology maturity development and space vehicle utilization lifecycle. TRL levels and Project Completeness/Phase are, however, independent of each other and technologies are fed into project phases as appropriate.

[3] The Platform typically consists of the following subsystems like: Command and Data Handling (C&DH) System; Communications system and antennas; Electrical Power System (EPS); Propulsion; Thermal control; Attitude Control System (ACS); Guidance, Navigation and Control (GNC) System; Structures and trusses etc.

**FIGURE 4 OUTLINE OF THE GENERAL TIMEFRAMES FOR TECHNOLOGY DEVELOPMENT AND EXPLOITATION TIME OF SPACE VEHICLES**




## 2.2. Efforts made to identify alternatives

### *2.2.1. Standards Development:*

The European space industry in conjunction with the European space agencies have initiated a process to develop a more detailed and better tailored European standard under the umbrella of the European Cooperation for Space Standardization (ECSS)[4]. This should introduce defined scenarios for space applications resulting in a tailored level of corrosion protection and could potentially result in the reduction in the overall use of $CrO_3$ for space applications.

### *2.2.2. Previous Efforts made to Identify Alternatives:*

The space community has undertaken research and development at individual company, agency and industry level to identify and test alternative substances that fulfil the requirements of space applications over many years. Two key studies are referenced below.

- Research and Development work was performed in the USA in 2003 for the American government, whose aim was to investigate several chromate free aluminium pre-treatments for a number of uses, aerospace and defence (NASA, USAF, etc.): http://www.industrialanodizing.com/Documents/ncapi.pdf.

[4] The ECSS is an organisation of stakeholders in the European space sector, representing agencies and industry.

- In 2008 ESA performed an assessment of several alternative treatments to Cr(VI). This report recommends the continued use of Alodine 1200 after spalling of the alternative coatings during thermal vacuum cycling (TVC) tests: http://esmat.esa.int/Publications/Published_papers/ESA-STM-276.pdf.

### *2.2.3. Current Efforts to Identify Alternatives:*

A coherent approach including all relevant stakeholders to find a common solution that can be made available to the entire European space industry is the ideal scenario. For this reason the replacement of chromium trioxide is a priority agenda item for the MPTB with the aim to coordinate test programmes and exchange test results. Three test programmes with European or State agency involvement are:

1. The joint ESA/NASA test campaign covering satellite and launcher applications:
    - Currently one of the main sources of information for the space industry into current alternative technologies is from the ESA/NASA Alodine 1200 replacement programme.
2. ESA complementary testing;
    - Additional complementary testing to the above, with the primary aim to investigate the process robustness of alternatives, and broaden the spectrum of possible replacement systems with new developments on the market.
3. The CNES-funded Airbus Defence & Space investigations for satellite applications;

CNES and Airbus Defence & Space have engaged in testing of alternatives which involves different families of aqueous based paints and hybrid sol-gel. This activity is more focused on satellite activities.

Additionally, individual space companies, in conjunction with formulators, have been performing their own R&D over the course of several years in order to find a viable alternative to $CrO_3$ based treatments for their specific needs.

Should test campaigns provide conclusive, positive results that an alternative is viable there is still the need for them to be followed by investigations into the impacts these alternatives might have on other systems as well as the need for qualification and industrialization stages. None of these test campaigns have concluded and results will need to be studied and further refined.

### *2.3. Conclusion on Alternatives:*

Current investigations, on a laboratory level, suggest that Cr (III) formulations are the preferred alternative candidates. They do not, however, fully meet the desired requirements e.g. corrosion resistance on high strength alloys. Additionally, the technology maturity of these candidates is low (TRL 3-4 after 10 years of development) for many space applications.

For the space sector, no other candidate formulations investigated are deemed suitable at this time; however investigations are on-going.

Despite these considerable efforts over the last decade, it is foreseen that the space sector will not be able to substitute $CrO_3$ used in CCC treatment on Al-alloys before the sunset date. A long review period is needed for the sector to not only develop a reliable alternative and build-up its heritage, but also to ensure the normal investment in R&D and obsolescence management procedures are adhered to, thus avoiding undue financial strain on the European space sector.

## 3. Comments on the Socio-Economic Analysis

### *3.1. Non-use scenario and its impacts*

In the non-use scenario the space industry would continue to look for alternatives for CCC. However, no alternative could be implemented before the sunset date for $CrO_3$. As a result, after the sunset date, the space industry would be forced to cease production of all the current operational systems relying on CCC treatments, either entirely or partly, until modified or new $CrO_3$ free systems could be put into production and accepted by customers.

The impacts of the non-use scenario are analysed on four levels based on how direct the impacts of the production interruption are: impacts on the surface treatment processors, impacts on the space industry manufacturers and launch service provider, impacts on the local business environment, and geo-political impacts on the EU.

- The surface treatment processors would have to shut down their facilities because they are subcontractors of the entire aeronautics and space sector which will be affected by a ban of $CrO_3$. It would consequently lead to a loss of business and jobs. The impact has been described in Chapters 6.2 and 7.2 of the Socio-Economic Analysis of the CTACSub authorisation application 0032-04. The space use of $CrO_3$ comprises around 2% of the total amount used by the Aerospace industry as described by CTACSub's dossier.

- The impacts on launcher and satellite manufacturing are based on the assumption that only the commercial customer market would suffer. The public sector would still continue development work and funding of space sector companies.

    - For the launcher industry, in the absence of a qualified replacement for $CrO_3$, the manufacturing capability could be at stake and have a loss of 0.85 B€/year sales[5] (2014) in Europe which is related to the commercial market (sales to the European launch service provider). For the satellite industry the loss would be based on lost satellite orders per year. Satellite application systems total revenue is 3.48 B€ per year[5] (2014) of which approximately 56 % is made up of commercial market sales (1.96 B€). According to the STF industry survey, from this 56 %, approximately 15 % would be the annual economic impact for the satellite industry due to lost satellite orders, equalling to 0.29 B€ loss per year.

      The loss for European space industry would be approximately 1.14 B€ in total and occur annually until a feasible solution for the industry is found and enough heritage will be built up.

      Developing a solution for the launcher and satellite industry would be technically challenging and time consuming but also a matter of funding issues, and depend on the market trend and successfully achieving cost reduction objectives. The non-use scenario would result in severe consequences for EU space programmes being delayed or cancelled, in addition to millions of euros of economic loss for space sector companies. The societal value of the space programmes would also be lost and there would be major geo-political implications.

5 ASD-EUROSPACE (2014)

- As a consequence, Europe and its launch service provider would have to find a replacement to European launchers, which is not feasible, given the specific environment of this sector and various European governmental commitments. With international competition from outside of the REACH area, the European launcher sector would be seriously impacted, resulting in financial and employment losses, as well as the potential for a "brain drain" of expertise from this sector.

- Space production facilities are located across Europe and an interruption in production, or reduced output, would not only impact the companies within the space sector but also the local business environments. Areas where these production sites are located are usually very dependant on them to provide income for workers and subcontractors. Shops and the service industry located close to these sites, many being SMEs, are dependent on the wages of space employees being spent locally. The non-use scenario could, therefore, result in a loss of demand for goods and services in these local regions. Economic input-output analysis[6] is used to quantify the impact the different sectors have for a particular region, based on the assumption that the output of one sector can in turn become an input for another sector. The potential indirect economic impact on the local business environments in Europe would be 1.46 B€ per year.

- As a conclusion, possible total economic impact on the European economy (space sector manufacturers and the local business environments) together could be 2.6 B€ annually until a solution is found for the industry.

- In this context the EU's space policy[7,8] aims to promote technological and scientific progress, support industrial innovation and competitiveness, enable European citizens to benefit from the space applications and increase EU's position in the international politics in the area of space. The space policy is important part of the European Commission's programme Europe 2020 goals, including space projects in Horizon 2020. To achieve these goals it is necessary to secure the EU's independent access to space. In the long run, there would additionally be several types of wider economic impacts[9,10]. First of all, the EU space industry's competitiveness in the global space market would suffer. The non-use scenario would have direct impact on development and deployment schedules of the EU space programmes[11], e.g. for Galileo, EGNOS and Copernicus. The most important direct benefit from space activities is the information that cannot be obtained otherwise. This can be commercially relevant, relevant for public administration and security and science. The

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6 Eurostat (2008) *"Eurostat Manual of Supply, Use and Input-Output Tables". Eurostat Methodologies and Working papers.* ISSN 1977-0375. Available at: http://ec.europa.eu/eurostat/documents/3859598/5902113/KS-RA-07-013-EN.PDF/b0b3d71e-3930-4442-94be-70b36cea9b39?version=1.0

7 European Commission (2013). *"EU Space Industrial Policy. Releasing the potential for economic growth in the space sector"*. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Brussels, 28.2.2013. COM(2013) 108 final. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013DC0108&from=EN

8 Council of the European Union (2007). *"Resolution on the European Space Policy"*. 4th SPACE COUNCIL. COMPETITIVENESS (Internal Market, Industry and Research) Council meeting. Brussels, 22 May 2007. Available at: http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/intm/94166.pdf

9 European Commission (2011). *"Towards a Space Strategy for the European Union that Benefits Its Citizens"*. Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions. Brussels4.4.2011. COM(2011) 152 final. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0152&from=EN

10 Council of the European Commission (2011). *"Resolution on " Benefits of space for the security of European citizens" "*. 3133rd COMPETITIVENESS (Internal Market, Industry, Research and Space) Council meeting Brussels, 6 December 2011.

11 European Commission (2014). *"EGNOS and Galileo – The EU satellite navigation programmes explained"*. Luxembourg: Publications Office of the European Union. 2014. ISBN: 978-92-79-36329-0. http://bookshop.europa.eu/en/egnos-and-galileo-pbNB0114211/

space industry, with its activities and applications, is vital for the EU's growth and development; therefore the wider economic impacts of the non-use scenario would be especially harmful.

In Table 1 below the non-use scenarios and the related impacts are summarised.

**TABLE 1 NON-USE SCENARIO AND RELATED IMPACTS**

<table>
<tr><th>The supply chain member</th><th>Non-use scenario</th><th>Impacts on the space sector</th><th>Impacts on the EU, its space programmes and local business environments</th></tr>
<tr><td>Surface treatment processors/in-house plating units</td><td>Shutdown of their facilities in the EU</td><td>- Loss of the entire business and jobs</td><td rowspan="3">- The EU space industry's competitiveness in the global space market would suffer<br><br>- The ability to ensure the political goal of Europe's independent access to the space would be jeopardized<br><br>- Poor financial performance may lead to layoffs and skilled workforce could leave Europe ("brain drain")<br><br>- The EU's ability to protect its citizen through space infrastructures may be jeopardized<br><br>- Other players in the local business environment would have economic losses<br><br>+ Decreased human health risk from not having any chromium trioxide exposure</td></tr>
<tr><td>Launcher and space vehicle manufacturers and their component subcontractors</td><td>Interruption of the production of operational systems, either entirely or partly</td><td>- Loss of contracts and income (due to penalties because of non-respect of the contract or due to lose of future contracts)</td></tr>
<tr><td>European launch service provider</td><td>Unable to provide launch services with European launchers</td><td>- Loss of contracts and income due to interruption in European launcher and space vehicle production, loss of experience etc.</td></tr>
</table>

## 4. Conclusion

There is a real need for the space industry to be allowed to continue using chromium trioxide in CCC treatments of Al-alloys to fulfil the MIL-DTL 81706 requirement. The current commercial products on the market do not provide a technical solution despite the development objective of having future launchers $CrO_3$ free. This presupposes that all funding is available and no significant engineering or programmatic challenges are encountered. Even though ESA and the European space industry have been working on alternatives to $CrO_3$ for spacecraft and launcher applications for nearly 10 years, no alternatives are currently technically suitable for this requirement. Replacement of $CrO_3$ and developing systems with equivalent performance for all space vehicles is, therefore, not currently feasible. Therefore, an economically viable technological replacement must be seen in the context of an extended long-term strategy.

The loss of manufacturing capability, as well as the impact on the local business environments, could be 2.6 B€ annually until a solution for the space industry is found. Additionally, the ability to ensure the political goal of Europe's independent access to space would be jeopardized, while promoting the space industries of non-REACH territories.

Additionally, unlike the aviation industry, the space industry is bound, by governmental agreements, to produce European space launchers and vehicles within the EU/EEA. Some parts of the launchers are under the Export Control regulation and cannot be outsourced outside of the EEA. This means that the European space sector is wholly reliant on the granting of Authorisations for the use of chromium trioxide for both the formulation and surface treatment use (consultation numbers: 0032-01 and 0032-04).

For these reasons the Space Chromates Task Force fully supports these applications for authorisation.

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