SOCIO-ECONOMIC ANALYSIS

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PPG Central (UK) Ltd in its legal capacity as Only Representative of PRC DeSoto International Inc. - OR5;

PPG Industries (UK) Ltd;

PPG Coatings SA;

Aviall Services Inc.

Submitted by: *AKZO Nobel Car Refinishes B.V.*

Substance: *Strontium Chromate; EC 232-142-6, CAS 7789-06-2*

Use title: *Formulation of Mixtures*

and

Application of paints, primers and specialty coatings containing Strontium Chromate in the construction of aerospace and aeronautical parts, including aeroplanes / helicopters, spacecraft, satellites, launchers, engines, and for the maintenance of such constructions, as well as for such aerospace and aeronautical parts, used elsewhere, where the supply chain and exposure scenarios are identical.

Use number: *1 and 2*

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LIST OF ABBREVIATIONS

AfA	Application for Authorisation
AoA	Analysis of Alternatives
BAAINBW	Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr (The Federal Office of Defence Equipment, Information Technology and In-Service Support)
CBA	Cost-Benefit Analysis
CCST	Chromium VI Compounds for Surface Treatment consortium
Cr(VI)	Hexavalent Chromium
CSR	Chemical Safety Report
DU	Downstream user
EASA	European Aviation Safety Agency
EC	European Commission
ECHA	European Chemicals Agency
ECSS	European Cooperation on Space Standardisation
EEA	European Economic Area
ELR	Excess Lifetime Risk
ES	Exposure Scenarios
ESA	European Space Agency
ETESS consortium	Expert Team providing Scientific Support for ECHA
EU	European Union
EUROSTAT	Statistical Office of the European Communities
FTE	Full Time working Equivalent
GDP	Gross Domestic Product
IARC	International Agency for Research on Cancer
ISCED	International Standard Classification of Education

MAIT	Manufacturing, Assembly, Integration and Test
MRO	Maintenance, Repair and Overhaul
MVE	Man via the Environment
NewExt	New Elements for the Assessment of External Costs from Energy Technologies
NPV	Net Present Value
NUS	Non-Use Scenario
OECD	Organisation for Economic Cooperation and Development
OEM	Original Equipment Manufacturer
PEC	Predicted Environmental Concentration
RAC	Risk Assessment Committee
RMM	Risk Management Measures
ROI	Return on Investment
SEA	Socio-Economic Analysis
SEAC	Socio-Economic Analysis Committee
SMEs	Small and Medium Enterprises
Specialty coating	Equally named speciality coating
STC	Supplemental Type Certificate
SVHC	Substance of Very High Concern
TC	Type Certificate
US	United States
VOLY	Value of Life Years lost
VSL	Value of Statistical Life
WTP	Willingness to Pay

1. SUMMARY OF SOCIO-ECONOMIC ANALYSIS

This application is the result of collaboration by numerous companies over several years to share data and prepare a reliable and representative health and economic impact assessment for the aerospace industry.

With reference to the specific provisions for authorisation set out in the REACH regulation, an upstream Application for Authorisation (AfA) is the only possible way to meet the needs of the aerospace Downstream Users (DU). An upstream AfA (e.g. by a manufacturer, importer or formulator) of a substance allows coverage of the entire supply chain where the relevant uses are already known. On the other hand, an AfA by a Downstream User (e.g. an Original Equipment Manufacturer (OEM)) covers that Downstream User's own use and its immediate suppliers' right to supply the substance (on its own or in a mixture) but not the suppliers' uses (if any), nor the rest of the supply-chain (subcontractors, other suppliers, customers).

The high complexity of the aerospace supply-chain, which contains many SMEs, is described in this document. Due to the nature and complexity of the supply chain, an AfA in any other format than an upstream application would have extremely limited benefit and result in an unacceptably high risk of supply-chain disruption. Moreover, a Downstream User authorisation approach would limit industry's ability to change source of supply for component manufacture or chemical processing which is occasionally necessary for quality, financial or other reasons.

Due to the maturity and efficiency of the industry and complexity of its supply chain, Downstream Users often do not have a direct relationship with manufacturers, importers or formulators. An upstream application based on a collective approach that draws input from all layers of the supply chain is necessary to cover the supply chain, support communication and deliver relevant data across and through the supply chain.

The aerospace industry also believes that the use of such a sector-specific upstream application should facilitate assessment by SEAC. In the absence of an upstream application, multiple applications for authorisation from across the supply chain are likely. In this case, different methodologies, assumptions and terminology are unavoidable such differences could present challenges for enforcement across the industry.

The SEA is based on extensive input and data held by the European aerospace sector and affiliated industries. The same companies and facilities have reviewed and validated the SEA, including non-use scenarios and assumptions and disclaimers, in detail and agree that the SEA is representative of the situation across the industry.

The SEA makes conservative assumptions, meaning it under-estimates the net benefits of authorisation. Exposure scenarios are based on well-defined uses, with limited associated uncertainty. Economic impacts are evaluated based on data gathered across the industry, such that data is reliable and necessary assumptions are agreed to be reasonable. The SEA provides examples to support the assumptions and findings therein. In this respect, it is important to note that clear and straightforward regulations to ensure airworthiness and worker safety apply across the aerospace industry, resulting in a high degree of consistency or homogeneity in operations between facilities and organisations. Aerospace companies agree that the examples provided in the SEA are representative of the sector.

To provide further assurance, the SEA includes and presents in section 8.2 a detailed sensitivity or uncertainty analysis to test important assumptions (e.g. extent and duration of loss of jobs following a decision not to grant an authorisation). The findings demonstrate the robustness of the conclusions of the assessment.

The Socio-Economic Analysis (SEA) addresses two uses of Strontium Chromate, namely:

(1) Formulation of Mixtures; and

(2) Application of paints, primers and specialty coatings[1] containing Strontium Chromate in the construction of aerospace and aeronautical parts, including aeroplanes / helicopters, spacecraft, satellites, launchers, engines, and for the maintenance of such constructions, as well as for such aerospace and aeronautical parts, used elsewhere, where the supply chain and exposure scenarios are identical

ECHA's Guidance on the preparation of an Application for Authorisation recognises that substances do not have a specific functionality at the formulation stage. Strontium Chromate does not have any functionality at the formulation stage, irrespective of its functionality in the downstream uses of that formulation. The role of the formulator is simply to formulate; the economic benefit of formulation is limited to the revenue realised from formulation itself, and may therefore be limited. Furthermore, for niche or specialty uses, due to the scale of formulation production, the economic benefit to the formulator can be marginal, and the real value is the ongoing relationship with the customer. In such cases, the most significant costs and benefits realised in the identified non-use scenarios of the formulators are similar and represent the costs and benefits expected in the identified non-use scenarios of the downstream users rather than the formulator itself. For these reasons, the costs and benefits of the formulation of mixtures containing Strontium Chromate and the subsequent use of those mixtures in the application of specialty coatings in the aerospace sector are presented together in this socio-economic analysis. Moreover, a decision not to grant an authorisation for formulation (use 1) while granting an authorisation for downstream (use 2) would disrupt the market and would only result in transfer of formulation to non-EEA countries, with several associated drawbacks (see section 7.2 A). Presenting the SEA argumentations for formulation and downstream use together allows a more pragmatic, cohesive and tangible discussion of the inter-dependence of these activities.

For the purpose of this SEA, a time frame of 12 years after the sunset date (review period) is assessed, although a longer review period might be necessary following the results of the assessment of alternatives. The review period of 12 years was selected because it coincides with estimates by the aerospace industry of the schedule required to industrialise alternatives to Strontium Chromate. It also reflects the duration of the standard long review period indicated by ECHA, although ECHA has confirmed that longer review periods may be justified.

The outcomes of this SEA are briefly summarised in the following. Details of the calculations can be found in section 7.

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[1] For the purpose of this document the terms specialty coatings and speciality coatings are the same.

Monetised residual risks to human health and the environment of a granted authorisation based on the ECHA guidance will be lower than:

- € 215.7 million (including impacts to workers in the supply chain and to the public "Man via Environment" both for formulation and downstream use of the substance). The residual risk to human health and the environment associated with a granted authorisation for formulation is a minor contributor (approx. 0.64%) to this value.

The applicants refer to and utilises the processes, methods, tools and values (e.g. the dose-response relationship) prescribed under ECHA 2011 and ECHA 2013 (1) (2). However, the applicants, CCST consortium members and companies in the supply chain that may directly or indirectly rely on the Application for Authorisation do not and should not by preparing this quantified Cost-Benefit Analysis or otherwise be construed to endorse, support, or otherwise accept the approach to the monetisation of health impacts. Independent studies such as Willingness to Pay reports have been referenced as required in order to give an estimate of the order of magnitude of the residual health risk of the use as authorised in the Cost-Benefit Analysis framework. This is done in accordance with ECHA 2011 (1). Given that the purpose of this analysis is to give an order of magnitude estimation, the applicants, CCST consortium members and companies in the supply chain consider that the monetised health impacts calculated according to the prescribed ECHA method have no real-world, commercial or legal relevance or merit.

Data have been collected directly at companies and are compatible with the results of the Chemical Safety Report. Despite extensive data collection for more than one year, some uncertainties and data gaps still exist. They have been tackled in the methodology in a way that the risks to human health and the environment are in no way underestimated. For practical reasons relating to the development of the Application for Authorisation, data presented here considers and does not distinguish between workers potentially exposed to products containing Strontium Chromate including sealants and jointing compounds as well as primers and paints. However, sealants and jointing compounds are not included within the final scope of this Application for Authorisation. The impact of this broader data set is that the number of workers reported as potentially exposed and therefore the overall risk to human health is further overestimated within the SEA.

This justifies the statement "lower than € 215.7 million". Uncertainties and the influence of different parameters on the results are documented in an extensive sensitivity analysis.

Quantified socio-economic impacts of a non-granted authorisation will be higher than:

- € 6,515 million (social impacts related to job losses only). For the purpose of this SEA, the socio-economic impacts associated with a non-granted authorisation for formulation do not contribute to this value to avoid double-counting.

Also for the calculation of socio-economic impacts intensive data collection was done in all Member States. The data for job losses were based on clear causal chains for the case of a non-granted authorisation and were confirmed by individual companies. Uncertainties and potential variations in these data are investigated in the sensitivity analysis, which comes to the conclusion that the result is stable and underestimates the real economic impacts to be expected.

Further economic impacts related to a non-granted authorisation have not been quantified, but are expected to be in the range of several billion Euros. In section 7.2, a qualitative analysis is provided that justifies the given estimation.

Referring to the figures above, the benefits of a continued use of Strontium Chromate clearly outweigh the risks to human health and the environment (see summary table of the impact assessment in section 8.1). A sensitivity analysis on health impacts (for formulators and DU) and social impacts (for DU only) is provided demonstrating that the outcome of the SEA remains unchangeable even assumptions are modified (see section 8.2).

Apart from the outcomes of the quantitative impact assessment conducted in this SEA, the following factors should be considered:

- The extremely high complexity of the aerospace supply chain and associated vulnerability for product quality, security and safety (see section 3).
- The low number of EEA formulators that are qualified to aerospace company and industry standards and the severe consequences for the DU in the case these formulators cease delivery of formulations (see section 7.2 A).
- Economic and strategic importance of the aerospace industry for the European Economic Area (see section 5.1).
- Complex adaptation processes within the aerospace industry relating to airworthiness requirements for the aviation sector according to EC Regulation 216/2008 (qualification, certification industrialisation and the required timespans related to these processes), as well as relating to rules for the space industry, e.g. stated by the ECSS standards (justification, qualification, industrialisation and the required timespans related to these processes) (see section 5.2.1).
- Long lifecycle stages of aircraft (including helicopters) and spacecraft (see section 5.2.2).
- Wider economic impacts because of (see section 7.2.2)
    - migration of the European aerospace industry to non-EEA countries
        - negative impacts on trade and distortion of the competition
        - expertise loss in the aerospace supply chain
        - possible negative impacts on the quality and safety of air and spacecraft components
        - negative impacts on national budgets due to loss of taxes paid
        - European independent access to space

These factors further support the clear outcome of the SEA demonstrating that the socio-economic impacts of a non-granted authorisation of a continued use of Strontium Chromate according to the use descriptions defined in section 3 outweigh the residual risks to human health of a granted authorisation.

2. AIM AND SCOPE OF SEA

2.1. Aim

Strontium Chromate ($SrCrO_4$) is classified under REACH as a Substance of Very High Concern (SVHC) (according to Article 57 of Regulation (EC) No 1907/2006 (REACH) (3). Strontium Chromate was included in the Annex XIV, making an Application for Authorisation (AfA) necessary to continue use of Strontium Chromate in the European industry after the sunset date in January 2019. Furthermore, Strontium Chromate is categorised as a non-threshold substance and therefore the so-called SEA route is foreseen under REACH (4).

This Socio-Economic Analysis (SEA) forms part of the Application for Authorisation (AfA) for two distinct, but inter-related uses: *formulation* and *downstream use* of Strontium Chromate in paints, primers and specialty coatings used in the aerospace industry.

Strontium Chromate does not have any functionality at the formulation stage, irrespective of its functionality in the downstream uses of that formulation. Furthermore, due to the small scale of formulation production, the most significant costs and benefits realised in the identified non-use scenarios of the formulators are similar and represent the costs and benefits expected in the identified non-use scenarios of the downstream users. For these reasons, the costs and benefits of the formulation of mixtures containing Strontium Chromate and the subsequent use of those mixtures in the application of specialty coatings in the aerospace sector are presented together as one document. Moreover, a decision not to grant an authorisation for formulation (use 1) while granting an authorisation for downstream use would disrupt the market and would only result in transfer of formulation to non-EEA countries, with several associated drawbacks (see section 7.2 A for details). Presenting the SEA argumentations for formulation and downstream use together allows a more pragmatic, coherent and tangible discussion of the inter-dependence of these activities.

Key parts of the SEA are presented as two sections, A and B:

In **Sections A**, the applicants apply for an authorisation for **(1) formulation** of mixtures prepared for (2) the continued use of Strontium Chromate ($SrCrO_4$) for certain applications, as described below, after the sunset date in January 2019. The applicants foresee that customers in their supply chain may benefit from such an authorisation.

In **Sections B**, the applicants apply for an authorisation for **(2) the use** of Strontium Chromate in paints, primers and specialty coatings to be used for applications in the construction of aerospace and aeronautical parts, including aeroplanes / helicopters, spacecraft, satellites, launchers, engines, propellers, and for the maintenance of such constructions.

Other documents prepared as part of the AfA include a Chemical Safety Report (CSR) and an Analysis of Alternatives (AoA). These documents are referenced here to provide context for the SEA.

The AoA demonstrates that there are no available (qualified, certified and industrialised**)** substitutes for Strontium Chromate for the use (2) until and beyond the sunset date (see AoA document). According to the definition, there is no alternative to the formulation use, therefore an AoA was not prepared for this use.

The goal of this SEA is to robustly demonstrate that the socio-economic benefits associated with the continued formulation and use of Strontium Chromate outweigh the remaining risks to human health and the environment associated with prevalent use conditions (see section 3 A and B).

2.2. Scope

The applicants import and formulate paints, primers and specialty coatings that are fundamental and integral to complex systems developed to prevent corrosion of critical metal components used in the aerospace-industry. For the purpose of this document the term aerospace includes aircraft (including helicopters), spacecraft (launchers and satellites), defence and all equipment used for support of these platforms.

It is the aim of the formulator to secure the use of Strontium Chromate, to ensure continued availability of critical aerospace components beyond the sunset date and to avoid any disruptions and severe consequences in the mature and complex supply chain of his customers. Products containing Strontium Chromate are used at Original Equipment Manufacturer (OEM), suppliers, customers (e.g. airlines) and Maintenance, Repair and Overhaul (MRO) companies within the aerospace industry.

Further background to the aerospace industry is provided in section 3 of this document. The European aerospace industry has evolved over 100 years and is characterised by a broad, integrated, complex and multi-tiered supply chain. Recognising the need to secure the use of Strontium Chromate to ensure continued availability of critical formulations and components beyond the sunset date, the severe consequences associated with failing to do so, and the challenges associated with working with a mature and complex supply chain, several aircraft, helicopters, spacecraft manufacturers and product suppliers organised a consortium (CCST[2]) as a platform to facilitate an Application for Authorisation of this substance. The consortium membership includes 28 companies (importers, formulators and distributors and articles manufacturers from across the industries) some members do not use Strontium Chromate themselves, but are reliant on the availability of Strontium Chromate for their business. Reference to the CCST, which provided the platform for collaborative efforts to prepare data necessary to support application, is given within this document.

The CCST members using formulations containing Strontium Chromate comprise of Original Equipment Manufacturers (OEMs), suppliers and Maintenance, Repair and Overhaul (MRO) companies within the aerospace industry.

The supply chain comprises Strontium Chromate producers / importers, formulators that produce mixtures ready to use or to be combined at the site of operation, distributors and suppliers / contractors and sub-contractors that supply OEMs with intermediate products treated with Strontium Chromate. Additionally, the supply chain includes OEMs that use Strontium Chromate formulations for metal parts against corrosion or that rely on supply of treated metal parts to their assemblies and sub-assemblies, customers who operate the aircraft and MROs that maintain and repair these aircraft and

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[2] Chromium VI Compounds for Surface Treatment

spacecraft, including legacy aircraft and spacecraft. For a more detailed description of the supply chain, please refer to section 3. For the avoidance of any doubt, helicopters, spacecraft, satellite and defence manufacturers are involved in the supply chain, using Strontium Chromate for formulations applied to critical parts and components.

The scope of analysis concentrates geographically on the territory of the European Economic Area (EEA), which is comprised of the European Union (EU)[3] and the states of Iceland, Liechtenstein and Norway. Thus, the impact assessment covers this area specifically.

For the purpose of this SEA, a review period of 12 years is assessed. The review period presents the outcome of the AoA coinciding with the estimates by the aerospace industry of the schedule required to industrialise qualified and certified alternatives to Strontium Chromate. Since the sunset date for Strontium Chromate is in January 2019, the period of time covered by the SEA runs from 2020 to 2031 (taking 2019 as a base year for calculations). A sensitivity assessment has been included to demonstrate that there is a robust case for the review period applied for.

The membership of the CCST consortium is by no means comprehensive in terms of coverage or representation across the aerospace industry. Information from members of the CCST consortium and the public domain has been used as the basis for evidence supporting this application. A primary concern of OEMs is that the use of Strontium Chromate is authorised in such a way as to protect the supply chain and customers.

Application by formulators (product (upstream) suppliers)) is necessary to support downstream use and continuity of supply of critical formulations to the industry. Data has been critically evaluated and, if necessary, extrapolated to cover the supply chain as fully as possible.

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[3] Means the ‘customs’ territory of the Community as defined in the REACH Guidance for the Navigator. The customs territory of the Community comprises the territory of: Austria; Belgium, Bulgaria, Croatia, Cyprus, The Czech Republic, Denmark (except the Faroe Islands and Greenland), Germany (except the Island of Helgoland and the territory of Büsingen), Estonia, Finland (including the Aland Islands), France (except New Caledonia, Mayotte, Saint-Pierre and Miquelon, Wallis and Futuna Islands, French Polynesia and French Southern and Antarctic Territories), Greece, Hungary, Ireland, Italy (except the municipalities of Livigno and Campione d'Italia and the national waters of Lake Lugano which are between the bank and the political frontier of the area between Ponte Tresa and Porto Ceresio), Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovenia, The Slovak Republic, Spain (except Ceuta and Melilla), Sweden, The United Kingdom of Great Britain (including Northern Ireland and the Channel Islands and the Isle of Man). The customs territory of the Community includes the territorial waters, the inland maritime waters and the airspace of the Member States and the territory of the Principality of Monaco, except for the territorial waters, the inland maritime waters and the airspace of those territories which are not part of the customs territory of the Community as listed above.

3. DEFINITION OF THE APPLIED FOR USE SCENARIOS

A. Formulators

The applicants apply for the continued use of Strontium Chromate for the formulation of mixtures.

Strontium Chromate ($SrCrO_4$) is of vital importance for the aerospace industry in Europe. A functional and key ingredient of products produced by the applicants, it is an excellent corrosion inhibitor for metallic structures with other important functional qualities (as described in the AoA). It is mainly used in paints, primers and specialty coatings. Strontium Chromate is extensively used in and relied upon by the aerospace sector, albeit in small quantities and under conditions of well-controlled worker exposure.

B. Downstream users

Strontium Chromate, as other chromates, is a very effective corrosion-inhibiting pigment that provides corrosion protection to metal surfaces (6).

The use of Strontium Chromate is described in further detail in the CSR and in the AoA, and is summarised below in laymen’s terms to provide appropriate context for the SEA.

Strontium Chromate is added to formulations, such as paints, primers and specialty coatings, which are applied to the surface of an aircraft and spacecraft part, and satellites´ components to perform a range of technical functions, particularly corrosion prevention. The technical performance of these paints, primers and specialty coatings is specified in standards and procedures having to comply with airworthiness and spacecraft requirements and other qualified procedures and can only be changed when adequate evidence is available to provide assurance regarding the performance of the alternative. The paints, primers and specialty coatings are generally applied by spray painting or by brush to form a thin outer layer upon the aircraft or the spacecraft part or component. As explained later in this document, aircraft and spacecraft have extremely long life cycles and are regularly repaired and maintained over that life cycle, reflecting both the value of the aircraft or the spacecraft part or component and the highest demands for safety within the aerospace industry. Extremely long lifecycles apply for spacecraft as well (e.g. typical lifetime of a telecommunications satellite being 15 years, with long development cycles for a new family of satellites or launchers). On the one hand, for some components, Strontium Chromate paints, primers and specialty coatings on components may be regularly renewed and / or repaired as part of scheduled and unscheduled maintenance in line with the approved standards and procedures in order to continue to meet airworthiness requirements. On the other hand, other inaccessible areas (e.g. internal parts, inside the wings of air / spacecraft) receive their coating and corrosion protection only once during their whole lifetime. As described in more detail in the Analysis of Alternatives (AoA), Strontium Chromate is an extremely important substance within the aerospace industry. For example, the aerospace main frame, engines, undercarriages and all parts attached to a satellite, space vehicle or missile have the highest possible technical requirements and therefore require reliable anti-corrosive and protective properties. Strontium Chromate acts as the main corrosion inhibitor in primers for metallic structures. It is mainly used in paints, primers and specialty coatings and is also used by some CCST consortium members in top coats for aerospace parts, often as part of an integrated anti-corrosion system. These Strontium Chromate based mixtures are protective coatings for aluminium, nickel based and corrosion resistant alloys (Cres[4]) and corrosion resistant steel fasteners, which provide superior airframe corrosion protection, adhesion, chemical resistance and lubricity. It is also used on aluminium rivets to provide primary anticorrosive sealing around the fastener (7).

Within the aerospace industry, the critical applications where Strontium Chromate is used are basic primers and bonding primers. Even after 30 years of intense research, no alternatives for these two applications have been found (8). Moreover, the particular properties of Strontium Chromate mean that it is generally not interchangeable with other hexavalent chromate substances in these applications. Consequently, chromates are still widely used as inhibitors in the aerospace sector wherever corrosion is a serious concern (7).

As it is explained in detail in the AoA, when qualifying an anticorrosion system, the whole system must be considered. Even if the various layers and required protections (anodisation, primer, top coat) are individually qualified, the whole multilayer system shall meet the relevant anti-corrosion characteristics. As a consequence, there is a link between substances, processes and products to ensure complete compatibilities of each element of a complex system and the ultimate characteristics or functionalities which each component, sub-system or system must meet. For example, the choice of the substitution process for the chromic anodising of aluminium (which requires the use of Chromium Trioxide) will also drive the choice of alternatives to the current Strontium Chromate containing coating.

The aerospace industry has been working for years towards a voluntary eradication of some of the most hazardous substances. In particular, chromate eradication policies have been set up amongst the main companies with related substitution roadmaps and collective mobilisation of the entire sector. Considering, in particular, the recognised adverse long-term effects of these substances, appropriate efficient controls have been put in place accordingly to best protect and comply with the Environment and Health / Safety requirements.

Although there are no authoritative figures, industry estimates over € 200 million has been invested in research to replace chromate use in the aerospace sector in the last 10 years, and this research is ongoing, with companies across the supply chain committing substantial resources to develop and test alternatives. There is significant uncertainty in estimating a schedule for successfully commercialising alternative formulations given the lack of success in developing candidates that meet the performance requirements. The AoA provides further detail on the schedule for research. Reflecting on research programs in place currently, it is clear that situation will continue to evolve. However, for the purpose of the SEA, it is important to reiterate that alternatives are currently not available, and are not projected to be available for the foreseeable future.

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[4] Cres: Corrosion resistant steel

The use of Strontium Chromate in the aviation industry is extensive, and often plays a critical role in meeting performance and safety standards, particularly those relating to airworthiness set by EASA. The same is applicable to the space industry, which has to comply with ESA requirements (e.g. ECSS requirements), and to the defence industry (e.g. national government requirements).

At the same time, the volumes used tend to be relatively low, and uses take place in well-controlled industrial settings (please refer to the CSR for more detailed information on the use conditions) (9).

Supply Chain

The supply chain for the aerospace industry is highly complex, spanning countries, having evolved over many years of successive investment, innovation and competition. The supply chain includes but is not limited to, chemical manufacturers, importers, distributors, formulators, component manufacturers, OEMs, operators and aftermarket repair and overhaul activities (9). The complexity of the supply chain can provide a challenge to efficient communication and data gathering. It is difficult to characterise inter-dependency within the supply chain; however, it is clear that the healthy functioning of the supply chain as a whole is necessary for the aerospace industry. Importantly, the complex structure of the supply chain also influences how quickly change can be assuredly affected.

Figure 1 shows, in highly simplified form, the various linkages between actors within the supply chain. The separations clarify that these companies are at different levels of production, however, not all the companies are limited to one single level or tier in the supply chain. For example, some component manufacturers and OEMs also provide MRO services.

In order to provide a clearer view on the individual actors in the supply chain, a generalised definition of each “tier” or group of companies involved is provided below.

The actors within the aerospace supply chain are:

- **Formulators** that produce or purchase the raw materials from **manufacturers** or **importers** of Strontium chromate. They develop mixtures (which are proprietary, such that formulation composition is highly confidential) to meet the requirements of their clients in each market and supply formulations containing Strontium chromate to meet performance specifications and industry approvals. Their customers are generally processors, component manufacturers, Original Equipment Manufacturers, Operators, and Maintenance Repair and Overhaul shops.
- **Distributors** that purchase Strontium chromate or formulation from the manufacturer or formulator and deliver it to the customer (processors, component manufacturers, Original Equipment Manufacturers, Operators, and Maintenance Repair and Overhaul shops).
- **Processors** that are involved in the process of producing parts or final products to meet the requirements of other companies (OEM or Component manufacturer); they either purchase or formulate Strontium chromate mixtures *in situ*.
- **Component manufacturers** that build to print or design and produce components to meet the performance requirements of OEMs. The components will be used by downstream OEMs in the final stage of production. Component manufacturers may utilise processors or produce

parts themselves. When producing parts themselves they either purchase or formulate Strontium chromate mixtures *in situ*.

- **Original Equipment Manufacturers (OEMs)** that define the performance requirements of the components and the materials and processes used in manufacturing and maintenance. OEMs are responsible for the integration and certification of the final product. OEMs may themselves treat parts in a similar manner to processors or component manufacturers.
- **Maintenance Repair and Overhaul (MRO) shops** that carry out maintenance, repair and overhaul activities using Strontium chromate during their processes.
- **Operators** and **space and defence prime contractors** are the **Customers** or end-users of formulations containing or products being treated with Strontium chromate.

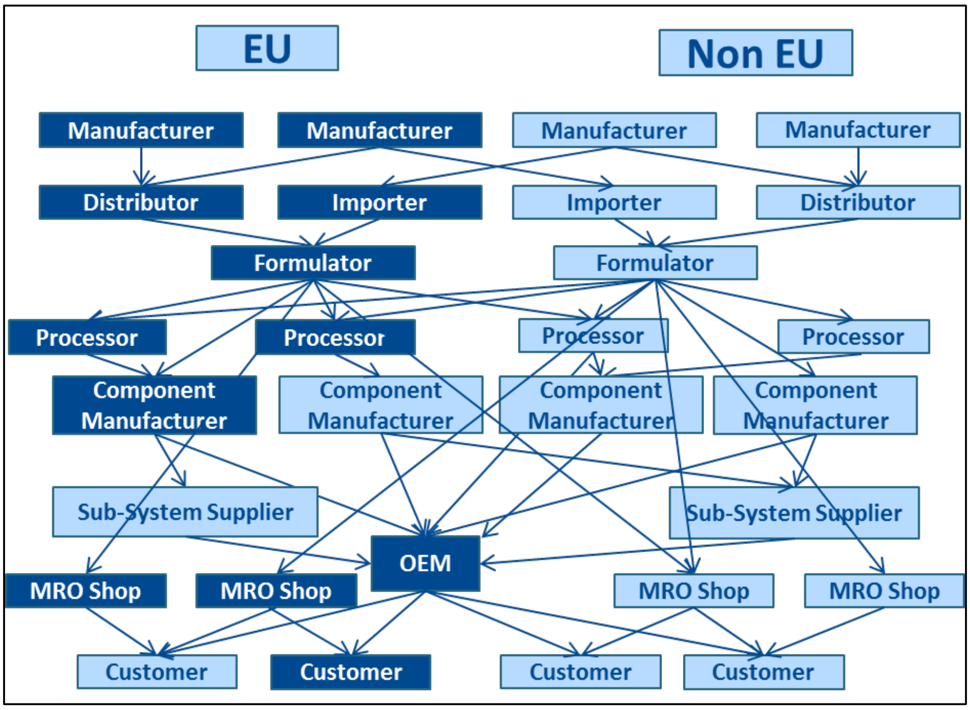

Figure 1: Typical supply chain in the aerospace sector (9)

Furthermore in the case of the space industry, at the end level of the supply chain, launchers, commercial operators and institutional operators of satellites are involved (10).

4. DEFINITION OF THE NON-USE SCENARIOS

A. Formulators

If an authorisation for the continued use of Strontium Chromate was not granted, formulators would either relocate the production of mixtures containing Strontium Chromate to a non-EEA country or shut down production.

The effects linked to the non-use scenarios of the formulators are dealt with in section 7.2 of this SEA.

B. Downstream users

The non-use scenarios were developed through multiple channels. In the first instance, members of the CCST prepared a description of the non-use scenario. These were then developed through a series of bilateral discussions, site visits and meetings, conducted by independent consultants experienced in the process of developing such scenarios for EU regulatory purposes, in order to test the robustness of, validate and elaborate these scenarios. Member companies from across the aerospace sector including OEMs, suppliers and MROs were involved in the process. Consolidated non-use scenarios representative of the industry were developed based on these responses and are presented below.

It is notable that the non-use scenarios described by the companies are significant. This can be seen to reflect the critical function that Strontium Chromate plays in aerospace manufacturing operations and maintenance, and the technical and logistical challenges associated with replacing Strontium Chromate in the foreseeable future.

OEMs: OEMs unanimously advise that they would stop production of aircraft and components that require Strontium Chromate in the production process in the EEA and relocate or subcontract these activities, including MRO activities, to a non-EEA country (assuming capacity is available) where the continued use of Strontium Chromate is possible or suspended (until capacity is made available). This non-use scenario is clearly implicated because no change is possible in the short-term to the manufacture of current aircraft, which is based on approved designs and certification (as described in section 5.2.1) (9). In the case of the space and defence sector there is no possibility to relocate activity due to the attendant difficulties related to achieving customer requirements, national security considerations, work share agreements, and financial restrictions. Additionally, it would mean losing European independent access to space.

Within the space industry, Strontium Chromate is used in major space programs, for example Ariane 5 and Vega launchers, and most satellite programmes. For these programmes relocation would be impossible, due to national security considerations and work share agreements. For example, an Ariane launcher can be composed of more than 150,000 parts and more than 1,500 suppliers can be involved on first level of the supply chain (11), which shows the high level of complexity and close integration between actors in the supply chain.

MROs: A partial shutdown of MRO activities would be necessary, relocating repair and maintenance of aircraft components use of Strontium Chromate to a non-EEA country. MRO may increase the size of inventories of finished components (or sub-assemblies) held at maintenance facilities in the EEA, because of the inability to continue on-site maintenance using Strontium Chromate.

However, no maintenance of airframes would be possible; all such maintenance would be moved outside of the EEA. For unexpected maintenance, the aircraft would have to be grounded and physically shipped, or flown with a special permit (Permit to Fly) issued by the State of Registry of the aircraft to a non-EEA country for maintenance.

Clearly, with only component replacement and non-chromate maintenance of components and aircraft being possible in the EEA, the economic viability of EEA-based maintenance operations would be significantly affected. MROs foresee the most likely scenario is that maintenance facilities in the EEA would be closed (at least eventually) and relocated to non-EEA countries. Furthermore, although moving ‘base maintenance activities’ (major maintenance checks) to a location outside the EEA is a comparatively easy step to make, as repair facilities exist in numerous other regions, this could never be justified in the case of “line maintenance activities” (i.e. day-to-day activities, including defect rectification). This is because being unable to undertake these activities where an aircraft lands would basically imply suspending the operation of the aircraft every time there is a defect, with the need to ship or fly it outside of the EEA for repair. Normal operation of revenue aircraft would be impossible under these circumstances, with consequent drastic implications for the entire commercial aviation industry (9).

Component Manufacturers report stop of production of parts treated with Strontium Chromate in the EEA as a non-use scenario. Companies that have the capability of relocating the production facilities to a non-EEA country will do so. Highly specialised Small and Medium Enterprises (SMEs) that do not have the financial capabilities will cease production.

Relocation of application of formulations (and, potentially, sub-assembly) activities will have important implications for product quality, supply times and security of supply. Some companies note, that considering the negative impacts in the non-use scenario, they might not be able to stay competitive. In these cases, the non-use scenario will result in a complete shutdown of all activities. This will result in loss of revenue and cancelation of contracts. Further negative impacts to the European economy include loss of expertise / technology to non-EEA countries, affecting Europe´s position as a technology leader.

The reactions of the different actors in the aerospace supply chain in case authorisation would not be granted result in considerable losses for the European Economic Area, jeopardising European competitiveness and workplaces. Furthermore, worker exposures will not reduce as a result of the relocation. In fact it is likely to increase due to less stringent regulations in many non-EEA countries. This is true for all industry sectors.

As a conclusion, the non-use scenarios can be summarised as follows:

- Stop of production processes related to Strontium chromate in the EEA
- Relocation of all affected processes to non-EEA countries in order to maintain production

These non-use scenarios will have the following consequences:

- Relocation of surface treatment processes (most probably to target markets in USA and Asia with available aerospace industry).
- Relocation of parts manufacturing and, most probably, final assembly lines (FALs) because it is not logistically or technically practical to only sub-contract/relocate the surface treatment processes to non-EEA countries, considering, *inter alia*:
  - Very short lead times required to implement surface treatment after machining (anti-corrosion).
  - High transportation costs compared to the value of surface finishing.
- Loss of 'value added' not only from surface treatment but also from further steps in the value chain (parts manufacturing and most probably also final assembly).
- Absence of one single part can severely disrupt or even prevent the delivery of an aircraft (see ANNEX D). Therefore, loss of even a limited number of parts treated with chromate substances will have substantial effects.
- As a consequence, a significant portion of the total turnover of € 197 billion[5] (2013) delivered by the European aerospace industry will be lost. For the avoidance of doubt, this does not account for the impact on loss of revenues of airlines that do not receive their aircraft, and cannot keep their fleet operational because of missing spare-parts and maintenance operations that rely on Cr(VI) (see ANNEX E).
- Chromate substitution plans in Europe will stop. Surface treatment expertise as well as research and development in alternative technologies will shift from the EEA to non-EEA countries.
- Surface treatment processes with and without Cr(VI) will be developed and industrialised outside of the EEA. An entire industry sector will be dismantled in Europe.
- The facilities needed for testing and implementing Cr(VI)-free alternatives will no longer be available in Europe.
- Cr(VI) workplace exposure will be transferred to another region, possibly to countries with more poorly managed and regulated exposure conditions in place, not eliminated.
- Considering the workload (as hundreds of thousands part numbers need to be considered) and resources required to validate the new production sites after relocation, production will most likely completely stop for at least 12 months after the sunset date. An estimation of the socio-economic impacts is provided in ANNEX F. For final assembly lines, experts estimate nine years until aircraft production can be continued at another site. Considering

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[5] http://www.asd-europe.org/fileadmin/templates/images/publications/Facts___Figures_2013.pdf

that more than 38,000 new aircraft are to be delivered within the next 20 years (12) and Europe counts for approximately half of the production volume, this will result in massive under-supply of new aircraft. This has consequences not only for development of the aerospace related market, but also for the development of the global economy.

- After this time frame, the relocated business will slowly restart. However it will not reach previous revenues because the entire European aerospace sector has been destabilised after this period of inactivity.

Because exact monetary values connected to the impacts stated above are very hard to quantify, Sections 7.2 and 7.2.2 aim to assess the minimum economic impacts connected to a non-authorisation.

However, it must be absolutely clear that the impacts assessed in these sections represent a massive underestimation of the real impacts to be expected. The overall scale of the impact to the aerospace industry alone is expected to be of the order of several billion Euros. The scale of the impact to industries that rely on the smooth operation of the aerospace industry (e.g. commerce, tourism etc.) will be many fold higher.

5. INFORMATION FOR THE LENGTH OF THE REVIEW PERIOD

In addition to the findings of the AoA, the following sections highlight the special characteristics inherent to the European aerospace industry to justify a review period of **12 years** for the use of the substance.

5.1. Importance of the European aerospace industry

Air transport is one of the most competitive industries in Europe, bringing major social and economic benefits to the European economy. At present, the industry directly and indirectly supports 9.3 million jobs and contributes approximately € 512 billion to the total EU GDP (13). In 2009 exports to non-EEA countries amounted to 60% of the aerospace industry's turnover, generating a trade surplus of € 2.2 billion (14). Furthermore, the European air transport system consists of a fleet of about nearly 5,000 aircraft and moves 1 billion people per year (14). As of 2014, there are 227 airlines in the EU and 959 commercial airports in Europe, allowing Europe to expand trade routes, enhance business relations and receive additional revenues through an increase in tourism (13). Europe is well positioned in the aerospace industry worldwide given the massive production of parts, aircraft and maintenance services provided by the European aerospace industry. Demand for air transport is expected to increase by an average of 4.7% per annum over the next 20 years, which is estimated to have the beneficial outcome of increasing the amount of supported jobs to 12.4 million (13). This demonstrates a healthy and growing industry for decades to come.

Additionally, the European aerospace industry is highly widespread in term of markets - Europe exports to all continents and has trade partners in more than 130 countries around the world (15).

The aviation industry must operate in a long-term perspective of at least 20 to 30 years, which is the average lifetime of an individual aircraft, while any particular aircraft spare parts may be manufactured for as many as 50 years. Accordingly, the policy framework that is established today and the respective allocated resources determine the perspectives and performance of the industry for decades to come (14). The space industry operates as well in long-terms, e.g. for new launchers to fulfil requirements of ESA a period of 10 years is needed (2 years for satellites (11)) and the average for production time of a satellite until is launched is 30 months (16). The space industry is a highly valuable sector and a major political concern; the EU wants to have its own capacity to access space (e.g. major programmes such as Ariane 5, Vega, and all satellite programmes for earth observation and telecommunications). The market is highly competitive and it would be absolutely critical for the whole telecom market if the EU could not deliver its satellites into orbit.

The European space industry is, in its domain, one of the best in the world but it is facing increasing world competition especially over the last few years (particularly with products from areas of the world with less regulatory requirements). It is still present on the market with successful products such as Ariane, Eurostar or Spacebus. Any inability to produce spacecraft parts inside Europe would endanger the European space industry (and related numerous jobs) and compromise autonomous European access to space. Relocation of manufacture of spacecraft parts to non-EEA countries is a major issue and a non-possible option, which would create a high distortion of the market causing higher costs, dependence on non-EEA industrialists and imports, and loss of European competitiveness and know-how.

Lifecycle stages of aircraft and spacecraft, and other challenges inherent to the aerospace industry are elaborated in more detail in section 5.2, since these are critical to understanding the issues surrounding the replacement of Strontium Chromate.

5.2. Special challenges inherent to the aerospace industry

Apart from the complexity of the supply chain, the aerospace sector faces particular unique challenges related to the operating environment, compliance with the airworthiness requirements and spacecraft requirements and the longevity of an aircraft and spacecraft that constrain its ability to adopt changes in materials and processes in the short, medium or even longer terms.

Section 5.2.1 and 5.2.2 describe the legal requirements relating to airworthiness and the aircraft lifecycle in more detail, respectively. These requirements demonstrated for the aviation industry (qualification, certification and implementation) as well as the complexity of the supply chain apply also in general for launchers and satellites. They are mainly based on the report “An elaboration of key aspects of the authorisation process in the context of aviation industry” authored by ECHA and EASA published in April 2014 (9). Furthermore, the space industry is also included in the following sections, due to the at least equivalent constraints, requirements and processes regarding, changes acceptance and qualification (e.g. performances and Manufacturing, Assembly, Integration and Test (MAIT) processes) by European or national agencies and customers.

5.2.1 Airworthiness requirements according to EU Regulation No 216/2008

Aircraft operate in environments that are highly challenging due to the extreme and varied conditions encountered (e.g. temperature and humidity). The consequences of failure in the industry are severe. As a result, today the aerospace industry is highly regulated, requirements on material, components and equipment is high, and stringent safety requirements must be met.

The industry must comply with country specific requirements in countries outside the EU. The European Aviation Safety Agency (EASA) was established to promote the highest common standards of safety and environmental protection in civil aviation across Europe.

In particular, the aviation industry must comply with the airworthiness requirements derived from EU Regulation No 216/2008 in Europe. According to the regulation, all components incorporated in an aircraft fulfil specific functions and must be *qualified, certified* and *industrialised* (see Figure 2) before serial production can commence. Similarly, if a substance used in a material, process, component, or equipment is changed, these processes must be followed before the change can be affected in order to comply with the airworthiness requirements according to EU Regulation No 216/2008 (17).

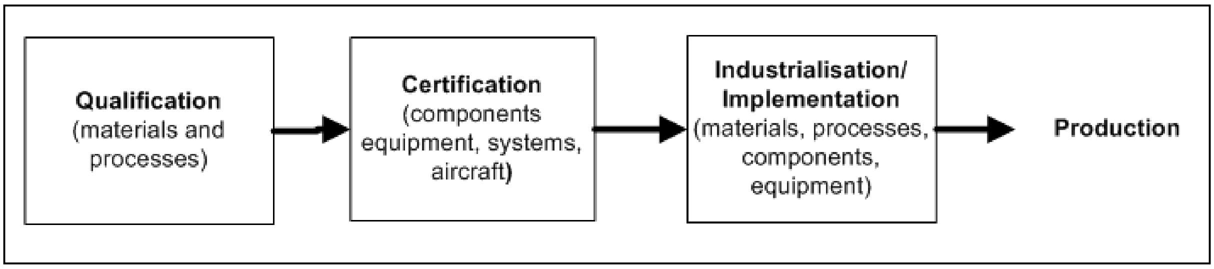

Figure 2: Qualification, Certification, and Industrialisation in the aerospace industry (9)

The qualification, certification and industrialisation processes are described in more detail below.

The space industry faces at least equivalent constraints, requirements and processes regarding changes acceptance and qualification (with respect to both performance and manufacturing, assembly, integration and test processes) by European or national agencies and customers.

The space industry operates in highly challenging environments due to the conditions in which space flight hardware has to function. It has demanding customer requirements for high reliability and performance over many years, due to challenging to impossible repair and maintenance scenarios once the satellite is in orbit. Customers (commercial, government and agencies) all demand extensive technology heritage and evidence of successful applications in orbit for low earth, geo-synchronous, interplanetary and deep space missions. This involves a wide range of space vehicles from launchers to telecommunication, earth observation, navigation and scientific satellites. Prior to the actual service in the space environment high levels of corrosion protection are needed during the terrestrial phases of the hardware life-cycle in order to provide the customers the required level of confidence associated with the space operational lifecycle. Even after lengthy phases of research and development testing, all new technologies require extensive qualification testing at all levels of the assembly, which can often go up to final space vehicle level. Then, once it is finally approved at industrial levels the end products themselves are also subjected to lengthy phases of product qualification and acceptance testing. Fulfilling the European Space Agency (ESA) requirements for a new launcher needs about 10 years.

Qualification

Qualification is the process under which an organisation determines that a material, process, component or equipment have met or exceeded specific performance requirements, as documented in the technical standard or specification relevant to that material, process or part. These specifications set out explicit performance requirements, test methods, acceptance testing, and other characteristics that are based upon the results of research, development and prior product experience.

This phase of research and development is an extensive internal process. Qualification typically involves many iterations of testing. After initial laboratory testing, *each specific application* must be reviewed. The final sub-assembly or assembly may also require testing. Depending on the complexity of the changes, the qualification process may require more than 100 iterations on any test (e.g. under different conditions) before a release specification is issued. For this reason, qualification commonly requires 3 to 5 years to complete, depending on the material requirements. This assumes the qualification process is successful, which may not always be the case.

Please refer to Figure 3 for a schematic overview of the qualification process.

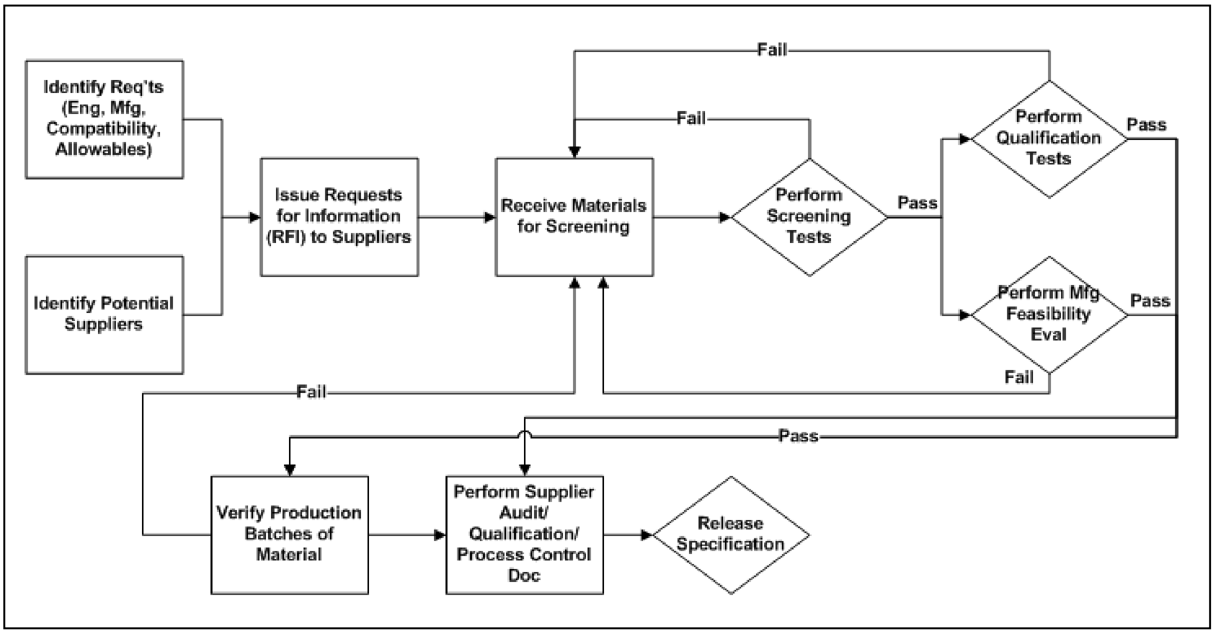

Figure 3: Qualification process (9)

Certification

Airworthiness Certification begins in parallel with qualification.

Certification is the process under which it is determined that an aircraft (or an engine, propeller or any other aeronautical part and appliance) complies with the safety, performance and environmental requirements contained in the applicable airworthiness regulations. The outcome of this formal and comprehensive process is the issuance of a Type Certificate (TC) by the relevant competent authority. This certifies that the aircraft “type” meets appropriate requirements; once issued, the design cannot be changed without additional approval.

Demonstration of compliance to those requirements generally takes several years for each type of aircraft. All the aspects covered by the Type Certificate together define the “approved type design” for that aircraft type. These include, among other aspects, all chemical products physically present in the aircraft as well as those that are used during manufacturing and maintenance activities. Each individual aircraft has to be produced and maintained in conformity with this approved type design (9).

Any changes to the approved type design must be shown to be compliant with the applicable airworthiness requirements. The original compliance demonstration must be reviewed for applicability and validity, in addition to a review of potential new aspects of the new material or design change that could affect the airworthiness of the aircraft.

Depending on the change, this review could be restricted to component tests, but for other changes this could involve rather extensive testing. For example, changes in protective coatings could affect not only the corrosion resistance but could also affect the friction characteristics of moving components in actuators in the different environmental conditions, changing the dynamic behaviour of the system, which in the end affects the dynamic response of the airplane. Such "after-effects" of changes in materials must be considered in the testing requirements.

Before the new material or design change can be introduced on the aircraft, all test and compliance demonstrations have to be successfully completed and approved by the competent authority. This approval results in the issuance of a Supplemental Type Certificate (STC), change approval or repair approval.

It is also important to note that laboratory testing cannot fully simulate in-service performance (for example, it cannot duplicate all relevant physics of in-service environments such as vibration, temperature, UV exposure). This limits the predictive power of laboratory tests. Consequently, laboratory performance is commonly validated with outdoor testing and monitoring under representative conditions over a period of several years. Again, the results must be reviewed and approved by airworthiness authorities. This process of approval until the issuance of a new TC or STC can take years depending on the application.

Extreme caution must be exercised and risks understood before replacing a material that has proven field experience, especially as some inaccessible locations cannot be inspected for the entire life of an aircraft (9).

Industrialisation

Industrialisation is an extensive step-by-step methodology followed in order to implement a qualified material or process throughout the manufacturing, supply chain and maintenance operations, leading to the final certification of the aerospace product. This includes (but is not limited to) re-negotiation with suppliers, investment in process implementation and final audit in order to qualify the processor to the qualified process.

An aircraft is assembled from several million parts provided by several thousand suppliers. This in itself, provides an indication of the complexity of the industrialisation stage of broad scale replacement of critical materials (and processes) that affect a significant proportion of these components, and involve many tiers in the complex supply chain providing these parts according to stringent procedures. The replacement of Strontium Chromate might imply the need for multiple different solutions for different applications as substitutes for one single, robust process. This would result in increased complexity of manufacturing and repairs solutions, higher costs and longer MRO stops (9).

For further details on the qualification, certification and industrialisation processes please refer to the corresponding AoA.

5.2.2 Lifecycle stages of an aircraft, spacecraft and satellites

The longevity of aircraft and spacecraft (launchers and satellites) makes it even more complicated for the aerospace industry to adopt new materials and processes – especially for aircraft in operation and aircraft that are not being produced anymore (hereafter "legacy aircraft").

A representative lifecycle of a typical aircraft product is illustrated in the following figure:

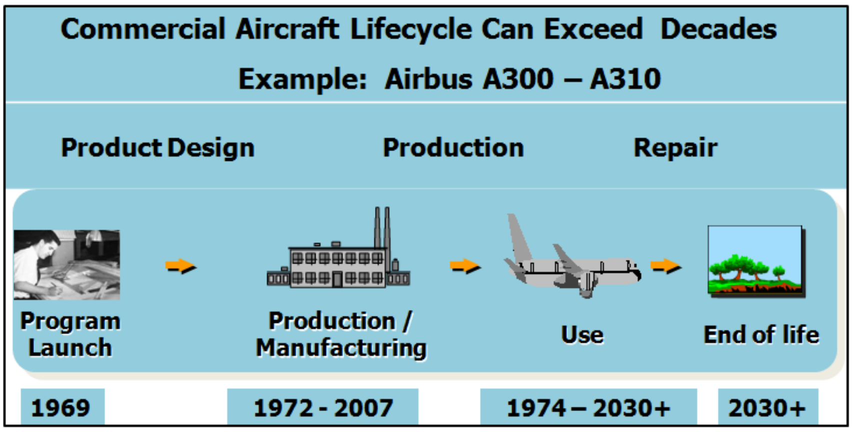

Figure 4: Commercial aircraft lifecycle (9)

Some key figures to be considered are the following:

- The development of a new aircraft can take up to 15 years.
- The production of one type of aircraft may span more than 50 years.
- The lifespan of an aircraft is typically 20-30 years.

Therefore, aircraft may be considered according to the following general categories:

- Legacy aircraft in operation (the aircraft type is not being produced anymore).
- Operating aircraft of a type which is still in production.
- Future aircraft for which a Type Certificate has not been issued yet (9).

For each application and category, the qualification, certification and industrialisation process must be performed in order to determine a suitable alternative. Importantly, the suitability of alternatives and the non-use scenarios for Strontium Chromate may differ between these three different aircraft categories.

For example, a substance may be easier (and less expensive when considering the cost over the production lifetime) to substitute in future aircraft, as the qualification, certification and industrialisation can be carried out as an integral part of the production program. On the contrary, for legacy and in-production aircraft, introduction of a new substance may require additional qualification, certification and industrialisation rounds that must dovetail with an existing design. Additionally, a new technology can be implemented on new aircraft, only if it is also certified on legacy aircraft, otherwise investment in separate production lines is necessarily, which makes it difficult to achieve acceptable Returns on Investment (ROI). This may lead to different non-use scenarios and related substitution costs between aircraft categories for a single substance and use.

The aviation industry uses the same substances for different purposes in the aircraft. For example, a substance could be used to produce or maintain the aircraft. The non-use scenarios may also differ between the different use categories. As ‘grounding’ (no permission to fly) is generally more expensive and cost-critical for newer aircraft, the age of the aircraft may also directly impact on the non-use scenario in terms of relocation or stop of production of the different aircraft (9).

In the case of space industry the lifecycle depends on the type of spacecraft (military or civil launchers, satellites etc.) but it can be at least as complex and challenging as aircraft regarding: lifecycle duration, environment exposure and high requirements.

5.3. Conclusion

All these processes relating to airworthiness are often as intensive as the primary certification process, adding another substantial layer of complexity and cost to the activities associated with replacement of Strontium Chromate, as well as affecting the timeline within which such changes can be executed. These processes require a large amount of resources and potentially covering long timescales (9).

The technical uncertainty related to qualification, certification and industrialisation of aircraft applies equally to the space industry, leading to the same level of requirements and similarly long, complex and robust processes for spacecraft as well.

The use of Strontium Chromate in the aerospace industry is extensive and plays a critical role in meeting performance and safety standards, particularly those relating to airworthiness set by EASA. Space and defence also have to fulfil requirements of other certification authorities (e.g. ESA and BAAINBw for German Airforce). At the same time, the volumes used tend to be relatively low and uses take place in well-controlled industrial settings (9).

In addition to the time needed to successfully replace Strontium Chromate and the related processes according to airworthiness, CCST consortium members note that a certain “buffer” or contingency within the schedule to substitute chromium VI is needed, in case serious delays in the process occur (time to complete additional R&D and additional processes according to EU regulation No. 216/2008).

The complex structure of the aerospace industry, the technical and logistical challenges associated with introducing broad scale changes around a critical function, the need to impose rigorous standards across aircraft fleets and to ensure that standards are met at all times mean that the costs of transitioning to alternatives and the cost of the non-use scenarios are significant.

To underline this, companies across the supply chain, including OEMs, suppliers and MROs, report it could be cheaper to relocate all manufacturing and maintenance activities outside of the EEA so that the use of Strontium Chromate can continue in the short and longer terms. In contrast, for the space and defence industry relocation of processes might not be possible due to customer restrictions, national security considerations and work share agreements.

As described in section 4, the shutdown and relocation of single activities requiring Strontium Chromate significantly affects the economic viability of associated EEA based operations as well. As activities start to relocate to non-EEA countries, it will become more efficient / profitable to relocate associated activities to those locations. Eventually, this could lead to wide-scale migration of the industry, where companies shut down all EEA production and maintenance facilities and relocate them to non-EEA countries. With it, the entire supply chain that is linked to these business activities (e.g. formulators, distributors, subcontractors) is likely to move / to be relocated to non-EEA countries.

In addition, in the case of non-authorisation for the European space sector, the relocation of spacecraft manufacturing in non-EEA countries is not possible, since it is clearly required by European and national agencies, and customers, that spacecraft are manufactured and produced only in Europe (e.g. only some specific waivers are accepted), which can lead to a more severe non-use scenario such as production disruption and closure of some workshops. Additionally, the Member States requirements for geographic return are mandatory.

In-house designed space vehicles include individual products and subsystems manufactured using chromate based processes provided by internal facilities or provided by external specialist organisations. Other products and subsystems are procured externally and delivered in the final state. All these individual products and subsystems are then integrated into next level higher assemblies and so on until the final assembly of the space vehicle. The final assembly is an in-house activity.

If Strontium Chromate applications are not authorised in Europe, all processes using Strontium Chromate would have to be relocated to non-EEA countries. Any programme heritage and experience would need to be transferred requiring extensive training and validation not only at product or subsystem level but more significantly at vehicle level in order to satisfy the customer demands for proven technology and reliable processes. During integration and test at the various higher assembly levels any need to repair or rework chromate treated surfaces would require return to the original source. As the assembly of the vehicle progresses, this then becomes ever more unfeasible and such complex assemblies could not be transferred from facility to facility because of the needs for high cleanliness and protection from the external environment.

While such scenarios may be considered worst-case for the European Economic Area they should not be considered unlikely, due to the lack of a viable alternative and safety concerns. Thus major European players in the aerospace industry identified this as an unintended but realistic outcome if an authorisation for the use of Strontium Chromate is not granted.

Furthermore, the CCST consortium members clearly note that these scenarios could quickly become reality if the review period issued for the continued use of Strontium Chromate is too short to allow delivery of research on viable alternatives and the subsequent qualification, certification and industrialisation process, as near- and mid- term decisions regarding substantial new investment could not tolerate uncertainty associated with the viability of the industry in the EEA (see below). Investment cycles in the aerospace industry cannot be overlooked when evaluating the likely non-use scenario. In this context, companies might opt for making major investments in a non-EEA country, where the continued use of the well-known and proven production processes using Strontium Chromate formulation would be allowed in the longer term, so uncertainty surrounding future operations is minimised.

Higher up the supply chain, the majority of component manufacturers and processors within the aerospace sector in Europe are highly specialised Small or Medium Enterprises[6] (SMEs).

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[6] As of 2009, 80% of the companies within the aerospace supply chain employed <50 people and 9% employed 50-250 people (12).

Individually, these companies might not be able to adopt alternative substances or alternative process within short periods of time, because of the capital and / or operating expenses involved. This would mean that these companies would have to cease their business activities resulting in welfare losses for the EEA. This again would be another driving force for the major players in the aerospace sector to relocate their business including their suppliers to a non-EEA country where supply of corrosion-resistance parts is assured.

The activities carried out by the aviation industry in its non-use scenarios may change over time. For example, in the short term it may be easier e.g. to do the maintenance outside the EEA before getting the alternative developed, qualified, certified and industrialised in a longer term (9).

As described previously, the non-use scenarios within the aerospace industry may differ depending on the lifecycle stage of the aircraft (including helicopters), satellite, or spacecraft in consideration and on the use of the substance (production or maintenance). As described in section 5.2.2, an additional re-certification process might not be economically viable for legacy aircraft or aircraft that are already in production, whereas certification of the use of a new substance is easier for aircraft in development stage.

For all the reasons stated and with reference to the findings of the AoA, a review period of at least 12 years is requested for the continued use of Strontium Chromate in the aerospace industry, as defined in section 3.

6. METHODOLOGY

The overall case for authorisation of Strontium Chromate for applications in the aerospace industry has been set out in ECHA & EASA (9). The economic implications of the non-use scenario are clear: if it is not possible to continue to use Strontium Chromate the aerospace industry in the EEA would need to relocate many of its activities to the US and Asia because no drop-in or other alternatives are available in the key applications. The wider economic impacts in the EU would be devastating as the aerospace industry relies on inputs from thousands of suppliers and service providers. At the same time, the critical services provided by the aerospace industry support and facilitate competitiveness to businesses across Europe.

ECHA (2011) makes it clear that a quantitative analysis is strongly recommended encouraged to underpin an Application for Authorisation[7] and recommends a Cost-Benefit Analysis (CBA) as the preferred tool for quantitative analysis[8] (18). This preference has further been underlined in the current practice of Applications for Authorisation where both the costs and benefits have been quantified and compared[9]. Furthermore, it has been clear in the seminars and presentations given by ECHA that a full Cost-Benefit Analysis, i.e. a fully quantitative SEA including the monetisation of the health impacts, would make it much easier for the Socio-Economic Analysis Committee (SEAC) to compare the costs of non-authorisation with possible remaining risks in the case of authorisation.

Therefore, an analysis of the i) monetised health impacts and ii) socio-economic impacts is presented here to allow an easier evaluation of the risks related to the authorisation. The aim of this analysis is to support the findings of the qualitative description, where it has been concluded that the benefits of continued use of Strontium Chromate would be substantial, while the remaining risks would be very well managed and limited, following an authorisation. The analysis is built on and takes into account evidence gathered during the preparation of the CSR, AoA and SEA.

The applicants refer to and utilises the processes, methods, tools and values (e.g. the dose-response relationship) prescribed under ECHA (2011) and ECHA (2013) (18) (2). However, the applicants, Consortium members and companies in the supply chain that may directly or indirectly rely on the Application for Authorisation do not and should not by preparing this quantified Cost-Benefit Analysis or otherwise be construed to endorse, support, or otherwise accept the approach to the monetisation of health impacts. Independent studies such as Willingness to Pay reports have been referenced as required in order to give an estimate of the order of magnitude of the residual health risk of the use as authorised in the Cost-Benefit Analysis framework. This is done in accordance with ECHA (2011). Given that the purpose of this analysis is to give an order of magnitude estimation, the

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[7] For example, the 4th paragraph of the box titled ‘How to identify and assess impacts?’ at page 22 of the Guidance on the Preparation of Socio-Economic Analysis as part of an Application for Authorisation which states monetisation should ideally be carried out.

[8] Section 4.1 of the Guidance on the Preparation of Socio-Economic Analysis as part of an Application for Authorisation.

[9] See e.g. the public versions of the applications available at http://echa.europa.eu/addressing-chemicals-of-concern/authorisation/applications-for-authorisation-previous-consultations and http://echa.europa.eu/web/guest/addressing-chemicals-of-concern/authorisation/applications-for-authorisation [Cited: 15 November 2014].

applicants, consortium members and companies in the supply chain consider that the monetised health impacts calculated according to the prescribed ECHA method have no real-world, commercial or legal relevance or merit.

6.1. General approach

The SEA has been conducted in accordance with the approach set out in the Guidance on the Preparation of Socio-Economic Analysis as part of an Application for Authorisation (18). The reader is referred to the guidance for appropriate context and general information on approach to the SEA, while more specific aspects relevant to this document are discussed below.

Specific data used for the analysis of impacts in the SEA at hand was gathered by the use of questionnaires sent out to all CCST consortium members. Formulators of the substance (use group iv) received separate questionnaires that allowed more detailed analysis of use-group specific differences.

In addition, site visits at CCST consortium members representative of particular industry sectors provided supportive information to be able to reflect the on-site situations in the authorisation dossiers. Additional benefits from the site visits were e.g. clarification of questions of details, discussion of non-use scenarios and maximisation of understanding of the uses of the substances and the production processes.

As an underlying basis for the assessment of impacts in this Socio-Economic Analysis, the estimation of health impacts was based on worst-case assumptions compared to purposefully conservative calculations of social impacts.

For example, the calculation of health impacts is based on upper bound estimates of people potentially exposed (maximum number of potentially exposed workers as stated in the questionnaires) and the upper bound of exposure times and values (combined worker exposure), as elaborated in the CSR. In addition, sensitive (upper bound) values instead of central (average) values[10] representing costs of health impacts, as reported in studies specified for use in Cost-Benefit Analysis, have been used in the health impact assessment. These derived values, therefore, can be considered worst-case estimates. In this sense, while the values themselves have no real-world, commercial or legal relevance or merit, the broad comparison of the health impact with social and economic impact can be considered a relative measure of their scale.

By contrast, the calculation of social impacts is based on the lower bound values provided by the CCST member companies (lower bound of job losses as stated by the companies used for the assessment of social impacts). In addition social impacts are only considered at downstream users to avoid double counting.

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[10] Central value is the median value (lower bound) of the Willingness to Pay; sensitive value is the mean value (upper bound) of the Willingness to Pay to monetise health impacts (see section 6.4.4).

As a consequence, human health impacts are highly overestimated and socio-economic impacts are very likely to be underestimated. It should be noted that the collection of data from members of CCST for the purpose of the SEA was subject to competition rules.

In order to evaluate impacts, data from across the supply chain is needed. An individual analysis of all suppliers / subcontractors or customers of the CCST consortium members that use products containing Strontium Chromate is not possible due to the large number of companies and the highly complex supply chain. Therefore, for the assessment of impacts an extrapolation approach for the entire supply chain was chosen based on available data from the CCST consortium, public available data and expert consultation.

6.2. Assessment of social impacts (salary cost method)

The primary social impact evaluated during this study is the impact of loss of earnings relating to job losses following production stop or relocation. Other social impacts are more difficult to quantify and have not been considered in the Cost-Benefit Analysis, but may include:

- foregone productivity of the workers (value-added that would have been generated by the workers)
- secondary and tertiary job losses
- additional costs for the society due to unemployment
- impacts of loss of purchasing power

In the course of the data gathering via the questionnaires, companies were asked if and how many jobs related to the substance use would be lost as a consequence of their individual non-use scenarios. At the same time, companies were asked to classify the jobs that would be lost according to their education levels low skilled / high skilled / academic.

In case companies were not able to specify the job losses according to the education levels, impacts of job losses were calculated for the lowest education level 2 (low skilled).

The economic impact of lost jobs that were classified as low skilled, high skilled, academic by the companies were monetised using the hourly earnings for workers with education levels 2, 3 / 4 and 5A in the EU-27, according to ISCED (derived from EUROSTAT as of 2010) as a basis[11] [12]. Average social contributions and other labour costs paid by employers in the EU-27 (as of 2010) of 22.7% were added. Hourly earnings were brought to salary costs per year by multiplying by 40 hours per week and 52 weeks per year (see Table 1).

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[11] http://www.uis.unesco.org/Library/Documents/isced97-en.pdf [Cited on 04 June 2013].

[12] http://epp.eurostat.ec.europa.eu/portal/page/portal/labour_market/earnings/database [Cited on 04 June 2013].

Table 1: Salary costs according to educational level EU-27 (EUROSTAT Data as of 2010)

ISCED Level	**Description**	**Hourly earnings EU-27**	**Incl. social contribution and other labour costs paid by the employer (rounded)**	**FTE salary costs per year (rounded)**
2	Lower secondary or second stage of basic education	€ 11.14	€ 13.67	**€ 28,434**
3 / 4	Upper secondary and post-secondary non tertiary education	€ 12.45	€ 15.28	**€ 31,782**
5A	First stage of tertiary education, programmes that are theoretically based / research preparatory or giving access to professions with high skills requirements	€ 21.54	€ 26.43	**€ 54,974**

To be able to reflect the real values of the jobs lost due to non-authorisation for the entire review period, the Net Present Value method (NPV) is used.

The NPV is a common methodology applied in economics. It is calculated according to the following equation:

$$NPV\ (i) = \sum_{t=0}^{N} \frac{R_t}{(1+i)^t}$$

where

i is the discount rate

N is the number of years for which the NPV is to be calculated (review period)

R_t is the cash flow / the amount of money in year t (e.g. social impacts)

An inflation rate of 1.517%[13] (geometrical mean of annual price increase rate from 2003-2013) was employed to inflate the 2010 values to the base year (2019). To discount the values from 2020-2031

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[13] This inflation rate is used for the entire impact assessment (see section 6.4.4 for further details).

to 2019 values (base year) a discount factor of 4% was employed. See section 7.2 for practical applications of the NPV methodology.

6.3. Assessment of economic impacts

Concerns by CCST members and within the supply chain regarding the release of confidential / sensitive business data and requirements of competition law hampered the collection and reporting of reliable economic data relating to business impact. Therefore, these impacts will only be assessed in a qualitative manner and are not considered in the quantitative assessment.

6.4. Assessment of health impacts

The worst-case assessment of health risks within this SEA utilises the results of a study endorsed by ECHA identifying the reference dose-response relationship for carcinogenicity of hexavalent chromium (2)[14]. This paper has been agreed on at the RAC-27 on 04 December 2013. Therefore, it can be applied to describe the final outcome of a service request on behalf of ECHA on the assessment of remaining cancer risks related to the use of chromium VI containing substances. These results on the carcinogenicity dose-response analysis of hexavalent chromium containing substances are acknowledged to be the preferred approach of the RAC and SEAC and therefore have been used as a methodology for the calculation of health risks in this SEA.

Accepting this, the following steps are necessary to complete the health impact assessment according to the ECHA methodology and a worst-case approach:

1. Evaluation of potential work exposure
2. Estimation of additional cancer cases relative to the baseline lifetime risk of developing the disease
3. Assessment of fatality rates (%) with reference to available empirical data
4. Monetary valuation of fatal and non-fatal cancer risks

These four consecutive steps are explained in detail in the following.

6.4.1 Data gathering on potential work exposure

Following the worst case approach, combined worker exposure values from the corresponding CSR (5) are taken for the assessment of health impacts. For further information regarding exposure values, please consider the corresponding CSR.

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[14] By reference to this, the applicants neither agrees nor disagrees with this dose-response relationship. However, the applicants acknowledges that the dose-response relationship is likely to be conservative and protective of human health, particularly considering the extrapolated linear relationship at low dose exposure concentrations.

6.4.2 Estimation of additional cancer cases in relation to baseline

ECHA has prepared a quantitative assessment of the dose-response relationship for hexavalent chromium based on epidemiological studies and experimental findings in rodents for inhalation, dermal and oral exposure (workers) and oral exposure and inhalation exposure (general population).

The dose-response relationship for hexavalent chromium with regard to lung cancer and intestinal cancer has been discussed in recent research published by ECHA (2). These dose-response functions of an excess risk for carcinogenic effects have been used as the basis for this assessment.

According to the exposure scenario stated in the CSR and in accordance with the ECHA paper (2), p. 4 (“in cases where the applicant only provides data for the exposure to the inhalable particulate fraction, as a default, it will be assumed that all particles were in the respirable size range”), only lung cancer is considered in this assessment. The share of particles that enter the gastro-intestinal tract is therefore assumed to be zero.

For dermal exposure to hexavalent chromium compounds, no evidence for skin or other tumours in humans is proposed by ECHA. The ECHA report concludes that exposure of the general population outside of the working site can also be regarded as negligible for skin or intestinal cancer.

For the calculation of health impacts related to lung cancer, **Excess Lifetime Risk** (ELR) is defined as the additional or extra risk of developing cancer due to exposure to a toxic substance incurred over the lifetime of an individual. Note that developing cancer may occur during working life or after retirement.

Linear exposure-risk relationship for lung cancer as estimated by ECHA (2):

$$Unit\ occupational\ excess\ lifetime\ risk = 4\ \times 10^{-3}\ \text{per}\ \frac{\mu g\ \mathrm{Cr(VI)}}{\mathrm{m3}}$$

The exposure-response relationship agreed upon by RAC refers to a working lifetime exposure with continuous working-daily exposure. As an average over different countries and economic sectors, full-time employee contracts (8 hours per day) and a working lifetime of 40 years are taken as a basis (2). Note that 8 working hours per day or 40 working hours per week, as well as 40 years per working life are explicit parameters used for the Full-Time working Equivalent underlying the exposure-response functions (2), p. 5, whereas 260 working days per year are given through the dose-response curve.

Adaptation factors for time frame of exposure

In order to apply this exposure-risk relationship to the case of authorisation, it has to be adapted according to the time frames used in this Application for Authorisation.

Therefore, the following factors are used to adapt the exposure-risk relationship to the respective situation of this Application for Authorisation:

- Factor for adaptation to the respective review period (years of authorisation granted up to the next revision envisaged)

$$\frac{review\ period\ [years]}{40\ years}$$

Methodology for the estimation of additional lung cancer cases

For an individual person, the excess lifetime lung cancer mortality risk derived in the ECHA paper (2) indicates the differential in probability to die of lung cancer during the future life, i.e. the increase in probability compared to the baseline risk for an individual to die from this disease.

As described above and in line with ECHA, Excess Lifetime Risk (ELR) of mortality associated with lung cancer = 4 * 10^{-3} * concentration [µg hexavalent chromium /m^3] (due to an exposure over the whole working lifetime of 40 years, which is higher than the relevant time frame for the intended authorisation).

Excess risk used in this equation is defined as:

$$P_{excess} = P(x) - P(0)$$

with

$$P_{excess}(x) = Excess\ risk\ at\ exposure\ x$$

$$P(x) = lifetime\ risk\ of\ persons\ exposed\ for\ dying\ from\ lung\ cancer$$

$$P(0) = Background\ risk\ (lifetime\ risk\ of\ a\ non - exposed\ comparison\ group)$$

It has to be emphasised that $P_{excess}(x)$ is an additional risk, the unit is the expected number of additional lung cancer deaths of a population exposed by a concentration x in the sum (2).

In the source of ECHA (2), based on the research of the ETESS consortium (19), and in underlying studies, excess risk is used in absolute terms, not percentage points. This is not always used uniformly in other epidemiologic studies. The excess risk $P_{excess}(x)$ is linear, i.e. proportional both to individual exposure and to persons exposed. Therefore, exposures of different persons can be added.

Consequently, the aggregated excess risk is the expected value of additional lung cancer deaths due to an exposure. The cumulative and weighted index of total exposure of the sum of workers affected is calculated as a total hexavalent chromium concentration [µg/m^3]. This value will be used as an input factor for the calculation of the excess risk (i.e. additional lung cancer deaths) over all employees exposed. The estimated amount of additional lung cancer deaths is the expected value due to a continued use of hexavalent chromium for the respective time frame allowed by an authorisation up to the next revision.

According to the ECHA document (2), it is explicitly spoken of an "excess lifetime lung cancer mortality risk". This is also consistent with the results of ETESS (2013) (19) where the respective table of a preliminary report is titled "unit occupational Excess Lifetime Risks (ELRs) of lung cancer death determined by different authorities or publications". This signifies that the dose-response function developed refers only to additional lung cancers ending fatal. In this study, only data on deaths caused by lung cancer has been taken into account for the estimation of the dose-response relationship. This will be included in step 4 of this methodology (Monetary valuation of fatal and non-fatal cancer risks).

6.4.3 Estimation of average fatality rates in %, based on empirical data from EU-27

The individual development of cancer diseases may be fatal or non-fatal. Non-fatal cancer is defined as cancer not causing a premature death, i.e. life expectancy is not reduced due to the cancer disease, whereas fatal cancer is defined as cancer leading to premature death. This distinction is important when applying the ECHA guidance on Socio-Economic Analysis (18) in order to use consistent categories of monetary values.

For the determination of fatality rates for lung cancer, demographic data on age-specific cancer incidences and mortality rates have been taken into account; these are mainly:

- age profile of a population
- gender profile of a population
- relationship of risk of developing the disease and risk of dying from the disease

For lung cancer, data of the International Agency for Research on Cancer (IARC) (20) for the EU-27, as well as data for the EU Member States, showing the age and gender profile of cancer risks in more detail have been analysed and compared to selected other EU Member States with similar data collection sets (21).

Data show that, although the incidence risk and the mortality risk themselves are higher for men than for women, the relationship between incidence and mortality risk (i.e. the fatality rate) shows, apart from random fluctuations, no major differences between males and females.

It has to be emphasised that any structural differences in the baseline risks (e.g. between men and women, between different EU Member States or between different age groups) do not influence the estimation of incremental cancer risks due to the hexavalent chromium exposure. Therefore, neither the share of male and female workers exposed at work nor the exact age of workers influence the outcome of the estimations.

The fatality rate is an important parameter for a monetary-based valuation of cancer risks. The reference dose-response relationship estimates additional fatal cancer risks only. A full health impact assessment will also consider lung cancer cases that do not result in fatality. Average mortality rates for lung cancer in the EU-27 is **82.8%** for both sexes (20). This value will be used for further analyses in this SEA.

6.4.4 Monetary valuation of fatal and non-fatal cancer risks

In order to evaluate the additional cancer cases in monetary terms, monetary values as suggested by ECHA are used.

In the current ECHA guidance on Socio-Economic Analysis (18), a Willingness to Pay (WTP) to avoid a cancer case of € 400,000 (2003) per non-fatal case and € 1,052,000 (2003) or € 2,258,000

(2003) per fatal cancer case (lower bound based on the median, upper bound based on the mean; see Figure 5) is given and recommended to be used. These rounded values are based on an empirical WTP study from the year 2003, derived from a research project on external costs during this year, published as NewExt Final Report (New Elements for the Assessment of External Costs from Energy Technologies)[15] (22). In NewExt, empirical Values of a Life Years lost (VOLYs) have been derived from a contingent valuation survey. Using this VOLY and estimations of Life Years Lost in case of a fatal cancer, the monetary Value of a Statistical Life (VSL) has been re-based and applied for the physical health endpoint of a fatal cancer.

To be consistent with ECHA guidance, this methodological approach is also used in the analysis of health impacts in section 7.1.

Since values are based on the year 2003, they are adjusted to the respective year of the sunset date (the base year for the calculation of Net Present Values of costs and benefits) by using Gross Domestic Product (GDP) deflator indexes. This will be explained in the following.

Implementation of a price adjuster

In this SEA, costs and benefits are made comparable by basing them to the year of the sunset date (the sunset date is used as the reference year for all cost estimations of the SEA). Therefore, health risks as well as additional costs relating to the continued use of Strontium Chromate in case of the authorisation are based to the year of the sunset date.

To adjust the WTP values to the base year, these values are multiplied by a price adjuster, which is the appropriate price index of the reference year divided by the appropriate price index of the year 2000. When using as appropriate price index the Gross Domestic Product (GDP) deflator of the EU-27 issued by EUROSTAT, data could be gathered up to the year 2013. The quarterly deflator is calculated from seasonally adjusted GDP values and rescaled so that 2000 = 100. For 2013, which is the last year with complete data sets, the deflators of the four quarters range from 121.4 (first quarter) to 122.1 (fourth quarter), with an arithmetic mean of 121.6 for the four quarters.[16] A price index development from 100.0 (in 2000 as the starting point where the index is based on) up to 121.6 in 2013 is equivalent to an average annual growth factor of 1.01517 (geometric mean over 13 years). We assume that in the average the calculated rate of price increase will continue in future from 2013 up to the reference year; therefore, the factor of 1.01517 per year is applied to extrapolate the price index development into the future, i.e. between 2013 and the reference year.

Adjusting the WTP values by the GDP deflator from 2003 to the year for which the sunset date is scheduled (i.e. it is implicitly assumed that Willingness to Pay increases by the same rate as the Gross Domestic Product in average) leads to the respective range of lower bound and upper bound values

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[15] It has to be noted that the ExternE project series stems from a different context of research, the external costs of energy and transport. However, the ECHA guidance suggests transferring these values to external costs of chemicals in the context of REACH, since more context-specific monetary values are not available.

[16] Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/product_details/dataset?p_product_code=TEINA110 [Cited: 14 October 2014].

for average cancer cases. The share of non-fatal cancers has to be added to the estimated number of fatal cancers (see Table 2).

As illustrated in Figure 5, the Willingness to Pay has a skewed probability distribution (f on the y-axis) – its minimum is zero but high runaway values emerge to the right. Therefore, median values are typically smaller than mean values.

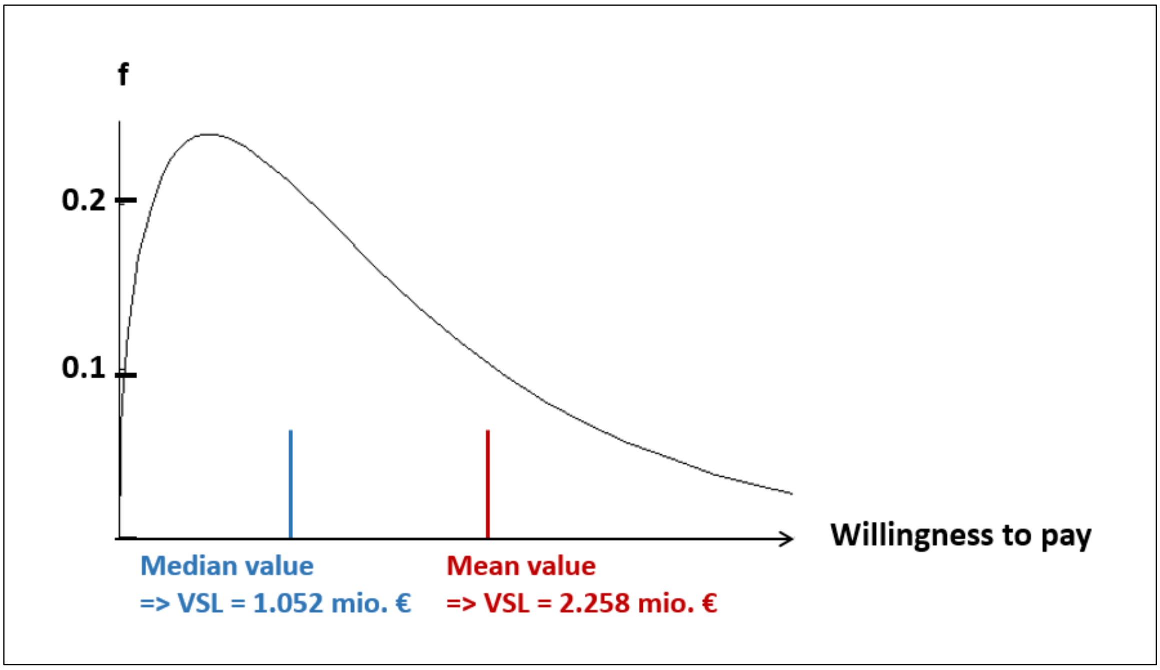

Figure 5: Median and mean Value of a Statistical Life, derived from NewExt (22), p. III-34

The ECHA guidance on Socio-Economic Analysis refers to the results of the NewExt Study (22) and suggests to use higher Values of Statistical Life (VSL) and of a Life Years lost (VOLY). This means, there is a lower (central) value and a higher (sensitivity) value. The differentiation stems from an econometric methodological discussion whether the median or the statistical mean shall be used as a basis to calculate the more robust and reliable Willingness to Pay values.

Following the ECHA guidance, it was decided to use the monetary values that are shown in Table 2 for the evaluation of cancer cases.

Table 2: Monetary values for fatal and non-fatal cancer risks, based on the ECHA Guidance

	Non-fatal cancer (morbidity)	**Fatal cancer (mortality)** **Central Value of Statistical Life based on the median value (lower bound)**	**Fatal cancer (mortality)** **Sensitivity Value of Statistical Life based on the statistical mean value (upper bound)**
2003 WTP value[17] based on NewExt (2004) – starting value in ECHA Guidance	€ 400,000 (2003)	€ 1,052,000 (2003)	€ 2,258,000 (2003)
Adjusting the 2003 values to the sunset date GDP deflator index 2003 – year of the sunset date; for multiplication[18]	$1.01517^{\text{sunset year – 2003}}$	$1.01517^{\text{sunset year - 2003}}$	$1.01517^{\text{sunset year - 2003}}$
Probability of lung cancer ending non-fatal/fatal (EU-27 average)	17.2%	82.8%	82.8%
Additional occurrence of non-fatal lung cancer per one fatal cancer estimated	17.2/82.8 = 0.208	n/a	n/a

The sensitivity range of lower and upper bound only applies to the share of fatal cancers, not to the share of non-fatal cancers (where the monetary value consists of both a cost-of-illness component and a component of Willingness to Pay to avoid the risk of a non-fatal cancer).

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[17] *Implicit discounting of latency*

It shall be emphasised that – in the calculation of these monetary values – the delay between exposure and actual appearance of cancer and the corresponding years of life lost is discounted implicitly. Those results from the design concept of the contingent valuation questionnaire developed in the NewExt study, which elicits the Willingness to Pay to reduce the risk of reduced life expectancy at the end of the life. Respondents implicitly

Monetisation of health impacts

In order to monetise additional risk of lung cancer relating to the authorisation of the continued use of the substance, first the excess risk is calculated according to the following equation:

$$ELR = \frac{review\ period\ [years]}{40\ years} \times 4\ \times 10^{-3}\ \times\ [\frac{\mu g\ Cr(VI)}{m^3}]$$

where

$\mu g\ Cr(VI)/m^3$

represents the total hexavalent chromium concentration corrected by the exposure times and the total number of exposed workers. In a second step, the monetised values for additional lung cancer cases are calculated by multiplication with the WTP values adjusted to the year of the sunset date. Following this methodology, the actual assessment of health impacts related to the authorisation of the continued use of Strontium Chromate is conducted in section 7.1.

6.4.5 Health impacts "Man via the Environment"

6.4.5.1 Relevant exposure concentrations

According to ECHA guidance Chapter R.16: Environmental Exposure Estimation (Version 2.1 – October 2012) (23), exposure to the environment should be assessed on two spatial scales: locally in the vicinity of point sources of release to the environment, and regionally for a larger area which includes all point sources in that area. Releases at the continental scale are not used as endpoints for exposure. The end results of the exposure estimation are concentrations - Predicted Environmental Concentrations (PECs) - in the environmental compartments for both, local and regional scale which have been calculated in the ES.

The regional Predicted Environmental Concentration ($PEC_{regional}$[19]) derived in the CSR has been assumed to represent the average exposure concentration for the general population. The local Predicted Environmental Concentration (PEC_{local}), based on measured and modelled data, is used to calculate potential risks for on-site workers not directly exposed as well as the direct neighbourhood.

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discount this benefit because it is only in the future. Consequently, these values would result from a situation where individuals have been asked in a certain year, with the respective price and income levels of this year, referring to a risk avoidance starting after this year.

[18] Index for the year of the sunset date is extrapolated using the geometrical mean of annual price increase rate: 1.01517 (over 2003-2013). Source http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=teina110&plugin=0 [Cited: 27 November 2014].

[19] The calculated $PEC_{regional}$ represents the average concentration in an area of 200 x 200 km around the point sources.

6.4.5.2 Number of potentially exposed people

For calculation of the health impacts for the general population resulting from exposure of men via the environment, the total number of people living in an area 200 x 200 km around the sites that will use the substance are considered in terms of potential exposure to the regional Predicted Environmental Concentration ($PEC_{regional}$). Since the locations of all affected downstream user sites is not available, the number of people living around this area have been estimated. Following a worst-case approach, the population of the European Economic Area (EEA)[20] was taken as basis, namely 512,888,463 people. For formulator sites, 20 million people living around one site are taken for the calculations.

The second group of indirectly exposed people are those local to the site. They comprise workers that do not work with hexavalent chromium, but work in the vicinity (potentially indirectly exposed workers) as well as people living in the direct neighbourhood of the sites. Determination of the size of both groups of people requires knowledge of the location and size of all companies that use hexavalent chromium. Since it is unrealistic to provide accurate estimates, it has been conservatively assumed that 10,000 people work and live in near neighbourhood at any one site. This number of people is recommended as the basis of the local exposure assessment in the Guidance on information requirements and chemical safety assessment, chapter R.16 (Version 2.1 – October 2012) (23). The total number of people exposed on a regional scale is then calculated as the number of people local to any one site 10,000 multiplied by the number of sites using hexavalent chromium, e.g. 10,000 people x 200 sites = 2 million people living in the local neighbourhood including on-site workers.

For the calculation of potential risk of the local population (on-site workers and the local population), the Predicted Environmental Concentration for local scale (PEC_{local}) is used. Since there is no basis for a reliable distinction between the number of indirectly exposed workers and people living in the neighbourhood, the dose-response curve for the general population is taken as basis following a worst-case approach (i.e. workers would be exposed for less time, e.g. 8 hours per day for 220- 260 days, than the general population (24 hours per day for 356 days of exposure)). Table 3 summarises the most important input parameters.

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[20] http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&tableSelection=1&labeling=labels&footnotes=yes&language=de&pcode=tps00001&plugin=0 [Cited: 19 November 2014].

Table 3: Overview of the most important input parameters for calculation of health impacts

Group of potentially exposed people		Number of potentially exposed people	Exposure concentration to be used from the ES	Dose-response curve for
Indirectly exposed	Indirectly exposed workers and direct neighbourhood	Number of sites using Cr(VI) substances x 10,000	PEC_{local}	general population
Indirectly exposed (DU)	general population in an area of 200 x 200 km around the site	512,888,463	$PEC_{regional}$	general population
Indirectly exposed (formulator)	general population in an area of 200 x 200 km around the site	Number of sites using Cr(VI) substances x 20,000,000	$PEC_{regional}$	general population

6.4.5.3 Worst-case approach

The overall calculation approach entails an overestimation of health impacts for the following reasons:

- The assumption of a local population of 10,000 per site assumes each site will be located independently and next to a village or town. In general, such sites are likely to be located in close proximity to similar sites and in areas designated for industrial use, often remote from residential areas. The overall potentially exposed population is therefore likely to be substantially over-estimated.
- On-site workers live in the direct neighbourhood or in the surrounding area (200 x 200 km). Therefore, a double counting appears when calculating health impacts for on-site workers and the general population.
- Calculating the excess of risk evolving cancer on basis of the dose-response curve published by ECHA (2) assumes a linear relationship between dose and response, even at low doses. This is a conservative assumption, likely to result in overestimation of the cancer risk.

6.4.5.4 Adaption factor

The dose-response curve for the general population considers 365 days of exposure and 70 years of life-time.

Accordingly, it is necessary to adjust the exposure duration to the foreseen review period of 12 years. The factor is shown in Table 4.

Table 4: Adaption factor of general population and direct neighbourhood

	Factor for adaptation of 70 life-time years to 12 years of authorisation
General population and direct neighbourhood	0.17

6.4.5.5 Monetisation of health impacts "Man via the Environment"

PEC$_{local}$

For the calculation of PEC$_{local}$, the total number of potentially indirectly exposed people is assessed taking into account the foreseen population of 10,000 as described in 6.4.5.2.

$$Number\ of\ potentially\ exposed\ people\ (PEC\ local) = number\ of\ sites\ \times\ 10{,}000$$

The exposure values for PEC$_{local}$ are taken from the CSR and the number of potentially exposed people are derived as described above. The excess risk calculation follows the methodology described in section 6.4 according to the following equation:

$$ELR = \frac{review\ period\ [years]}{70\ years} \times 2.9\ \times 10^{-2}\ \text{per}\ \frac{\mu\text{g Cr(VI)}}{\text{m3}} \times\ \text{exposure value PEC local} \times\ \text{number of people potentially exposed}$$

In a second step, the monetised values for additional lung cancer cases are calculated by multiplication with the WTP values adjusted to the year of the sunset date.

PEC$_{regional}$

The calculations for PEC$_{regional}$ are equivalent to the calculations of PEC$_{local}$ only using a different exposure value for PEC$_{regional}$ and the number of potentially exposed people is assumed with the population of the EEA (512,888,463) for downstream users and with a population of 20 million per site for formulators.

7. ANALYSIS OF IMPACTS

In the following section, the expected impacts for the non-use scenario are described and assessed. Firstly, the human health and environmental impacts related to the non-use scenarios are assessed (section 7.1). The subsequent analysis of the socio-economic impacts in section 7.2 focuses on job losses and economic impacts in the aerospace sector.

The impact assessment is carried out for a period of 12 years, since this is the minimum necessary review period required (see AoA).

7.1. Human health and environmental impacts

As stated in section 6.4 in accordance with the corresponding CSR (5) the risk assessment for humans exposed is restricted to inhalation of airborne residues of Strontium Chromate (lung cancer). The oral route (swallowing of the non-respirable fraction) is not considered here. This is appropriate and consistent with a worst-case approach since:

(i) available information on potential exposure (airborne concentrations) does not provide reliable detail regarding particle size fractions (inhalable / thoracic / respirable);

(ii) the Excess Lifetime Risk (ELR) for intestinal cancer is one order of magnitude lower than that for lung cancer; the assessment of health impacts is therefore dominated by the risk of lung cancer due to inhalation of Strontium Chromate dust;

(iii) the document on a reference dose-response relationship for hexavalent chromium compounds (RAC/27/2013/06 Rev.1) states that “in cases where the applicant only provides data for the exposure to the inhalable particulate fraction, as a default, it will be assumed that all particles where in the respirable size range”.

Therefore, in accordance with the above findings and provisions, it has to be assumed that all particles are in the respirable size range hence no exposure via the oral route needs to be considered. This constitutes a worst case approach, since the lung cancer risk, is an order of magnitude higher compared to the gastrointestinal cancer risk, based on the dose-response relationships.

The assessment of human health impacts considers workers potentially exposed at facilities of CCST members, at facilities in the relevant supply chain and the general population. For practical reasons relating to the development of the Application for Authorisation, data presented here considers and does not distinguish between workers potentially exposed to products containing Strontium Chromate including sealants and jointing compounds as well as primers and paints. However, sealants and jointing compounds are not included within the final scope of this Application for Authorisation. The impact of this broader data set is that the number of workers reported as potentially exposed and therefore the overall risk to human health is further overestimated within the SEA.

Despite the expected growth of the industry (see 5.1) within the review applied for, the demand and with it worker exposure to chromates will continuously decrease due to ongoing research on chromate-free alternatives, an increasing degree of automation and new materials like carbon fibre that do not need chromates for corrosion protection. In consequence a further overestimation of potentially exposed people within the timeframe of this SEA can be assumed.

The analysis is based on gathered data from CCST members and assumptions in accordance with ECHA guidance regarding the number of workers and the members of the general population respectively that are *potentially* exposed.

The number of potentially exposed workers (industrial) has been assessed to account for exposure in the EEA supply chain. Upper bound exposure concentrations are based on measured and modelled data as set out in the Chemical Safety Report.

A. Formulators

Table 7 below shows the monetised health impacts, derived in accordance with ECHA guidance, for workers exposed to Strontium Chromate during formulation at nine sites.

Table 5: Summary of monetised health impacts for potentially exposed workers at formulators

	Central value (lower bound) [€ million]	**Sensitivity value (upper bound) [€ million]**
Total	**0.017**	**0.036**

Exposure to the public has been estimated based on conservative assumptions regarding airborne releases from facilities and a substantial population consistent with a small town (10,000 population) at the site boundary (PEC_{local}) and 20 million people per site ($PEC_{regional}$).

Table 6 below sets out the monetised health impacts, derived in accordance with ECHA guidance, for members of the general population exposed to Strontium Chromate and potentially indirectly exposed workers to Strontium Chromate as a result of formulation. The analysis is based on a review period of 12 years.

Table 6: Summary of monetised health impacts in the general population considering 9 formulator sites

	Central value (lower bound) [€ million]	**Sensitivity value (upper bound) [€ million]**
PEC_{local}	0.658	1.352
$PEC_{regional}$	0.00004	0.00008
Total	**0.658**	**1.352**

B. Downstream users

Table 7 below shows the monetised health impacts, derived in accordance with ECHA guidance, for workers exposed to Strontium Chromate during the application within the EEA aerospace supply chain including members of the CCST consortium.

Table 7: Summary of monetised health impacts for potentially exposed workers in the European aerospace sector considering 616 sites

	Central value (lower bound) [€ million]	**Sensitivity value (upper bound) [€ million]**
Total	**32.7**	**67.4**

Exposure to the public has been estimated based on conservative assumptions regarding airborne releases from facilities and a substantial population consistent with a small town (10,000 population) at the site boundary (PEC_{local}) and the population of the EEA ($PEC_{regional}$).

Table 8 below set out the monetised health impacts, derived in accordance with ECHA guidance, for members of the general population exposed to Strontium Chromate and potentially indirectly exposed workers to Strontium Chromate as a result of activities within the European aerospace supply chain. The analysis is based on a review period of 12 years.

Table 8: Summary of monetised health impacts in the general population considering 616 sites

	Central value (lower bound) [€ million]	**Sensitivity value (upper bound) [€ million]**
PEC_{local}	71.2	146.9
$PEC_{regional}$	0.0001	0.0002
Total	**71.2**	**146.9**

An assessment of the sensitivity of key assumptions is provided in section 8.2. Further details for the calculation of the values provided above are given in ANNEX B.

A report by the Institute of Occupational Medicine (2011) concluded there are no significant environmental impacts foreseen related to hexavalent chromium (24). Indeed, under normal environmental conditions, hexavalent chromium will not persist, but be transformed to trivalent chromium, which has limited if any effects on the environment. As hexavalent chromium can be effectively captured in filters or treated in wastewater treatment plant, emissions to air and water from current surface treatment operations are very limited.

It could be postulated that environmental benefits related to the non-use scenarios of companies using Strontium Chromate include CO_2 emission reduction and removal of emissions from surface treatment facilities in general within the EEA as a result of production stop, relocation to a non-EEA country or similar. However, it is important to recognise that these impacts are not eliminated but just shifted to another (non-EEA) geographical region. It cannot be discounted that emissions would in fact increase as a result of less stringent regulation in non-EEA countries. In addition, CO_2 emissions are likely to be substantially increased as a result of increased distribution or transportation associated with importing surface treated articles into the EEA in the event of relocation and / or reduced product lifespans caused by less effective corrosion protection in the event of substitution.

7.2. Socio-economic impacts

This section summarises the expected socio-economic impacts in the non-use scenarios. The primary social impact, job losses resulting from either relocation of the facilities, production stop or shutdown of facilities, is examined here. Following the approach to under-estimate socio-economic impacts, further socio-economic impacts have intentionally not been quantified in order to limit uncertainties.

The direct economic impacts in the sense of purchasing losses occurring at the suppliers of the CCST consortium members were also investigated, but reliable data to support quantification could not be released due to its sensitive nature and with reference to competition rules. Nevertheless, considering the importance and size of the European aerospace industry, which contributes 3.9% to the European GDP, economic impacts due to purchasing losses following non-authorisation of continued use of Strontium chromate are expected to be in the dimension of several billion Euros per year. Other, wider economic impacts including loss in taxes, loss of economic development, and less reliable trade and product quality are only considered qualitatively as the monetisation of these impacts would require a set of assumptions and would considerably increase the uncertainties to be dealt with.

Therefore, the quantitative assessment of socio-economic impacts is based on job losses alone and, as such, can be considered to significantly under-represent the total socio-economic impact of a decision not to grant an authorisation. Again, this follows the underestimation approach of the socio-economic impact assessment.

Nevertheless, the economic impacts realised in case of a non-authorisation would include and reflect those that are qualitatively and semi-quantitatively described section 4. The socio-economic impacts are expected to be in the order of many billions and to significantly impact the GDP of the EU.

A. Formulators

As an introduction, the European aerospace industry relies heavily on a few approved and niche formulators for several ‘specialty’ formulations used in the course of aircraft manufacture, maintenance and repair. These formulators generally have extensive expertise in the production of these formulations to the aerospace industry: their formulations have been developed over many years continuous testing and development and the formulations themselves are the intellectual property of those companies. The choice of formulations is very limited. To be more specific, 3 or less companies generally serve a particular specialised need of the aerospace sector with a limited number of specific specialty formulations. For some applications, there is only one formulator that can supply these products. In addition, the formulations are protected by patents and the only products certified to be used by OEM regulations.

Obtaining a certification for an entirely new product requires several years, as described in section 5. Certification of a new formulator of an existing product may take approximately up to two years, providing of course such new formulator for the same product can be found.

As in the majority of cases, the formulators themselves own the intellectual property, qualification of a new supplier may not be possible at all.

Re-qualification may require up to 40,000 hours of testing on the alternative supply, this re-qualification process must be successfully completed before an alternative supply can be introduced.

Thus, in the event that authorisation is not granted to these existing approved formulators, it can be expected that some or all of this particular knowledge (i.e. formulation recipes) will be lost within the EEA and that it will take time to be repaired by alternative suppliers outside the EEA (imports to EEA). It is likely that formulators in non-EEA countries (e.g. US) would supply the EEA market with the formulated product. Recertification and requalification would be required as well as possibly an AfA for downstream users if the importers are unwilling to file an upstream application due to the low volumes purchased by EEA downstream users. In addition and even more significantly, the technical and scientific leadership that underpins research and development in the area of specialty coatings will be damaged within the EEA. It can be expected that future research and development in this area will migrate from the EEA to non EEA countries, where formulation will continue.

Formulators that are willing and economically able might relocate their formulation processes to non-EEA countries. This would require substantial financial investment and significant lag time while facilities are established. Given the investment required and margins associated with formulation, it can be expected that many smaller or medium sized companies will not have an option to relocate.

Formulators may also have the possibility to license formulation of specific products to a non-EEA company, although this may not be financially beneficial and would also transfer intellectual property and know-how from the EEA to non-EEA countries.

As failure to obtain an authorisation under REACH results in transfer of formulation from the EEA to non-EEA countries, the transport costs and the resulting unnecessary emissions from and risk associated with transportation will be increased. On the other hand, relocation of formulation only shifts exposure from the EEA to other regions, so there is no overall reduction in risk to the health or the environment.

From an industry perspective, there are also further concerns related to business continuity in this scenario that must be carefully managed. In particular, this includes increased uncertainties about future control over and security of supply, including ability to check and control quality. It can be expected that companies will need to increase stock to compensate for the increased distance to the supplier and the perceived business and supply risk of transfer of raw materials essential to European key industries caused by non-EEA suppliers.

Failing increased storage of supplies, there would be risks of supply disruptions which may force production / maintenance stops. Considering the total socio-economic impacts and the value conferred by the European aerospace sector, a production / maintenance stop even for only a few days would lead to tremendous negative impacts for the European DUs within the aerospace sector.

All the possible outcomes described above are “emergency strategies” to respond to a situation where the supply of a formulated product was no longer available. Each of these outcomes will result in considerable costs and disadvantages. Taking into account the re-certification and / or re-qualification costs, the costs associated with production / maintenance downtime, the increased transport costs and related emissions relating to importing from outside the EEA and the absence of an overall reduction in risk to the environmental or to health, it is clear that the health impacts at the formulators[21] of € 1.4 million are by far outweighed by the negative effects that a decision not to authorise formulation would have.

Adding to this, the conditions under which the formulation would take place in non-EEA countries would most probably lead to higher negative impacts on human health and the environment. This would mean a shift of impacts to less developed countries which is clearly against the basic idea of REACH.

In conclusion, there is no point to authorise the downstream use but not the formulation.

B. Downstream users

The primary social impact, job losses resulting from either relocation of the facilities, production stop or shutdown of facilities, is examined here. Further social impacts have not been quantified.

The direct economic impacts in the sense of purchasing losses occurring at the suppliers of the CCST consortium members were also investigated, but reliable data to support quantification could not be released due to its sensitive nature and with reference to competition rules. Nevertheless, considering the importance and size of the European aerospace industry, which contributes 3.9% to the European GDP, economic impacts due to purchasing losses following non-authorisation of continued use of Strontium Chromate are expected to be in the dimension of several billion Euros per year. Other, wider economic impacts including loss in taxes, loss of economic development, and less reliable trade and product quality are only considered qualitatively as the monetisation of these impacts would require a set of assumptions and would considerably increase the uncertainties to be dealt with.

Therefore, the quantitative assessment of socio-economic impacts is based on job losses alone and, as such, can be considered to significantly under-represent the total socio-economic impact of a decision not to grant an authorisation. Again, this follows the underestimation approach of the socio-economic impact assessment.

At least 19,441 employees are indicated to suffer job losses as a result of a decision not to grant an authorisation. This estimated number of job losses is conservative (lower bound of social impacts considered in CCST and lower bound of European aerospace sites (136 sites)) (see ANNEX A); the actual number of jobs lost in the non-use scenario is expected to be much higher than the figures mentioned in this report.

A further important assumption for the calculation of social impacts is that workers that lose their job due to closure / relocation will either:

- remain unemployed for the entire duration of the review period (12 years); or

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[21] Health impacts at formulators are vastly overestimated, due to lack of data and the need to apply modelling for the environmental concentrations.

- replace another unemployed person in case of re-employment (workers that lose their job in company A and get a new job in company B prevent other unemployed persons from getting this job). Consequently, the value-added that has been created by the original workplace is not compensated by re-employment of workers in other companies, leaving the macro-economic impacts of the original job loss untouched.

These assumptions are justified on the basis of the non-use scenario as long as there is not full employment in Europe. Full employment has never been the case and will not be the case for the length of the review period. The average unemployment rate in EU-28 was approximately 9.15% (2003-2014)[22]. Therefore, the salaries paid for the workplaces that would be lost in the non-use scenario are applied for the entire review period. Please note that uncertainty analysis and further discussion around this assumption is also provided in the assessment (section 8.2.2.3).

The impact of job losses due to the non-use scenarios of the European aerospace sector is calculated using the salary cost method (see section 6.2).

The resulting total Net Present Value (NPV) of the future payments of wages in 2019 within 12 years from the sunset date comprised by this application sums up to **€ 6,515 million**. This means a loss of € 6,515 million appears to the EU society in 2019 in case of non-authorisation.

An assessment of the sensitivity of key assumptions is provided in section 8.2. Further details for the calculation of the values provided above are given in ANNEX C.

7.2.1 Other employment effects

Apart from the consideration of direct employment effects caused by a non-authorisation, the SEA guidance (1) suggests that further employment impacts should be considered (see below).

The consideration of **employment impacts due to a change in demand for an alternative product or process** (as recommended in the SEA guidance Annex B.3 (18)) is not relevant for the present case, as there will be no alternative available that is technically and / or economically feasible for the duration of the review period (see AoA for detailed information).

Estimation of displacement effects: There is no redistribution or substitution of jobs elsewhere in the scope of the SEA because all non-use scenarios relate to a shutdown of production in Europe and / or relocation to a non-EEA country.

Substitution of jobs within the company, e.g. change from manufacturing jobs to jobs related to distribution and storage and service is not relevant in case of shut down or relocation. In case of a production stop it seems unrealistic to place manufacturing workers or painters in the R&D department to increase workforce there.

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[22] Source: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=0&language=de&pcode=tesem120 [Cited 28 August 2015].

7.2.2 Wider economic impacts

In addition to the socio-economic impacts described in the previous section, a non-authorisation is expected to incur wider economic impacts. These impacts are described briefly in the following.

Impacts on the governments (loss in taxes)

If authorisation for the continued use of Strontium Chromate would not be granted, the amount of taxes and fees paid in Europe will be reduced by the amount which is linked to the supply, manufacturing, operation, maintenance repair and overhaul of all products produced by the sector (aircraft of all types, spacecraft etc.). This represents a loss of income for the European Economic Area.

Impacts on economic development

As a consequence of the non-use scenarios of the CCST consortium members, the European supply chain for aerospace products would gradually move to non-EEA countries preventing revenue streams from the sector to continue and leading to considerable welfare losses for the European Economic Area. Regarding the European space industry, non-authorisation would threat European independent access to space as well as European competitiveness in this field due to fierce competition from non-EEA producers with less regulatory requirements.

Impacts on trade and product quality

Because of the shift of aerospace supply chains to non-EEA countries, the exports of the European aerospace sector would cease and Europe would become dependent on imports of aerospace products possibly causing quality and security concerns. As corrosion inhibition is a key safety concern, not only in civil air transport, product quality is imperative for the aerospace industry.

Together with the aerospace supply chain, European know-how and technology would also move to non-EEA countries. Additionally, an interruption of the global air transportation system cannot be excluded.

8. COMBINED ASSESSMENT OF IMPACTS

To summarise the previous assessment and to estimate the overall costs and benefits of a decision to grant or deny this Application for Authorisation (AfA), a combined assessment of impacts is set out here. A subsequent uncertainty analysis aims to assess the effects of uncertainties on the overall result of the SEA.

8.1. Comparison of impacts

Table 9 summarises the effects of a non-authorisation.

Table 9: Comparison of impacts for the applied for use and the non-use scenario

Type of impact	Applied for use scenario	Non-use scenario
Human Health	➢ Maximum potential exposure of 239 workers to Strontium Chromate at formulators ➢ Maximum potential exposure of 22,951 workers to Strontium Chromate at downstream users	➢ No potential exposure of 239 workers in Europe† at formulators ➢ No potential exposure of 22,951 workers in Europe† at downstream users
Environmental impacts	➢ Negligible environmental impacts related to Strontium Chromate	➢ No environmental impacts related to Strontium Chromate in EEA‡.
Economic impacts	➢ Maintenance of purchases at EEA suppliers / subcontractors	➢ Loss of sales for the suppliers / subcontractors
Social impacts	➢ Maintenance of at least 19,441 jobs directly related to the use of Strontium Chromate	➢ Loss of 19,441 jobs directly related to the use of Strontium Chromate
Wider Economic impacts	➢ Maintenance of taxes paid ➢ No negative impacts on the European aerospace supply chain and competitiveness ➢ No impacts on trade and quality ➢ Maintenance of independent European access to space	➢ Loss of taxes paid in Europe ➢ Shift of the European aerospace supply chain to non-EEA countries and loss of competitiveness ➢ Cease of exports of aerospace products from the EEA ➢ Possible quality and security issues ➢ Loss of independent European access to space
† Expect at least the same number of workers would be exposed in non-EEA countries due to relocation, where lower RMM and regulations might exist. ‡ Expect environmental impact to be shifted to non-EEA countries. Increased impact associated with increased distribution of plated parts from non-EEA.		

Table 10 below summarises the impacts for the applied for use and the non-use scenario in terms of monetised costs and benefits which were calculated in section 7.

Table 10: Quantitative comparison of impacts for the applied for use and the non-use scenario

Type of impact	Discounting over 12 years [€ million]
Benefits in economic terms of avoiding potential health impacts associated with the continued use of Strontium Chromate **at downstream users**	67.4
Benefits of avoiding health impacts through potential exposure “Man via Environment” **at downstream user sites**	146.9
Benefits in economic terms of avoiding potential health impacts associated with the continued use of Strontium Chromate **at formulators**	0.036
Benefits of avoiding health impacts through potential exposure “Man via Environment” **at formulator sites**	1.353
Social impacts	6,515.0
Net benefits of a granted authorisation	**6,299.3**

8.2. Uncertainty analysis

This uncertainty (or sensitivity) analysis is an important part of the SEA that evaluates the use of Strontium Chromate in well-defined uses in the aerospace sector as part of this upstream application for authorisation. The SEA is a well-established tool to evaluate the net impacts of a proposal. In many cases, such as this, there is limited relevant data to evaluate specific impacts. Therefore, best available data is identified and applied in order to evaluate the impacts. Such assumptions must be carefully scrutinised to ensure they are appropriate and adequate. The sensitivity analysis is a way of first testing which variables or assumptions are most likely to have a significant effect on the outcome of the SEA, and then to check whether changing those specific variable within a credible range (from likely to unlikely) based on available data will affect the outcome of the assessment.

An upstream authorisation for the use of Strontium Chromate is necessary for the aerospace industry in order to secure the supply chain, where even local interruptions or uncertainty in supply could result in substantial consequences. However, upstream applications for authorisation necessarily require the aggregation and extrapolation of data. In the case of this application, the data base upon which the SEA is based in well-populated and consistent, providing confidence in the results. In particular, uses and exposure conditions are well-defined, such that uncertainty is limited. This uncertainty assessment allows further confidence that the effect of aggregating or extrapolating data to support an upstream application is cautious and reasonable, and the findings of the assessment are therefore acceptable.

The ECHA Guidance on SEA (18) proposes an approach for conducting the uncertainty analysis. This approach provides three levels of assessment that should be applied if it corresponds.

- Qualitative assessment of uncertainties
- Deterministic assessment of uncertainties
- Probabilistic assessment of uncertainties

The ECHA guidance further states: level of detail and dedicated resources to the assessment of uncertainties should be in fair proportion to the scope of the SEA. Further assessment of uncertainties is only needed, if assessment of uncertainties are of crucial importance for the overall outcome of the SEA.

Hence, a qualitative assessment of uncertainties has been conducted to summarise and describe potential sources of uncertainty related to the impact categories. In addition, a deterministic assessment of uncertainties in the form of a broad scenario analysis has been conducted to assess the sensitivity of the results against all changing input parameters and covering all expectable scenarios – including more likely realistic as well as less realistic cases.

Socio-economic impacts resulting from non-use scenarios **at formulators** are **not** considered in this SEA and are therefore not considered within this uncertainty analysis.

8.2.1 Qualitative assessment of uncertainties

Table 11 illustrates the systematic identification of uncertainties related to human health impacts.

Table 11: Uncertainties on human health impacts

Identification of uncertainty (assumption)	Classification	Evaluation	Criteria and scaling (contribution to total uncertainty)
Shape of exposure-response function (linear versus non-linear)[23]	Model uncertainty	If non-linear, particularly at low exposure levels: overestimation	High
Working days (260 days) given by the dose-response curve	Parameter uncertainty	Not taking into account holidays, bank holidays, illness: overestimation	High
Monetary values used for a statistical life[24]	Parameter uncertainty	Range	Medium
Number of companies in European supply chain related to Strontium Chromate	Parameter uncertainty	If too high: overestimation	Medium
Number of exposed employees in companies outside the CCST consortium	Parameter uncertainty	If too high: overestimation	High
Exposure values at companies outside the CCST consortium	Parameter uncertainty	If exposure values too high: overestimation	Medium
PEC_{local} includes exposure concentration of $PEC_{regional}$	Parameter uncertainty	Double counting of health impacts for people already considered in PEC_{local} values: overestimation	Low

Table 12 illustrates the systematic identification of uncertainties related to social impacts.

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[23] The study conducted by ETeSS on behalf of ECHA clearly states that: "[…] the lower the exposure (certainly below 1µg/m^3), the more likely it is that the linear [dose-response] relationship overestimates the cancer risk." The study further states that "the risk estimates for […] exposures lower than 1 µg Cr(VI)/m^3 might well greatly overestimate the real cancer risks. It is also considered that at progressively lower Cr(VI) air concentrations (from about 0.1 µg/m^3 downwards), cancer risks may be negligible." (19)

[24] Sensitive values were used from the outset in order to avoid underestimation of health impacts.

Table 12: Uncertainties on social impacts

Identification of uncertainty (assumption)	Classification	Evaluation	Criteria and scaling (contribution to total uncertainty)
Number of jobs related to Strontium Chromate would remain constant over the review period	Parameter uncertainty	If number of jobs related to Strontium Chromate would increase over time: underestimation	Medium
Education level low skilled for all employees where no further information is available	Parameter uncertainty	Some employees have higher education levels ergo higher salaries: underestimation	High
Number of sites using Strontium Chromate	Parameter uncertainty	Range	Medium

8.2.2 Deterministic assessment of uncertainties

The deterministic assessment of uncertainties seeks to investigate the robustness of the results presented in section 7 against changing input parameters regarding the assumptions made for the analysis of impacts.

The input parameters that will be investigated are:

- Number of sites **using** Strontium Chromate in the European aerospace supply chain.
- The monetary Value of a Statistical Life (VSL) used to monetise health impacts.
- The duration of unemployment of people that find themselves jobless in case of non-authorisation.

Note: Since monetised ***social impacts at the formulator are not considered*** *in the overall assessment, these impacts are not subject to the following uncertainty analysis. However,* ***worst-case health impacts resulting from formulation are considered*** *throughout the analysis.*

8.2.2.1 Number of downstream user sites

As described in ANNEX A of this SEA, the number of downstream user sites (including CCST companies) that are taken into account for the uncertainty analysis sums up to:

- 152 sites for the scenario “low”
- 616 sites for the scenario “high

Table 13 summarises the input parameters regarding the number of sites considered in the uncertainty analysis.

Table 13: Input parameters "number of sites"

Scenario	Value [number of sites]
Low	152
High	616

The number of sites directly influences the number of potentially exposed people that are taken into account for the assessment of health impacts. This is true for directly exposed workers as well as for indirectly exposed workers and people potentially exposed in the direct neighbourhood of the facilities, which are covered in the health impact assessment "Man via Environment".

In addition, the number of sites directly impacts the number of people that will be dismissed in the case of the non-use scenario (see ANNEX A for details).

8.2.2.2 Health impacts

In section 7.1 health impacts are quantified using the Willingness to Pay (WTP) method. The WTP study used (22) provides a median and mean value. This means, there is a lower (central) and a higher (sensitive) Value of Statistical Life.

In addition to the number of people potentially exposed (directly / indirectly exposed, indirectly exposed neighbourhood, general population), the monetary Value of a Statistical Life (VSL) used to monetise health impacts in section 6.4.4 is part of the uncertainty analysis. For the sake of the uncertainty analysis the following values are taken into account:

- Central (median) value of the Willingness to Pay (WTP)
- Sensitive (mean) value of the Willingness to Pay (WTP)

Table 14 summarises the input parameters for monetisation of health impacts.

Table 14: Input parameters "Willingness to Pay"

Scenario	Value 2019 [€]
Central	
Fatal cancer	1,338,555
Non-fatal cancer	508,956
Sensitive	
Fatal cancer	2,873,058
Non-fatal cancer	508,956

8.2.2.3 Social Impacts

Following the assumptions presented in ANNEX C, and in accordance with the number of sites in section 8.2.2.1, a lower bound of job losses and an upper bound of job losses are assumed for the sensitivity analysis regarding social impacts.

In addition, the following scenarios are considered to account for uncertainties regarding the average period of unemployment of the people that would lose their job in the NUS:

- **Social Impact Sensitivity Assessment Scenario 1** – Salary costs for all workers are considered for the entire review period.
- **Social Impact Sensitivity Assessment Scenario 2 –** all persons unemployed due to relocation / shutdown will find a new job after the average duration of unemployment in Europe (2003-2013), which is 15.1 months (OECD data[25]). Following the underestimation approach for socio-economic impacts and to avoid too much detail, salary costs are considered only for one year in this scenario.
- **Social Impact Sensitivity Assessment Scenario 3 –** 70% of the persons that find themselves unemployed would find a new job after one year after the sunset date. The remaining 30% of the workers remain unemployed for the duration of the review period.

These scenarios were considered for both, the lower bound and the upper bound of the number of workers that would be dismissed in the non-use scenarios.

Table 15 summarises the input parameters regarding the number of job losses considered in the various scenarios. For reasons of readability, these scenarios were named social impacts 1a – 3b.

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[25] Source: http://stats.oecd.org/ [Cited: 8 November 2014].

Table 15: Input parameters "job losses"

Scenario code	Scenario	Value [job losses considered]
Social impacts 1a	All job losses considered for the length of the review period; lower bound	19,441
Social impacts 1b	All job losses considered for the length of the review period; upper bound	57,947
Social impacts 2a	All job losses considered for 1 year only, lower bound	19,441
Social impacts 2b	All job losses considered for 1 year only, upper bound	57,947
Social impacts 3a	70% of job losses considered for 1 year only, the remaining 30% considered for the length of the review period; lower bound	13,609 job losses considered for one year only 5,832 job losses considered for the length of the review period
Social impacts 3b	70% of job losses considered for 1 year only, the remaining 30% considered for the length of the review period; upper bound	40,563 job losses considered for one year only 17,384 job losses considered for the length of the review period

Further factors that were not taken into account in this sensitivity analysis, but are expected to substantially add to the negative socio-economic impacts in the non-use scenario include:

- foregone productivity of the workers (value-added that would have been generated by the workers). The EU-27 average labour value added for the period 2001-2013 was 30.7 € per hour worked. Considering 8h working day and 220 working days per year, the annual average labour productivity per worker would be €[26] 54,032.

- additional costs for the society due to unemployment: € 25,439 per person unemployed. Those costs were estimated as an average of the results of the average of cost of unemployment for UK, Spain, France, Germany and Sweden presented on the report "Why invest in employment? A study on the cost of unemployment" (25). Based on these data the annual cost of unemployment for society includes unemployment benefits received by the workers as well as guidance and administrative costs, loss in social contribution of employers and employees and loss in direct and indirect taxes.

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[26] Source: http://appsso.eurostat.ec.europa.eu/nui/show.do?query=BOOKMARK_DS-055408_QID_5590D855_UID_-3F171EB0&layout=TIME,C,X,0;GEO,L,Y,0;INDIC_NA,L,Z,0;UNIT,L,Z,1;INDICATORS,C,Z,2;&zSelection=DS-055408UNIT,EUR_HRS;DS- [Cited: 25 November 2014].

8.2.2.4 Summary of scenarios considered in the uncertainty analysis

Given that

- 2 scenarios are considered regarding the number of sites using Strontium Chromate in the European aerospace supply chain,
- 2 scenarios are considered regarding the monetary Value of a Statistical Life for the assessment of health impacts and,
- 6 scenarios are considered regarding the assessment of social impacts,

24 scenarios are considered in the scenario analysis in total.

Table 16 summarises the input parameters for each of the 24 scenarios.

Table 16: Summary of input parameters for the scenarios considered in the deterministic assessment of uncertainties

Scenario	Number of sites	Health impacts	Social impacts
S1	low	central value	1a
S2	low	central value	1b
S3	low	central value	2a
S4	low	central value	2b
S5	low	central value	3a
S6	low	central value	3b
S7	low	sensitivity value	1a
S8	low	sensitivity value	1b
S9	low	sensitivity value	2a
S10	low	sensitivity value	2b
S11	low	sensitivity value	3a
S12	low	sensitivity value	3b
S13	high	central value	1a
S14	high	central value	1b
S15	high	central value	2a
S16	high	central value	2b
S17	high	central value	3a
S18	high	central value	3b
S19	high	sensitivity value	1a
S20	high	sensitivity value	1b
S21	high	sensitivity value	2a
S22	high	sensitivity value	2b
S23	high	sensitivity value	3a
S24	high	sensitivity value	3b

8.2.3 Findings of uncertainty analysis

Table 17 summarises and combines the different scenarios analysed, showing the broad variations on the balance.

Table 17: Uncertainty analysis – summary

Scenario	Health impacts [million €]	Social impacts [million €]	Balance (social impacts - health impacts) [million €]	Ratio [health impacts : social impacts]
S1	38.7	6,515	6,476	1: 168
S2	38.7	14,445	14,406	1: 373
S3	38.7	618	579	1: 16
S4	38.7	1,370	1,331	1: 35
S5	38.7	2,387	2,348	1: 62
S6	38.7	5,292	5,254	1: 137
S7	79.9	6,515	6,435	1: 82
S8	79.9	14,445	14,365	1: 181
S9	79.9	618	538	1: 8
S10	79.9	1,370	1,290	1: 17
S11	78.5	2,387	2,308	1: 30
S12	79.9	5,292	5,213	1: 66
S13	104.6	11,487	11,383	1: 110
S14	104.6	19,417	19,313	1: 186
S15	104.6	1,090	985	1: 10
S16	104.6	1,842	1,737	1: 18
S17	104.6	4,209	4,104	1: 40
S18	104.6	7,114	7,010	1: 68
S19	215.7	11,487	11,272	1: 53
S20	215.7	19,417	19,202	1: 90
S21	215.7	1,090	874	1: 5
S22	215.7	1,842	1,626	1: 9
S23	215.7	4,209	3,993	1: 20
S24	215.7	7,114	6,899	1: 33

Figure 6 presents the monetised social and human health impacts in the respective scenarios. The graph illustrates the ranges obtained for different parameters across the scenarios analysed. It shows that the outcome of the SEA is invariable, such that socio-economic impacts always outweigh human health and environmental impacts. This is the case for all 24 scenarios in which key parameters or assumptions relating to social and health impacts were varied. The ratio of health to social impacts ranged from 1:5 (S21) up to 1:373 (S2) across these 24 scenarios that considered variations in the number of downstream users, the extent of the job losses incurred in the event that an authorisation is not granted, and assumptions relating to monetisation of the health impact (in accordance with guidance). Considering these results, including the lowest ratio of 1:5, as described below, the overall outcome of this SEA must be considered robust.

Scenario S21 describes the case in which all job losses were considered for one year only with the lower bound of job losses expected due to a non-granted authorisation. At the same time, the highest likely health impacts are considered here. For the avoidance of doubt, this means that the (higher) sensitive value of the WTP and the maximum number of people potentially exposed were used for the monetisation of health impacts to workers. In addition, the upper bound of companies expected to use Strontium Chromate in the EEA was assumed, resulting in extraordinary high numbers of potentially exposed people[27] when considering the general population exposed. It is also important to re-emphasise that health impacts at formulators are counted, but no social impacts have been taken into account (to avoid any double counting).

Notwithstanding this important finding, the assumption that all workers that lost their jobs following a decision not to authorise the use of Strontium Chromate in the aerospace industry would be re-employed within an average period of a year is not considered reasonable. A person who loses their job always replaces another unemployed person in case of re-employment (workers that lose their job in company A and get a new job in company B prevent other unemployed persons from getting this job). Consequently, the value-added that has been created by the original workplace is not compensated by re-employment of workers in other companies, leaving the macro-economic impacts of the original job loss untouched. These assumptions are justified on the basis of the non-use scenario as long as there is not full employment in Europe. Full employment has never been the case and will not be the case for the length of the review period. The average unemployment rate in the EU-28 was approximately 9.15% (2003-2014)[28]. Therefore, the salaries paid for the workplaces that would be lost in the non-use scenario can be applied for the entire review period. An assumption of only one year of job losses for specific employees whose jobs are directly linked to the use of Strontium Chromate results in a substantial, if not massive, underestimation of socio-economic impacts.

In addition, this AfA represents the situation for the entire European aerospace industry. If this application is not granted, or a too short review period is applied, the complete industry sector is affected. Therefore it is not valid to suggest that workers that lose their job might get a job at another company within the same sector quickly. This means skilled workers that lose their job would need to change the sector for which they work and would likely need requalification training.

Regions which form a cluster of aerospace companies and their suppliers (e.g. Hamburg (Germany), Aerospace Valley (France) and Asociación Aeronáutica Aragonesa (Spain)) would suffer the effects of high unemployment even harder. Many suppliers which are also not counted in the scenarios above would have to lay off employees. None of the scenarios within this SEA monetise or otherwise took into account the value added at various suppliers of the European aerospace companies. This value is expected to reach easily several billion Euro each year. If a closer look at the effects of unemployment of thousands of people is taken, the lower bound of expected job losses (19,441) would result in loss of a yearly annual average labour productivity of more than 1 billion Euro and add additional costs

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[27] For PEClocal 10,000 potentially exposed people were assumed per site using Strontium Chromate. For PECregional the entire population of the EEA (>500,000,000 people) were assumed as a basis for the monetisation of health impacts.

[28] Source: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=0&language=de&pcode=tesem120 [Cited 28 August 2015].

for the society due to unemployment of almost half a billion Euro each year (please see section 8.2.2.3 for further details).

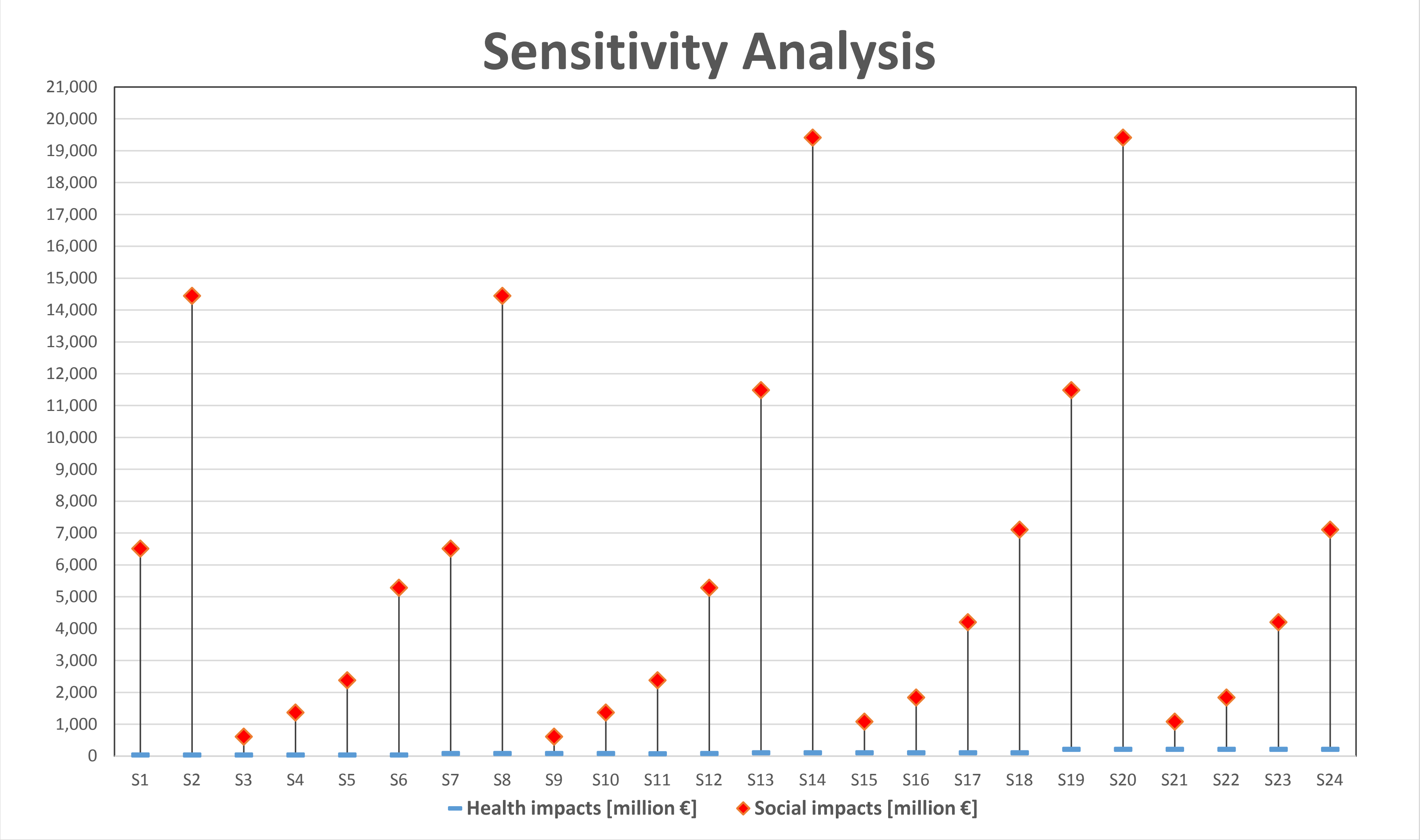

Figure 6: Scenario analysis - summary

9. CONCLUSIONS

The aim of this Socio-Economic Analysis is to describe the socio-economic impacts of a non-granted authorisation of continued use of Strontium Chromate according to the use description defined in section 3 and compare them to the residual risks to human health in case of a granted authorisation. The approach is in line with ECHA guidance. Given the aims of the SEA, the analysis purposefully sought to characterise certain impacts but also, where appropriate, to under-value social and economic impacts, and over-value health impacts. This approach supports confidence in the findings of the assessment.

The outcomes of this SEA for an assessment period of 12 years are briefly summarised in the following. Details of the calculations can be found in section 7.

Monetised residual risks to human health and the environment of a granted authorisation

- € 215.7 million (including impacts to workers in the supply chain and to the public "Man via Environment" both for formulation and downstream use of the substance). The residual risk to human health and the environment associated with a granted authorisation for formulation is a minor contributor (approx. 0.64%) to this value (see section 7.1)

Socio-economic impacts of a non-granted authorisation:

- € 6,515 million (social impacts related to job losses only). For the purpose of this SEA, the socio-economic impacts associated with a non-granted authorisation for formulation do not contribute to this value to avoid double-counting (see section 7.2)
- economic impacts related could not be quantified, but are expected to be in the range of several billion Euros (see section 7.2)

Referring to the figures stated above, the quantitative assessment clearly supports a conclusion that the benefits of continued use outweigh the risks to human health and the environment (see summary table of the impact assessment in section 8.1).

The CSR indicates exposure to workers and the public is well managed and limited. Against the background that health impacts are most certainly vastly overestimated and socio-economic impacts are intentionally highly underestimated, this outcome can be considered as robust.

A review period of 12 years was selected because it coincides with best case (optimistic) estimates by the aerospace industry of the schedule required to industrialise alternatives to Strontium Chromate. It also reflects the duration of the standard long review period indicated by ECHA, although ECHA has confirmed that longer review periods may be supported.

Apart from the outcomes of the quantitative impact assessment conducted in this SEA, the following factors should be considered for the assessment of the duration of the review period:

- The extremely high complexity of the aerospace supply chain and associated vulnerability for product quality, security and safety (see section 3).

- The low number of EEA formulators that are qualified to aerospace company and industry standards and the severe consequences for the DU in the case these formulators cease delivery of formulations (see section 7.2 A).
- Complex adaptation processes within the aerospace industry relating to airworthiness requirements for the aviation sector according to EC Regulation 216/2008 (qualification, certification industrialisation and the required timespans related to these processes) as well as relating to rules for the space industry, e.g. stated by the ECSS standards (justification, qualification, industrialisation and the required timespans related to these processes) (see section 5.2.1).
- Economic and strategic importance of the aerospace industry for the European Economic Area (see section 5.1).
- Long lifecycle stages of aircraft and spacecraft (see section 5.2.2).
- Wider economic impacts because of (see section 7.2.2)
  - migration of the European aerospace industry to non-EEA countries
    - negative impacts on trade and distortion of competiveness
    - expertise loss in the aerospace supply chain
    - possible negative impacts on the quality and safety of air and spacecraft components
    - negative impacts on national budgets due to loss of taxes paid
    - loss of European independent access to space

The use of Strontium Chromate in the aerospace industry is critical for the manufacture of its products in the frame of new, current and legacy programs and aftermarket services for civil and defence applications, as demonstrated here and in the Analysis of Alternatives. Strontium Chromate is used in limited quantities.

Stringent regulations, including the Carcinogens and Mutagens Directive (2004/37/EC), are in place that require implementation of measures to minimise workplace exposure to Strontium Chromate. These regulations require employers to implement a hierarchy of Risk Management Measures relating to any use of Strontium Chromate. Appropriate and efficient controls are in place to protect and comply with the environmental, health and safety regulatory requirements. Substantial improvements to Risk Management Measures to further minimise exposure have been made as a result of significant research and investment by industry, as evidenced by measurement data. It is expected that ongoing improvements will be effected as industry continues its commitment to minimise exposure.

The aerospace industry has invested heavily in research to identify alternatives to Strontium Chromate for use in paints, primers and specialty coatings. However, no chromate free options have been realised to date, despite many years of intensive research and mobilisation of the aerospace sector worldwide.

The research to date proves that implementing an alternative solution involves a substantial timeframe, involving many years, if not decades. The development process requires stringent, long and intensive testing for qualification (reliability, test programs) and substantial efforts to adapt the supply chain before it can be considered fully effective.

Potential alternatives have differing chemical properties. Substances such as Strontium Chromate in specialty formulations that often form part of even more complex corrosion prevention systems cannot be easily replaced or ‘swapped’ around. Substituting substances and changing formulations can impacts specific applications. Even a seemingly small change in functionality can have substantial effects as part of a complex and critical system such as an aircraft. It is absolutely necessary to ensure any potential alternatives provide complete compatibility with every aspect of the aircraft, in particular regarding the anti-corrosion characteristics to meet the overall specification.

In this respect, the aerospace sector is governed by strong regulation to protect product integrity. Any alternative which affects any element of the above certification basis is subject to careful and substantiated change control.

Moreover, the need to safely operate and maintain various aerospace structures throughout their life-cycle is mandatory, according to certification obligations (EASA and other aviation safety agency worldwide) and cannot be compromised.

The elimination of Strontium Chromate requires substantial efforts across a highly complex and non-transparent, multi-level, international and supply chain that involves numerous suppliers (and many SMEs). There is a high risk of inducing disruptions within the supply chain, with major detrimental consequences to individual business, the supply chain and, ultimately, the aerospace sector and its beneficiaries.

Considering all factors elaborated in this SEA, a review period of 12 years should be clearly justified.

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ANNEX A EXTRAPOLATION TO AEROSPACE SUPPLY CHAIN

1) Estimation of number of production sites using Strontium Chromate (use iii)

Following a supply chain approach, the assessment of this SEA relies on an estimation of European aerospace production sites using Strontium Chromate. An exact number cannot be stated here due to the high complexity of the aerospace sector. Nevertheless expert consultations revealed that an **upper bound of 600 European aerospace production sites using Strontium Chromate** can be assumed. This upper bound is used within this SEA for the calculation of health and social impacts. According to expert consultations and available studies (14), these companies are mainly categorised small (less than 50 people).

A **lower bound** of companies is assessed using CCST data and a study of the European aerospace industry (14). All CCST member companies (with exemption of some formulators) can be categorised as large companies (more than 250 people). Therefore, according to the study, they are part of the 11% of large companies in the European aerospace industry, counting overall 3,040 companies within the European aerospace supply chain. The total number of companies in the study counts all companies providing any parts to the sector, clearly also parts not treated with any chromates at all. We therefore assume that the majority of large companies relying on processes with chromates are presented in CCST. Their share within the group of large companies is almost 5% (16 CCST members using Strontium Chromate out of 334 large categorised companies in the European aerospace sector). Further on, it is assumed that this share can be transferred to the company size categories small and medium as a rough assumption of a lower bound of companies using Strontium Chromate. The study categorises 80% of the companies as small (2,432 companies) and 9% as medium (274 companies). Applying the share of 5% to these numbers, 122 additional companies in the category small and 14 companies in the category medium would use Strontium Chromate. Therefore it can be concluded that at least **136 additional companies** in the European aerospace supply chain are using Strontium Chromate.

2) Extrapolation of exposure data within CCST

Data within CCST was assessed using questionnaires sent to all members, site visits and expert consultation. However, not all CCST member companies within this use group were able to quantify data due to their high level of uncertainty. To consider all health and social impacts of CCST members for the SEA at hand, an extrapolation approach is applied. The data received by CCST use group members is extrapolated by a factor: Number of CCST use group members applying the substance divided by number of CCST use group members which quantified data. For health impacts it is assumed that the average number of exposed workers and the respective distribution regarding exposure times is equal to the values derived from the data basis (CCST members that delivered data). For social impacts the distribution of job losses according to education levels among the companies which delivered data is assumed to be equal for companies that did not deliver data. Figure 7 illustrates the applied approach in this SEA.

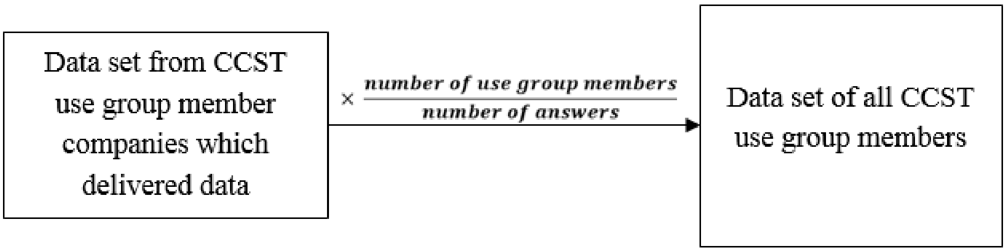

Figure 7: Extrapolation approach within CCST

3) Extrapolation approach for the European aerospace sector

As stated above, CCST member companies cannot be regarded as representative for the whole sector as they are categorised as large, whereas the majority of aerospace companies has to be regarded as small (14). Therefore a direct conclusion from CCST to the overall sector cannot be drawn. For the impact assessment of this SEA, CCST member impacts are considered separately and added to the impacts of the aerospace sector. Figure 8 illustrates the approach.

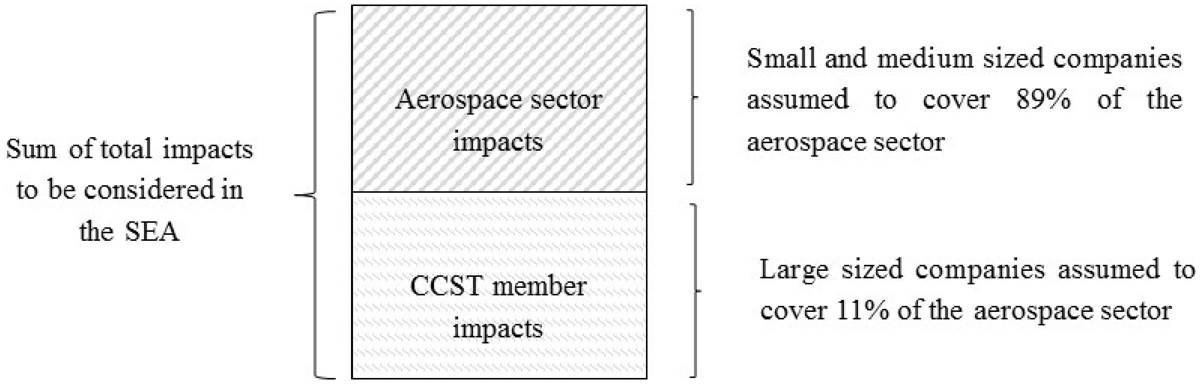

Figure 8: Extrapolation approach for the aerospace sector

Aerospace sector extrapolation for potentially exposed workers

According to the commonly applied definition of the EU, small sized companies employ between 10 to 50 people and medium sized companies employ between 50 to 250 people. For the following calculations an average number of employees in the range of 10 to 50 for small (α) and in the range of 50 to 250 for medium sized companies (β) is taken into account. Due to Confidential Business Information (CBI) of CCST member companies an exact number cannot be stated here, as this could be used to calculate back numbers to single companies. Further it is assumed that 50% of the employed workers are exposed to Strontium Chromate. Based on the results of an aerospace study (14) the share between small and medium sized companies can be regarded as 90% to 10%. The estimation of production sites using Strontium Chromate is given with 600 companies in the upper bound and with 136 companies in the lower bound, consequently 540 small and 60 medium sized companies have to be considered for the upper bound and 122 small and 14 medium sized companies for the lower bound. Therefore the number of potentially exposed workers can be calculated as follows:

$$\begin{aligned} Number\ of\ potentially\ exposed\ workers \\ &= 50\%\ exposed\ workers \\ &\times (avg.employees\ small\ companies \times number\ of\ small\ companies \\ &+ avg.employees\ medium\ companies \times number\ of\ medium\ companies) \end{aligned}$$

Upper bound:

$$Number\ of\ potentially\ exposed\ workers = 0.5 \times (\alpha\ \times 540 + \beta \times 60)$$

Lower bound:

$$Number\ of\ potentially\ exposed\ workers = 0.5 \times (\alpha\ \times 122 + \beta \times 14)$$

Within CCST, companies were asked to categorise potentially exposed employees according to exposure time categories. Following categories have been used: workers exposed for 6-8 hours per day, 3-6 hours per day, 1-3 hours per day, less than 1 hour per day, workers not regularly exposed. The same share of these exposure time categories computed for this use in CCST have been applied for the health impact assessment of the aerospace sector.

Aerospace sector extrapolation for social impacts

For small sized companies, the average number of employees (α) in the range of 10 to 50 is used to calculate the number of job losses which will occur in case of a non-use scenario. It can be clearly assumed, that the small companies are very specialised and do not have any possibility to change to non-aerospace work, which means a loss of contracts and consequently shutting down the company and dismissing employees. For medium sized companies only the number of potentially exposed people (50% of β) is used to calculate social impacts, assuming that these companies also have non-aerospace clients. Therefore they could continue business only closing down the aerospace related business.

Within CCST, job losses were categorised to education levels (low / high skilled and academic). As this categorisation cannot be assessed for other companies in the aerospace sector, the social impact calculation follows the conservative approach. Hence the assessment of lost salary costs considers only an education level “low skilled”.

ANNEX B HEALTH IMPACT ASSESSMENT

A. Formulators

Calculation of health impacts for potentially exposed people

The calculation of health impacts for potentially exposed people at formulators follows the same logic as described in section *B. Downstream users* below.

For formulators the accumulated exposure data for 6 formulators is 7.44 (please consider Table 23 for an exemplary calculation at downstream users). For another two formulators, data could not be gathered. Therefore, average health impacts of formulators for S6 were added for these two formulators.

The resulting health impacts for workers at eight European formulators can be found in the table below.

Table 18: monetised health impacts for workers at European formulators

	Central value (lower bound) [€ million]	**Sensitive value (upper bound) [€ million]**
Monetary value for fatal cancers	0.012	0.02569
Monetary value for non-fatal cancers	0.001	0.001
+ 2*average at S6 formulators	0.0022	0.027
Total	**0.0174**	**0.036**

Exposed population "Man via Environment" human health impact assessment

The estimation of health impacts at formulators "Man via Environment" again follows the same logic as in the respective section below but with the following input parameters.

Table 19: Input parameters "MVE" for formulators

Input parameter	Value
Number of sites	9
PEC local [µg/m3]	0.0009521
PEC regional [µg/m3]	2.9E-11
Number of exposed people per site (PECregional)	20,000,000

Table 20 and Table 21 below summarise the health impacts at formulators through the exposure path "Man via Environment".

Table 20: Monetised health impacts for PEC local at formulators

	Central value (lower bound) [€ million]	Sensitive value (upper bound) [€ million]
Monetary value for fatal cancers	0.454	0.975
Monetary value for non-fatal cancers	0.039	0.039
+ 2 * average S6 formulators	0.082	0.169
Total	**0.658**	**1.352**

Table 21: Monetised health impacts for PEC regional at formulators

	Central value (lower bound) [€ million]	Sensitive value (upper bound) [€ million]
Monetary value for fatal cancers	0.0000270	0.0000580
Monetary value for non-fatal cancers	0.0000023	0.0000023
+ 2 * average S6 formulators	0.0000047	0.0000100
Total	**0.00004**	**0.00008**

B. Downstream users

Number of potentially exposed people

The extrapolation undertaken in ANNEX A provided the relevant number of potentially exposed workers in the European aerospace sector (see Table 22). As a conservative assumption, exposure by "Man via the Environment" is assessed for the whole population of the European Economic Area (EEA) as sites may be spread all over Europe and cannot be located in this assessment.

Table 22: Number of people potentially exposed

Industrial workers in sites of the European aerospace industry	22,951
General population (EEA in 2014[29])	512,888,463
PEC_{local}	616 sites x 10,000 people = 6,160,000

Strontium Chromate or products containing the substance are not used by professionals. Therefore, these workers are not listed in the table above.

The human health impact assessment in the following sections is based on the methodology suggested by ECHA and described in section 6.4 of this SEA.

Calculation of health impacts for potentially exposed people

Following the methodology described in section 6.4, the calculation of the monetised health impacts of the European aerospace sector is given by the following equations. The combined exposure values of the respective CSR (use group iii) is used corrected by the exposure times for the number of potentially exposed people to calculate the total concentration as input factor for the Excess Lifetime Risk (ELR) (see Table 23).

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[29] Source:http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&tableSelection=1&labeling=labels&footnotes=yes&language=de&pcode=tps00001&plugin=0 [Cited: 19 November 2014].

Table 23: Corrected exposure times with number of potentially exposed people at the downstream users

Criteria	%	Total numbers of workers exposed EEA supply chain	exposure value [µg Cr(VI)/m3]	Correction factor applied for calculation	Total concentration EEA supply chain (rounded) [µg Cr(VI)/m3]
Workers potentially exposed for less than 1 hour/day	13%	3,073	1.93	0.125	741.46
Workers potentially exposed for 1-3 hours/day	11%	2,518	1.93	0.375	1,822.11
Workers potentially exposed from 3-6 hours/day	15%	3,376	1.93	0.75	4,886.04
Workers potentially exposed from 6-8 hours/day	21%	4,758	1.93	1	9,183.52
Workers not regularly exposed (e.g. once a week, month, year)	40%	9,226	1.93	0.125	2,225.80
TOTAL	**100%**	**22,951**			**18,858.9**

Based on the value for the total concentration of hexavalent chromium (18,858.9 see Table 23) and a review period of 12 years, the equation for the calculation of Excess Lifetime Risk is as follows:

$$ELR = \frac{12}{40} \times 4 \times 10^{-3} \text{ per } \frac{\text{µg Cr(VI)}}{\text{m3}} \times \text{Total concentration}[\frac{\text{µg Cr(VI)}}{\text{m3}}]$$

With the expected sunset date being in 2019, the monetary values for the additional cancer cases are calculated according to the following equations:

Monetary value for fatal cancers (central value):

$$€_{fatal,central} = ELR \times € \, 1{,}052{,}000 \times 1.01517^{(2019-2003)}$$

Monetary value for fatal cancers (sensitive value):

$$€_{fatal,sensitive} = ELR \times € \, 2{,}258{,}000 \times 1.01517^{(2019-2003)}$$

Monetary value of non-fatal cancers (central/sensitive value):

$$€_{non-fatal} = 0.208 \times ELR \times € \, 400{,}000 \times 1.01517^{(2019-2003)}$$

Table 24 summarises the monetised impacts derived from the equations above derived in accordance with the ECHA guidance, for workers potentially exposed to Strontium Chromate during the application of surface treatment within the European aerospace supply chain including members of the CCST consortium. The analysis is based on a review period of 12 years. Following the worst-case approach by applying upper bound number of potentially exposed people within the CCST consortium.

Table 24: Monetised health impacts for workers in the European aerospace sector

	Central value (lower bound) **[€ million]**	**Sensitivity value (upper bound)** **[€ million]**
Monetary value for fatal cancers ($€_{fatal}$)	30.3	65.0
Monetary value for non-fatal cancers ($€_{non-fatal}$)	2.4	2.4
Total	**32.7**	**67.4**

Exposed population "Man via Environment" human health impact assessment

The applied methodology and main underlying assumptions are given in section 6.4.5. The calculations are provided for PEC_{local} and $PEC_{regional}$ and follow generally the calculations presented for the health impact assessment of potentially exposed workers. It should be noted that the following calculations are based on worst-case assumptions and therefore have to be regarded as overestimated. This fact is given by the very high number of people potentially exposed, which was taken into account following ECHA guidance (23). Additionally there is uncertainty about the dose-response curve at very low exposure values. The linear dose-response curve recommended by RAC might be too conservative for this exposure level.

PEC_{local}

The total number of potentially indirectly exposed people is assessed taking into account the foreseen population of 10,000 people around a production site (23).

$$Number\ of\ potentially\ exposed\ people\ (PEC\ local) = number\ of\ sites\ \times\ 10{,}000$$
$$= 616 \times 10{,}000 = \mathbf{6{,}160{,}600}$$

With the exposure values for PEC_{local} provided by the corresponding CSR and the above calculated number of potentially exposed people the further calculation follows the methodology described in section 6.4:

The excess risk is calculated according to the following equation:

$$ELR = \frac{review\ period\ [years]}{70\ years} \times 2.9\ \times 10^{-2}\ \text{per}\ \frac{\text{µg Cr(VI)}}{\text{m3}} \times\ \text{exposure value PEC local} \times \text{number of people potentially exposed}$$

$$= \frac{12\ years}{70\ years} \times 2.9\ \times 10^{-2}\ \text{per}\ \frac{\text{µg Cr(VI)}}{\text{m3}} \times 1.61 \times\ 10^{-3}\ \frac{µg}{m^3} \times 6{,}160{,}000$$

In a second step, the monetised values for additional lung cancer cases are calculated by multiplication with the WTP values adjusted to the year of the sunset date.

Monetary value for fatal cancers (central value):

$$€_{fatal,central} = ELR \times €\ 1{,}052{,}000\ \times 1.01517^{(2019-2003)}$$

Monetary value for fatal cancers (sensitive value):

$$€_{fatal,sensitive} = ELR \times €\ 2{,}258{,}000\ \times 1.01517^{(2019-2003)}$$

Monetary value of non-fatal cancers (central/sensitive value):

$$€_{non-fatal} = 0.208 \times ELR \times €\ 400{,}000\ \times 1.01517^{(2019-2003)}$$

Table 25: Monetised health impacts for PEC local at downstream users

	Central value (lower bound) [€ million]	**Sensitivity value (upper bound) [€ million]**
Monetary value for fatal cancers ($€_{fatal}$)	65.99	141.64
Monetary value for non-fatal cancers ($€_{non-fatal}$)	5.22	5.22
Total	**71.21**	**146.86**

PEC$_{\text{regional}}$

The total number of potentially indirectly exposed people is assumed for the whole EEA due to missing possibilities to locate all the production sites.

$$Number\ of\ potentially\ exposed\ people\ (PEC\ regional) = \mathbf{512{,}888{,}463}$$

With the exposure values for PEC$_{\text{regional}}$ provided by the corresponding CSR and the above calculated number of potentially exposed people the further calculation follows the methodology described in section 6.4:

The excess risk is calculated according to the following equation:

$$ELR = \frac{review\ period\ [years]}{70\ years} \times 2.9\ \times 10^{-2}\ \text{per}\ \frac{\text{µg Cr(VI)}}{\text{m3}} \times\ exposure\ value\ PECregional$$
$$\times\ number\ of\ people\ potentially\ exposed$$
$$= \frac{12\ years}{70\ years} \times 2.9\ \times 10^{-2}\ \text{per}\ \frac{\text{µg Cr(VI)}}{\text{m3}} \times 2.9 \times\ 10^{-11}\ \frac{µg}{m^3} \times 512{,}888{,}463$$

In a second step, the monetised values for additional lung cancer cases are calculated by multiplication with the WTP values adjusted to the year of the sunset date.

Monetary value for fatal cancers (central value):

$$€_{fatal,central} = ELR \times € \, 1{,}052{,}000 \; \times 1.01517^{(2019-2003)}$$

Monetary value for fatal cancers (sensitive value):

$$€_{fatal,sensitive} = ELR \times € \, 2{,}258{,}000 \; \times 1.01517^{(2019-2003)}$$

Monetary value of non-fatal cancers (central/sensitive value):

$$€_{non-fatal} = 0.208 \times ELR \times € \, 400{,}000 \; \times 1.01517^{(2019-2003)}$$

Table 26: Monetised health impacts for PEC regional at downstream users

	Central value (lower bound) [€ million]	**Sensitivity value (upper bound) [€ million]**
Monetary value for fatal cancers ($€_{fatal}$)	0.00010	0.00021
Monetary value for non-fatal cancers ($€_{non-fatal}$)	0.00001	0.00001
Total	**0.00011**	**0.00022**

ANNEX C SOCIAL IMPACT ASSESSMENT

Social impacts that are considered quantitatively here are limited to extrapolation and estimations of ANNEX A. It should be noted that this estimated number of job losses is conservative; the actual number of jobs lost in the non-use scenario is expected to be much higher than the figures mentioned in this report.

The impact of job losses due to the non-use scenarios is calculated using the salary cost method as described in section 6.2 of this SEA. Number of workers and salaries are assumed to remain constant for the authorisation period, the salaries only being adjusted by the GDP deflator factor (1.01517/year). Therefore, the salaries paid for the workplaces that would be lost in the non-use scenario are applied for the entire review period. Uncertainty analysis around this assumption is also provided in section 8.2.2.3. Data on number and classification of lost jobs were taken from company information of the CCST consortium members. In cases where companies encountered uncertainties regarding the classification of job losses to educational levels, job losses were counted as low skilled workers (conservative calculation / underestimation approach). This approach was also taken for job losses in the aerospace sector.

Note: Other costs associated to the job losses such as unemployment compensation and foregone value-added are not part of this assessment.

The total salary costs of all job losses as of 2010 is used as a base value for the NPV calculation. It is inflated at the above mentioned rate to account for standard price increases. After that, the values from 2020-2031 are discounted to the present value in the base year used for the assessment (2019) by employing a discount factor of 4%.

The resulting total Net Present Value (NPV) of the future payments of wages in 2019 within 12 years from the sunset date comprised by this application sums up to at least € 6,515 million. This means a loss of € 6,515 million appears to the EEA society in 2019 in case of non-authorisation.

ANNEX D IMPACT OF NON-AVAILABILITY OF PARTS ON THE ASSEMBLY OF AN AIRCRAFT

The following figure shows a highly simplified supply chain of parts needed for the final assembly of an aircraft.

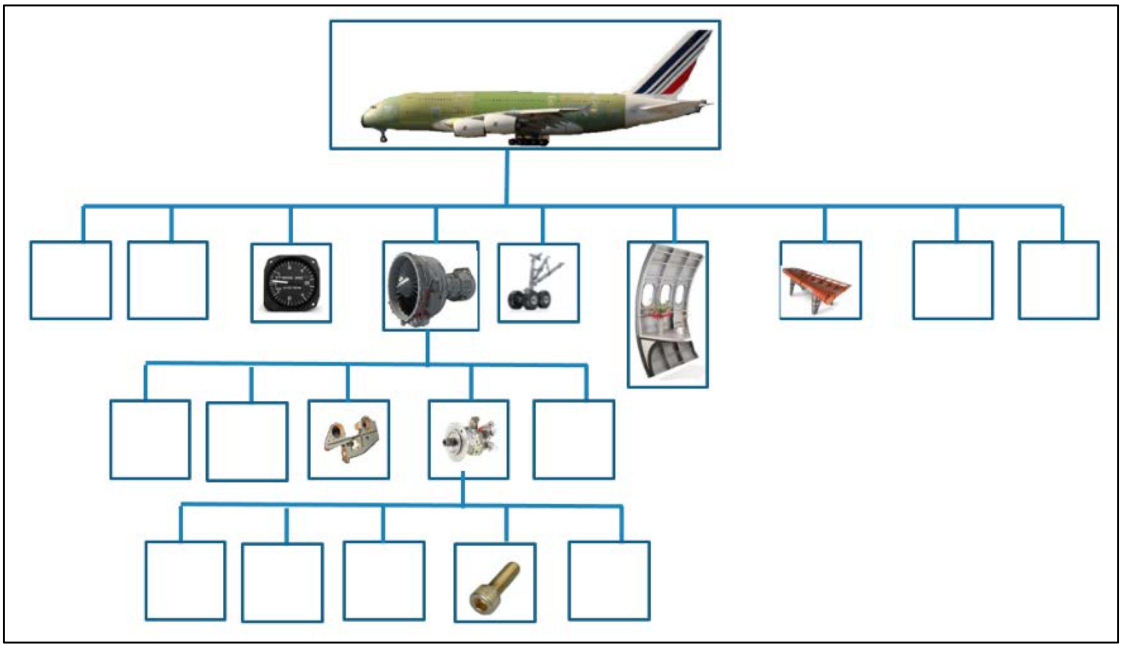
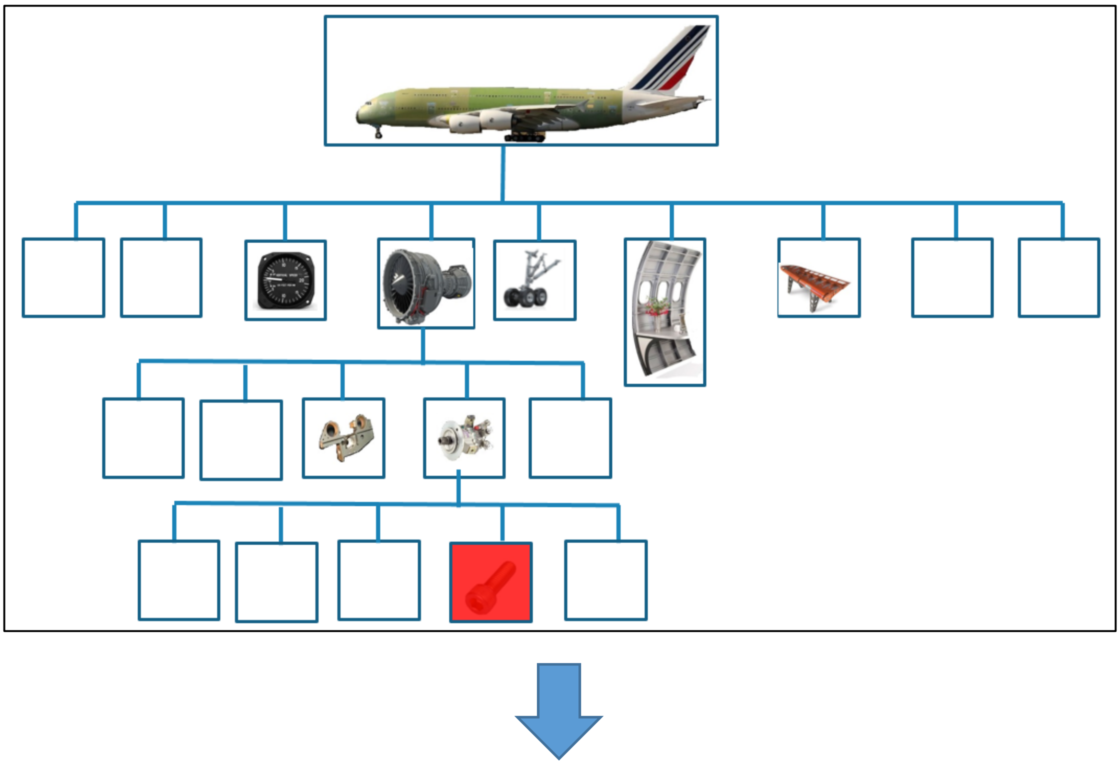
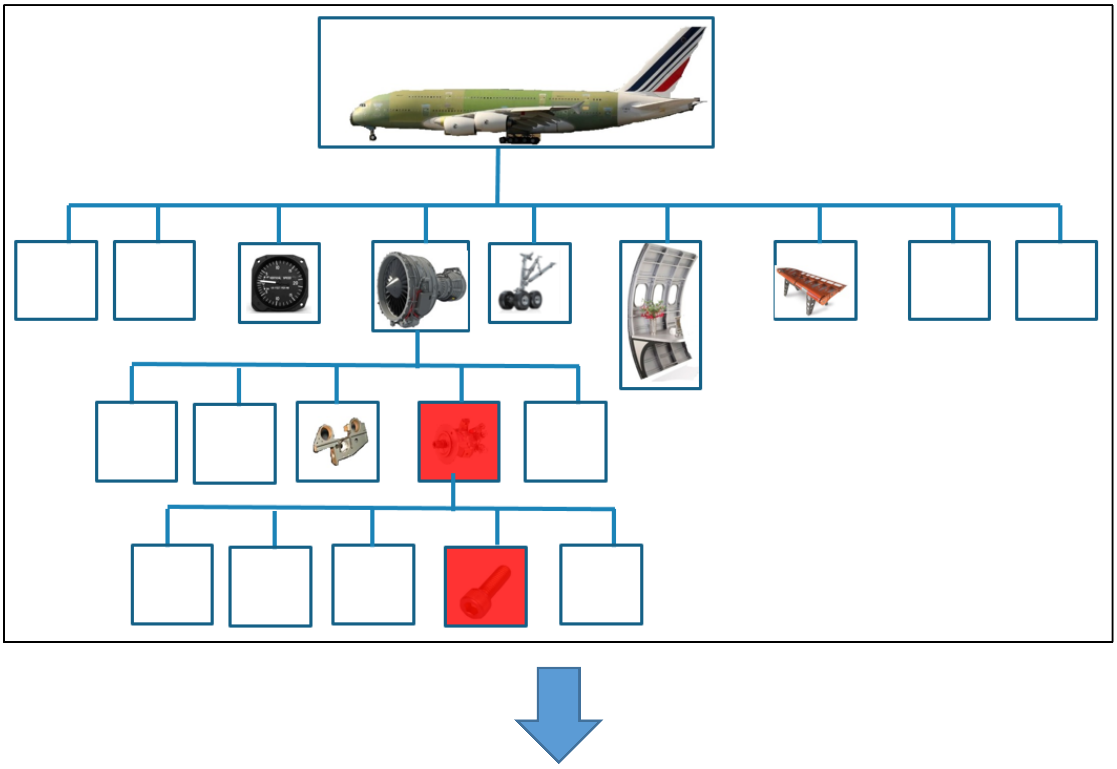
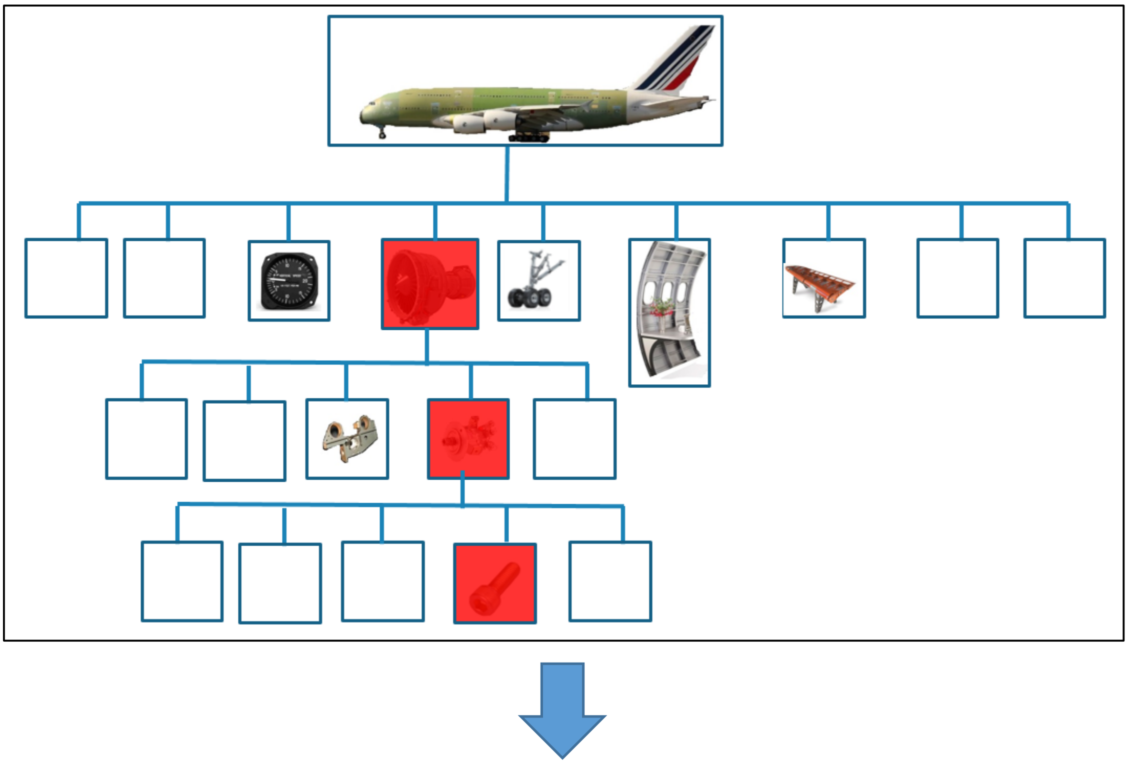


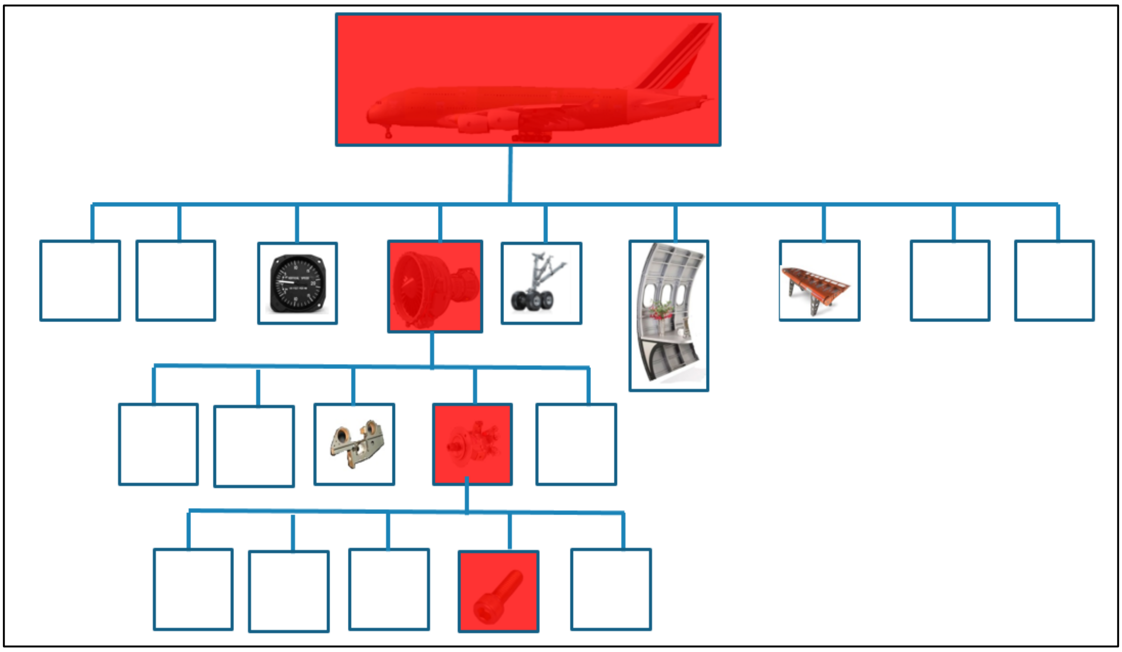
Figure 9: Highly simplified supply chain for aircraft manufacture

If only one part cannot be produced according to the regulations governing the airworthiness requirements (cf. section 5.2.1), the manufacture of the entire aircraft is jeopardised (see figures below).









ANNEX E CASE STUDY: IMPACT ON AIRLINES

Airlines or flight operators rely on daily maintenance, repair and overhaul (MRO) activities to maintain the permission to fly of aircrafts and fulfil all safety requirements. The MRO business is a highly competitive one, in which service providers seek to save even minutes in part handling and overhaul activities to provide customers a better turnaround time (time until the aircraft can be used for flight operations again) and offer best service prices. In this regard, outsourcing even regularly scheduled and mandatory checks (e.g. A-Check which usually takes place all 1 to 2 month) to non-EEA countries would increase time and equally costs dramatically, and is not economically feasible. Expert consultations revealed that in Europe every day roughly 5,000 aircraft inspections take place, 6,100 engine parts and 2,500 aircraft components are overhauled. Assuming conservatively that 20 % of these parts rely on chromates, 1,700 parts a day depend on authorisation.

However, a non-granted authorisation creates even greater problems for maintenance operations associated with daily (overnight) stops and unforeseeable damages (e.g. like bird strikes, lightning strikes or bumps by package loading cars or stairway vehicles). With regard to overnight stops, it is not possible to plan which parts have to be renewed. If parts that have to be replaced – as mandated by maintenance manuals – cannot be provided, the aircraft loses permission to fly and has to stay grounded (AOG Aircraft On Ground). This results in high costs for the airlines (for example, the logistic company DHL states a high cost scenario for an Airbus A380 of 925,000 Euro per day (26)). This problem becomes even more significant if bumps, scratches or any other damage to the surface of the aircraft are considered. In this case there is no chance to replace single parts, instead repair tasks have to be fulfilled at the whole aircraft. With around 20,000 to 30,000 flights a day (27) (28) in Europe and an aircraft fleet of more than 5,000 planes, it is just a question of time (assumedly 1-2 months) until all aircraft are grounded because daily MRO activities are not permitted. Airlines will not be able to maintain a viable business if a higher percentage of aircraft cannot be used. This scenario is valid for every airline, independent of whether it is based within Europe or not, if damages occur and the aircraft is grounded at any European airport.

Aircraft operators rely on the trust the traveling public has in the safety of the airline. An airline would never compromise aircraft safety in order to accommodate a chemical regulation with substandard repairs. Such a short-sighted philosophy cannot be accommodated in the long-term. Airlines state that they would simply eliminate (hopefully temporarily) operations in regions where they cannot safely maintain their aircraft rather than risk the reputation and viability of the entire company. The safety culture the airline operators reflect on a day to day basis underpins and mandates such decisions.

IATA published a study of the impact of Eyjafjallajokull’s volcanic ash plume in 2010 (29). At the peak, airlines lost US$400 million revenues a day, as aircraft had to stay grounded and more than 1.2 million passengers were affected every day. The same situation will happen if chromates cannot be used anymore. European airlines represent approximately 70% of lost revenues at the peak of the ash plume and 75% of European airline operations were stopped for those days. Considering that a non-granted authorisation affects 100% of the European airline operations, a daily loss of approximately

375 million US-Dollars revenues for European airlines has to be estimated, equivalent to 0.28 billion Euro revenue loss per day[30].

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[30] Avg. 2010: US-Dollar: Euro = 1.3257 : 1. https://www.ecb.europa.eu/stats/exchange/eurofxref/html/eurofxref-graph-usd.en.html [2015/10/08].

ANNEX F CASE STUDY: IMPACTS IN THE AVIATION, SPACE AND DEFENCE INDUSTRY

According to ASD (represents the Aeronautics, Space, Security and Defence industries in Europe) the impact of a non-granted authorisation of chromates in the production process is as follows:

All new products relying on one or more chromates for one or more component parts will be stopped. Production interruption for the majority of aerospace and defence industry products will last until either one of the following occurs:

a. Relocation of all affected processes takes place to a non-affected country - including requalification of new supply sources and processes. But it should be noted that relocation of just surface treatment processes outside of Europe is unrealistic. It is very much more probable that the complete production of parts would have to be also done outside of Europe, for logistical reasons and for technical reasons as surface treatment is providing anti-corrosion properties to the parts and therefore needs to be done quickly after manufacturing. This would affect the complexity of production relocation and substantially increase the time and resources necessary to accomplish it. In addition relocation of large parts of the supply chain for military products is unlikely to be achievable due to the sensitivity of the product design and functional requirements.

b. An alternative is developed and substituted after technology validation, certification and industrialisation of the modified process and material (unlikely for many uses based on known technology developments).

Aftermarket repair activities will be disrupted by impact on supply of spare parts for both legacy and non-legacy products, and through an inability to repair products in Europe. Due to the size of such products, repair in non-European locations is rarely practical (the aircraft on ground scenario).

As a result of the above, there is expected to be significant knock on operational impact on space, defence and aviation customer operations.

The annual turnover of the European Aviation, Space and Defence industries is 197 billion Euro. The impact of a non-granted authorisation on turnover can be conservatively estimated at a minimum of 50% turnover, for a minimum of 12 months – i.e. 99 billion Euro. Assuming an average profit of 10% of turnover, the profit loss as a result of non-granted authorisation may be estimated at 9.9 billion Euro (per year).

However, 50% is likely to be a very low estimate because chromates are needed for thousands of components, lack of supply of even one component affects delivery of any assembled product; refurbishment and repair in the aftermarket would also be affected so both new production and aftermarket sales are impacted. It may be possible to transition a few supply lines to outside Europe in 12 months including requalification and acceleration to full production capacity, but not as many supply chains as would be affected and certainly not highly complex sub-assemblies. Due to the international nature of the aerospace and defence supply chain, the above effects would also impact non-European products due to their dependence on supply of components or chemical products from inside Europe, and also due to their need for product repairs at European customer locations.