# REACH Restriction on PFAS

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**ASD Initial Advisory Input to the public consultation on the proposed EU restriction for PFAS**

The Aerospace, Security and Defence Industries Association of Europe (ASD) is providing this initial response to the public consultation on the proposed EU restriction dossier for PFAS to bring attention to the Aerospace and Defence (A&D) sector dependence on PFAS, including many fluoropolymers, that are within scope of the current restriction proposal and for which there are no alternatives available today.

ASD is the voice of European Aeronautics, Space, Security and Defence Industries, representing directly and indirectly around 3,000 companies. It has 20 major European companies as direct members and 22 National Associations active in 18 European countries. This response is also supported by the Space Restrictions Task Force (RTF), an initiative of the Materials and Processes Technology Board of the European Space Components Coordination (ESCC MPTB), which is a partnership of the European Space Agency (ESA), national space agencies, and space industry represented by ASD-Eurospace.

ASD submitted a comprehensive response to the 2nd Stakeholder consultation in 2021 (copy attached), identifying several uses of PFAS essential to the Aerospace and Defence sector, for which there are no qualified and certified alternatives available. It is disappointing that the information provided is not well reflected in the current restriction dossier or proposed derogations.

In addition to PFAS-reliant uses for A&D sector already identified, there are likely to be further missing uses. These are not visible today given the complexity of supply chains and the limited visibility on PFAS substances many of which are not required to be disclosed in Safety Data Sheets or REACH Article 33 declarations. Accordingly, the A&D sector has not been considered as a main application in the restriction proposal other than partially included in Transport. Moreover, the defence industry and (other) niche applications being key areas of concern have been flagged as uses not yet researched in detail. Supply chain enquiries requiring sectoral coordination have been started, but responses may not arrive within existing REACH consultation windows. This challenge is aggravated by the absence of an official list of CAS numbers.

For the A&D sector, the proposed Universal PFAS restriction presents significant risks of wide-spread obsolescence for materials and processes and unpredictable side effects within the A&D and related industrial supply chains. Advisories received so far of planned PFAS-based product withdrawals by manufacturers and consequent specification changes by users show that this restriction proposal is already causing impacts that have to be managed to ensure business continuity for affected applications. It is uncertain today whether and to what extent these first cases can be managed without negatively affecting our activities and product performance.

A&D is heavily regulated and with many product-specific requirements, which need to be given full attention when assessing alternatives and impact of withdrawal. Changes to the A&D products and processes are subject to stringent contractual, qualification and certification requirements, which may be overseen by regulatory bodies and agencies such as the EASA (European Aviation Safety Agency) and the FAA (United States Federal Aviation Administration). Our sector is reliant on PFAS in a wide range of applications due to their unrivalled performance properties, making them the only choice currently available to meet the demands required by many uses in products and processes across the sector.

PFAS are essential for the continued operability of products currently in service which may have a service life lasting more than 40 years as well as for the manufacture of new products, spare parts and future technology programmes.

PFAS are currently key enablers for new technology development programmes across the sector. It is unknown if alternatives for affected parts and manufacturing processes can be found and qualified for implementation across all existing and new products and future technology programs.

Any alternative must be shown to perform equivalent to the current PFAS-based material in every area where it will be used to prevent the need for withdrawal of current and in-service products and to ensure product safety and reliability is not compromised.

Further derogations will certainly be necessary to assure the continued functioning of the European A&D sector whilst alternatives are being developed, qualified, certified and implemented across every affected part, process and product throughout the global and complex supply chain.

We are in the process of gathering further information and compiling a more detailed response to further illustrate the current identified PFAS uses across the sector and to provide information on the lack of alternatives, challenges for finding, qualifying and implementing these alternatives and estimated timelines for such activities, which will greatly exceed 12 years.

A mechanism to allow further derogation extensions will be required based on revised assessment of alternatives to ensure the continued viability of the Sector's activities under the restriction. This is because it cannot be assured that alternatives will be successfully deployed in a given timeframe.

Please expect our detailed input in due course. In the meantime, we remain available for discussion and exchange on this issue.

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[Signed by] Jan Pie, Secretary General of ASD

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# 2nd Stakeholder Consultation on a Restriction for PFAS

## A. For which use would you like to submit information? Please select all uses on which you would like to provide information.

√ Cleaning agents, polishes, waxes (non-industrial uses)

X Cosmetics

X Food contact materials & packaging

√ Lubricants

X Construction products

X Medical devices

X Medicinal products

√ Metal plating & manufacturing of metal products

X PFAS production (manufacturing)

X Ski treatment

√ TULAC (textiles, upholstery, leather, apparel and carpets)

X Petroleum & mining

√ F-gases

√ Electronics & energy

√ Transportation

X Waste

√ Defence – new section added

√ Fire suppression function - new section

If relevant, please further specify your use (e.g. textiles used in personal protective equipment).

PFAS are used in the manufacture, operation and maintenance of Aerospace and Defence (A&D) products and/or in the manufacture of component parts (articles), sub-assemblies and formulations (mixtures) in aerospace and defence (A&D) supply chains. A&D products include and are not limited to:

- Commercial aircraft for transportation of passengers and cargo. Both fixed wing aircraft and helicopters.
- Military aircraft, including fast jets, training aircraft, large transports and helicopters.
- Naval vessels: surface ships - including aircraft carriers - and submarines.

- Land vehicles, such as tanks, communications vehicles, weapons launchers and transportation vehicles for military personnel and munitions.
- Weapons, munitions and ammunition .
- Agents used in total flooding (Cargo & APU compartment, Engines Nacelle) and streaming (Cabin & Avionic bay handhelds, lavatory receptacles) fire suppression systems including Halon, HFCs and 2-BTP.

PFAS are also used in process equipment used to manufacture and/or maintain the above A&D products.

The data provided in this consultation response is limited because ASD member companies are usually downstream users of PFAS. They typically design and manufacture A&D products and in doing so utilise component parts, sub-assemblies and formulations from complex, multi-layered supply chains. Furthermore, ASD members do not operate the products they supply, instead providing support to other organisations, e.g. airlines, ministries of defence (MoDs), through provision of services, e.g. maintenance, technical support.

### Are certain uses of PFAS missing in the categories above?

Yes.

Defence use of PFAS is not included. Therefore:

- Military platforms such as aircraft, naval vessels and land vehicles have been added to the Transportation category because the techniques used to manufacture them are often (but not always) similar to those used to manufacture their civilian transport counterparts.
- A separate 'Defence' category for PFAS uses specific only to defence, including weapons, munitions and ammunition has been added.

Additionally, we have included a section with information on fire suppression function.

## Cleaning agents, polishes and waxes (non-industrial uses) – section B, questions in relation to the use

ASD members design and manufacture civil and military aircraft and other defence platforms. As such, they normally specify (i) the cleaning fluids that should be used on the product. (ii) the rain repellent fluids that should be used for aircraft windscreens and military aircraft canopies. PFAS substances are used in both of these product types for the repellent properties that they impart in the temporary surface coatings that such products leave on the aircraft after use.

However, although responsible for specifying the products that can be used on their systems, ASD members are not the majority users of such products. Rather it is the end customers who are operating and maintaining the relevant aircraft and defence platforms who actually use the cleaning and rain repellent fluids. Consequently, it is difficult for ASD members to provide estimates of PFAS volumes used in these applications in the EU at this time.

For industry, it is difficult to provide precise estimates of the PFAS contents because in most cases SDS do not provide such information and our direct suppliers might not be aware of such information.

The use of PFAS in cleaning fluids and rain repellent fluids will increase and decrease in line with the number of aircraft and defence platforms in service. This number is expected to remain constant, notwithstanding the impact of the Covid 19 pandemic upon civil aviation.

## Cleaning agents, polishes and waxes (non-industrial uses) – section C, questions in relation to alternatives

Information in this section has been provided by individual companies and has been collated at A&D industry level by ASD.

The investigation report summary indicates that the viability of non-PFAS cleaning fluids and rain repellent fluids for aeroplane windscreens is unknown. It is important that any alternative formulations or reformulations of existing fluids maintain the performance of existing products because

(i) maintaining pilot visibility in rain is safety critical.
(ii) fuel efficiency is maintained through use of cleaning fluids that leave behind a coating which reduces adherence of rainwater and dirt to aircraft surfaces, thus minimising drag.

## Cleaning agents, polishes and waxes (non-industrial uses) – section D, questions in relation to impact of legislative measures

Cleaning fluids are important to ensuring cleanliness of the aircraft surfaces which repel rainwater and dirt, thus enabling minimal drag on aircraft in flight. In the absence of suitable alternatives, increased drag will increase fuel consumption and thus the environmental impact of aircraft.

Rain repellent fluids enable good pilot visibility and thus fluid performance is safety critical. In the absence of suitable alternatives which provide the same performance, safety would be compromised with potential for grounding of commercial and military aircraft fleets.

If cut-off concentrations of PFAS in cleaning fluids and rain repellent fluids were specified at levels that are not achievable within a restriction, affected products would disappear from the market.

An obligation to label cleaning fluids and rain repellent fluids visibly with "Contains PFAS" would fall upon the manufacturer / supplier of the formulation.

## Lubricants – section B, questions in relation to the use

The Aerospace and Defence (A&D) industry is a downstream user of lubricants & hydraulic fluids that contain PFAS.

Lubricant uses in A&D products include and are not limited to:

- Aircraft gas turbines (jet engines), including actuators
- Aircraft flight control systems
- Aircraft landing gear
- Maritime gas turbines
- Combustion engines
- Bearings – plain, roller, sliding
- Valves, actuators, regulators
- Gears, gearboxes
- Chains
- Friction reduction in various mechanical devices
- Door / hatch / window opening mechanisms
- Fasteners – screws, bolts, nuts, etc.

Critical uses include, but are not limited to:

- High temperature greases and dry film lubricants which are typically used to lubricate bearings and moving parts in specialised applications. The PFAS substances comprise the bulk of these types of formulations. PFAS-containing grease/lubricant remains on the articles as delivered. Previous work to find alternatives for these has been unsuccessful due to inability to find replacement materials that match fluorinated grease's unique properties (e.g. temperature capability, life, etc.). Substances affected are PTFE (CAS 9002-84-0), perfluoropolyalkyl ether (CAS 60164-51-4).
- High performance, long-life lubricating oils, able to withstand pressure / heat and minimise wear in engines and gearboxes.
- Thermoset / thermoplastic moulds / unmoulding agents

Hydraulic fluid uses in A&D systems include and are not limited to:

- Aircraft flight control systems, actuators for flying surfaces
- Aircraft landing gear
- Actuators in defence systems. These include, but are not limited to steering mechanisms, munitions loading systems, turrets

Of the uses listed above, all are critical and require the use of PFAS. However, our sector uses a great number of specialist lubricants and hydraulic fluids in a variety of applications and not all require or contain PFAS. Insufficient data is available within some Safety Data Sheets to be certain whether specialist lubricants and hydraulic fluids contain PFAS or not.

A further difficulty in providing estimates of PFAS volumes used in lubricants & hydraulic fluids in the EU at this time is that affected products are not only used in the EU, but also can be used outside the EU and imported already applied to the finished products. These lubricants and fluids may also be specified for use by customers who operate the relevant A&D products, and by third party repair and maintenance facilities. Intensive use by the operator will increase frequency of maintenance with a consequent increase in the volume of lubricants and hydraulic fluids used.

Once an A&D product is filled with a liquid lubricant/hydraulic fluid or a lubricant (e.g. grease) is applied to an A&D product, then we expect that any environmental releases are likely to be minor since these products are expected to remain (long lasting) on the components to which they are applied. When liquid lubricants/hydraulic fluids are drained and disposed of along waste streams, exposure to the environment is expected to be minimised by compliance with existing HSE requirements that necessitate used fluids to be disposed as hazardous waste.

## Lubricants – section C, questions in relation to alternatives

Information in this section has been provided by individual companies and has been collated at A&D industry level by ASD.

Lubricants & hydraulic fluids used and specified by A&D companies have to meet stringent performance requirements and are required to operate in extreme conditions. PFAS substances are often present in order that such products are able to meet such stringent requirements. Some of the high temperature greases comprise 100% PFAS and there are not currently alternative chemistries that meet the same performance requirements. Many lubricant & hydraulic fluid applications have a combination of performance requirements and the use of PFAS substances enable all of these to be met. Consequently, the introduction of suitable alternatives will be difficult, and in some cases, impossible. Performance requirements include but are not limited to:

- Resistance to pressure / weight / load / vibration

- Resistance to extreme temperatures
- Resistance to rapid temperature change
- Longevity – long service intervals
- Compatibility with the materials used to manufacture the lubricated parts
- Corrosion resistance
- Anti-seize properties
- Anti-wear properties
- Resistance to chemicals / solvents
- Compatibility with alternatives

High-performance lubricants & hydraulic fluids that contain PFAS are also used in A&D manufacturing and maintenance operations. Consequently, any alternatives also need to be suitable for these activities and be compatible with existing products in service, that may no longer be manufactured but which have extremely long service lives.

In summary, many A&D industry uses of lubricants & hydraulic fluids have a combination of exacting performance requirements which currently can only be met by the use of PFAS substances.

A blanket PFAS restriction will mean that the PFAS-containing lubricants & hydraulic fluids , for which there are no current viable alternatives and that are relied on for the manufacture and safe operation of many A&D products, are no longer able to be used within the EU. If such a restriction entered into force before new PFAS-free alternatives were developed, validated and qualified for use in the myriad A&D parts and products, then the sector would be faced with a critical obsolescence impeding the ability to manufacture and maintain the types of products previously mentioned in section B.

Where lubricants & hydraulic fluids are able to be reformulated, high integrity A&D products that use them will have to undergo rigorous and costly qualification which (if successful) demonstrates that stringent safety and performance requirements continue to be met. Ultimately, qualification supports independent certification and approval of A&D products in the EU and other domains. Reformulation and testing of lubricants & hydraulic fluids by manufacturers, followed by qualification and certification of high-integrity A&D products may take from 3 to 10 years, depending on complexity. It is important to note that if reformulated lubricants and hydraulic fluids do not meet performance specifications and pass qualification testing, they cannot be used.

An ASD member company highlighted the risk of incompatibility between lubricants. Two incompatible greases were used in the same aircraft system and as a consequence, the mixed greases solidified and the system seized. This highlights the criticality of ensuring that even changes that may seem 'minor' at the formulation level, are adequately tested and qualified prior to being allowed to be used for A&D products.

## Lubricants – section D, questions in relation to impact of legislative measures

The consequential economic (in euros) and social (e.g. jobs) impacts arising from any restriction of PFAS in lubricants & hydraulic fluids is difficult to quantify. However significant financial impacts will arise from:

- Reformulation and testing of lubricants & hydraulic fluids by manufacturers.
- Requalification and recertification of high-integrity A&D products following changes to the formulation of high performance lubricants & hydraulic fluids.
- Reduced performance resulting in end product reduced environmental performance.
- Reduced maintenance intervals arising from changes to the formulation.

- Lack of availability of suitable lubricants/hydraulic fluids for certain A&D systems/products and maintenance of the same.
- Consequential withdrawal of A&D systems/products from service.

If cut-off concentrations for PFAS in lubricants and hydraulic fluids were specified at levels that are not achievable, within a restriction, that came into force before suitable alternatives were qualified for use, the affected A&D products would disappear from the market. Furthermore, residues of PFAS contained within lubricants and hydraulic fluids present in new or reused complex articles placed on the market could fall within the scope of a restriction.

An obligation to label lubricants & hydraulic fluids visibly with "Contains PFAS" would fall upon the manufacturer / supplier of the formulation. If such an obligation applied to new or reused complex articles in which lubricants & hydraulic fluids containing PFAS were present, then direct labelling of those complex articles may not be practicable – especially when incorporated within aircraft and defence platforms.

An obligation to report the amount of PFAS in lubricants & hydraulic fluids used within A&D products, together with respective emissions would be a new burden on the A&D industry. Provision of such data to regulators and/or waste processors would present an additional cost burden.

Current practises for disposing of waste liquids and lubricants require them to be correctly classified with a European Waste Code prior to disposal. If PFAS-containing fluids were accommodated a specific code(s) under this system, the waste stream containing PFAS could be classified and processed separately. In the absence of a specific waste code, it would fall onto operators to note the presence of PFAS when describing the waste prior to collection by specialist hazardous waste contractors.

## Metal plating and manufacturing of metal products – section B, questions in relation to the use

- PFAS are used as 'mist suppressants' by the A&D industry in the chrome plating process.
- PTFE and PDV tank liners are used for Hydrofluoric acid processes to ensure safety by protecting tanks against corrosion.
- PTFE is also used for seals on transfer pumps and pipes used in chemical process lines.
- PTFE in nickel PTFE coating is used as replacement for hard chrome plating.
- PFAS is present in anti-corrosion liquids present on imported parts in order to protect those parts against corrosion. These formulations remain on the parts as shipped to the EU. The affected substances we have identified are perfluoropolyalkyl ether (CAS 60164-51-4). Quantities are expected to be very low since this is a niche application.
- PFAS are used as degreasing agents for preparation of metal parts plating.
- PTFE is used to obtain rubbing surfaces with a very low rubbing coefficient.
- PTFE is able to be used as varnished (MICROFLON ™, MICROFAL ™) or as solid lubricant dispersed in a surface treatment (steel or aluminium alloy).

## Metal plating and manufacturing of metal products – section C, questions in relation to alternatives

Information in this section has been provided by individual companies and has been collated at A&D industry level by ASD.

For metal process operations PFAS use is an adjunct to manufacture and is very unlikely in most cases to be a residual in the finished product (there may be some exceptions to this e.g. in electroless-nickel deposits where PFAS surfactant could be occluded in the finished coating itself). Additionally, this is a closed process with low quantities used, low residues, low if any release in environment and low worker exposure.

The great advantage of PFAS is their extreme chemical resistance and outstanding surface activity i.e. they promote wetting and thus promote uniform surface reaction.

## Metal plating and manufacturing of metal products – section D, questions in relation to impact of legislative measures

All changes to the processing of metal parts must be tested to ensure no impact upon finished parts. Parts affected must be retested and requalified in order to uphold certification of A&D products. As described elsewhere in this ASD consultation response, industry standards are stringent, therefore testing must be rigorous in order to demonstrate that standards continue to be met. This can take many years because different alternatives must be tested until success is achieved. Ultimately, testing, qualification and certification of A&D products is a significant cost driver in our industry (please see information provided under "Transportation" section under "Product approval schemes").

Ultimately, allowed uses and concentration tolerances are needed for this use as a too harsh restriction will simply prevent A&D systems/products to function at all which could translate into an EU Defence/security problem. Furthermore, the exemption in Annex 1 Part A of the POPS regulation (EU) 2019/1021 allowing the use of PFOS as a mist suppressant for non-decorative hard chromium (VI) plating in closed loop systems would no longer be of use.

If cut off concentrations for PFAS in manufactured metal parts was specified within a restriction at levels that are not achievable, then processes which left a residue of PFAS on the part could not be operated in the EU, nor could those parts be imported. The example given above is electroless-nickel plating and aforementioned use in anti-corrosion liquids.

An obligation to report the amount of PFAS in mixtures used for metal processing, together with emissions would increase costs in the A&D industry.

## Metal plating and manufacturing of metal products – section E, specific questions for the use

Chemical processes could not be run without the use of PTFE or PVDF tank liners and PTFE seals/pipes for chemical safety in prevention of degradation when using corrosive substances.

Tank liners are used for very aggressive chemicals including but not limited to hydrofluoric acid, Nitric Acid and Sulfuric Acid baths or baths for hexavalent chromates. They are used to line PE and stainless steel tanks. PTFE or PVDF are used for such tank liners since they have good corrosion resistance, are easy to clean and have good thermal resilience (some baths operate at elevated temperatures).

Currently, there are not known alternative tank liners that have comparable performance. There are safety concerns in case these liners are no longer available; for PE tanks particularly there is a tendency towards brittle fracture when attacked by acids and this would result in catastrophic failure rather than a small leakage that could be contained and repaired; use of liners prevents against this.

If PFAS could not be used in Anti-corrosion liquids, there are no suitable alternatives. It would be impossible to produce parts which meet performance standards in terms of corrosion resistance – a crucial attribute in terms of safety and product longevity.

## Textiles, upholstery, leather, apparel and carpets – section B, questions in relation to the use

ASD members and their suppliers specify textiles required for manufacture and/or operation of commercial and military aircraft, and other defence platforms. PFAS is used in the manufacture of / applied as a surface treatment to many high performance textiles. Such textiles may be used for clothing worn by military personnel in hostile environments, to cover vehicle seats and to provide fire/oil resistant acoustic insulation. There are multiple performance requirements for the textiles used to manufacture the anti-g suits worn by military jet fighter pilots. Amongst other things, these suits must respond quickly to protect aircrew subjected to rapidly changing g-forces and temperatures, and in the event of aircrew ejection they must perform as a survival suit in a multitude of hostile environments.

A&D uses are 'niche' and therefore quantities of PFAS used are likely to be small.

ASD companies are downstream users of high performance textiles and as such do not have data on PFAS emissions / environmental release or the associated risk management measures.

## Textiles, upholstery, leather, apparel and carpets – section C, questions in relation to alternatives

Information in this section has been provided by individual companies and has been collated at A&D industry level by ASD.

Stringent customer requirements for product performance, safety and longevity are expected to make substitution of textiles which rely upon PFAS difficult. Substitution, if at all possible, can only take place following rigorous testing and qualification which (if successful) demonstrates that the requirements of the A&D industry and its customers continue to be met. Such requirements include, but are not limited to:

- Water repellence
- Resistance to chemicals
- Stain resistance
- Durability over the long life of products in complex environment

The manufacturers of high performance textiles required by the A&D industry are best placed to provide information on the viability of potential alternatives. Alternatives, if technically feasible, should be also economically feasible considering the costs arising from testing and qualification of alternatives in niche, highly complex, small volume A&D products such as anti-g suits. Qualification supports independent certification and approval of A&D products in the EU and other domains. Hence qualification and certification of alternatives, if feasible, would take many years.

## Textiles, upholstery, leather, apparel and carpets – section D, questions in relation to impact of legislative measures

The consequential economic (in euros) and social (e.g. jobs) impacts arising from any restriction of PFAS in textiles used by the A&D industry is difficult to quantify. However significant financial impacts will arise from:

- Reduced fabric durability
- Reduced maintenance/renewal intervals
- Redesign and testing of high performance textiles by manufacturers in A&D supply chains
- Requalification and recertification of high-integrity A&D products following changes to the design of high performance textiles.

If cut off concentrations for PFAS in high performance textiles were specified at levels that are not achievable within a restriction, then affected products would disappear from the market. Furthermore residues of PFAS contained within textiles present in new or reused complex articles placed on the market could fall within the scope of a restriction.

## Textiles, upholstery, leather, apparel and carpets – section E, specific questions for the use

None of the PFAS uses that are specific to A&D and mentioned in this response to the call for information are reported in the summary report. The functionalities are mentioned in section C. The quantities of PFAS used and the lifecycle emissions are unknown to ASD as we are downstream users of high-performance fabrics.

## F-Gas – section B, questions in relation to the use

Fluorinated Gases (F-Gases) are used for:

- Cooling:
    - In Defence platforms, including military aircraft (such as jet fighters, surveillance platforms, transports), naval ships & submarines and land vehicles. F-Gases are used in refrigeration equipment for food conservation and in weapon systems to cool high-output electrical and electronic equipment.
    - In Commercial Aircraft. F-Gases are used for refrigeration purposes, for conservation of perishable goods during transport (e.g. food, medicines) and to store food for passenger consumption and air conditioning.
- Fire Suppression:
    - Halons, HFCs and 2-BTP are used for fire suppression in civil and military aircraft.
    - Fluorinated firefighting foams are used for fire suppression in all types of naval vessels - including aircraft carriers and submarines.
- Leak Testing
- Cleaning: fluorinated solvents are also used as cleaning agent for hydrogen tanks

The Aerospace and Defence (A&D) industry specifies use of F-Gases that contain PFAS in its products. The end-users of A&D products should have access to data on total F-Gas volumes used. Emissions occur only upon leakage of F-Gas – we assume that leakage is very low, however it is the end users of A&D products who have access to leakage data. F-Gas use in defence platforms is 'niche', therefore overall quantities used are very low. Yet these uses are essential to their operation.

Measures to minimise human exposure and emissions to the environment specifically for PFAS where it is contained in F-Gases are centred on sound design of cooling systems and adherence to in-service maintenance protocols for such systems. Use of F-Gas is subject to risk management which, amongst other things, takes into account the information provided in Safety Data Sheets. Our industry uses it due to its low toxicity and due to the fact that it is most often not flammable.

## F-Gas – section C, questions in relation to alternatives

Information in this section has been provided by individual companies and has been collated at A&D industry level by ASD.

**Cooling:** Currently, many industries are focused upon substituting F-Gases which have high Global Warming Potential (GWP) and replacing them with F-Gases which have lower GWP. This presents some challenges for the A&D industry because F-gases with a low global warming potential are flammable and therefore cannot be systematically used for cooling in commercial aircraft and in air, maritime and land defence platforms.

The potential alternatives to F-Gases are identified together with their drawbacks in the summary report attached to the survey questionnaire.
Known alternatives are more flammable and/or hazardous and less performant. These drawbacks render these potential alternatives unviable for use in A&D products.

**Fire suppression (aircraft):** The use of Halons is controlled under the ozone depleting substance regulation (EC No 1005/2009). Recently the A&D industry has successfully substituted Halon 1211 in portable (handheld) and lavatory receptacle extinguishers used in commercial aircraft and is working to substitute Halon in commercial aircraft fire suppression systems. However some of the agents replacing Halon 1211 are concerned by the F-Gas regulation EC No 517/2014. Others will be directly concerned by restrictions of PFAS. It now appears that Halon 1211 substitutes constitute 'regrettable substitution', if new restrictions make the solutions non-viable.

In addition, the industry has been working for many years to substitute Halon 1301 in Cargo & APU compartment and Engines nacelles commercial aircraft fire suppression systems. Despite these efforts, viable Halon alternatives have not been found. Many potential alternatives turned out to be technically not feasible, because they do not meet the specific performance requirements. On top of that, fire suppression is a safety item and specific airworthiness requirements apply that need to be complied with in the frame of the aircraft certification process. Many of the remaining potential Halon 1301 substitutes the industry is currently investigating are PFAS. Therefore, additional restrictions of PFAS potentially used in fire suppression systems would put at risk the industry's achievements and potentially require a restart of the research by focussing on non-PFAS agents. A non-compliance with outstanding EU ODS ban dates will become more probable requiring the industry to request a derogation. Aircraft airworthiness cannot be maintained without these agents.

## F-Gas – section D, questions in relation to impact of legislative measures

The consequential economic (in euros) and social (e.g. jobs) impacts arising from any restriction of PFAS in F-Gases is difficult to quantify. However significant financial impacts will arise from:

- Testing of alternative Gases by manufacturers.
- Requalification and recertification of high-integrity A&D products following changes to the formulation of Gases - noting that currently, the introduction of alternative gases is not feasible.
- Development of alternative cooling, fire suppression and leak testing technologies.

If a restriction resulted in F-Gases becoming unavailable, this would cause significant cost and disruption to the aerospace and defence industry. We estimate that F-Gas substitution programmes would exceed 10 years (based upon the existing chemicals substitution programs already in progress). Substitution of alternatives is currently not feasible, so substitution depends upon future emergence of viable and available alternatives for each application.

There are so many variables in the development of technologies it is not possible to provide an estimate of costs. Variables include and are not limited to: the technology itself, adaptability of the technology to solving the problem, potential for 'regrettable substitution'.

. If aerospace and defence use of F-gases fell within scope of any PFAS restriction, this would lead to these substances no longer being allowed for use in our products .This would lead to the costly development and introduction of new technologies. New technologies must be tested and qualified and product recertification would be necessary. Where new technologies cannot easily be introduced into legacy platforms, such platforms may have to be withdrawn from service.
Used F-Gas is normally returned to the supplier for processing.

## F-Gas – section E, specific questions for the use

**Cooling:** If we have to move away from non-flammable F-gases, we would have to move to completely different cooling technologies for weapon electronic systems and food conservation on military and commercial platforms. This would entail significant redesign and for legacy platforms, retrofitting might not even be possible which would dramatically reduce the lifespan of end products designed for decades of continuous use. Hence military exemption from the proposed PFAS restriction is essential to the continued operation of defence products. Exemptions are also needed to allow for commercial aircraft refrigeration in both cargo and passenger aircraft.

**Fire suppression (aircraft):** With regard to PFAS used as agent in aircraft fire suppression systems, a REACH restriction on this critical use would be an additional hurdle for the Halon substitution projects that comes on top of already existing European (E.C.) and International (ICAO) ODS regulations and risks to disqualify already introduced or potential Halon alternatives with no other technically equivalent alternative available in the years to come. Many years of effort, research and investment would suffer significant loss and setback and the industry would face the unrealistic challenge to reset the Halon substitution projects in an extremely short time frame.

## Electronics & energy – section B, questions in relation to the use

The Aerospace and Defence (A&D) industry and its supply chains manufacture high-integrity electronics and electrical systems which provide a wide range of essential functionalities in A&D platforms. Due to the nature of A&D products, electronics have a vital role to play in ensuring safety. Manufacturing quantities of A&D products are typically very low, hence PFAS volumes specific to the A&D industry are likely to be very low.

The majority of PFAS use by aerospace and defence is indirect through the procurement of articles which contain cured fluoropolymers or require their use for manufacture. These include and are not limited to:

- Cable insulation, particularly in high performance co-axial cables or cables where reliable, high-volume data transmission is essential.
- Printed circuit boards and assemblies.
- Gaskets and moulded products such as fluorocarbon O-rings used to seal casings for electronic assemblies.

- Semiconductors.
- High Temperature Film Capacitors.
- Electronic displays and touch screens.
- Lithium (Li) ion Batteries.
- Proton exchange membrane (PEM)in Hydrogen fuel cells for range extension in electric aircraft.

Manufacturers of the above articles are likely to possess information on volumes of PFAS used and emitted during manufacture in the EU, as well as partial information of the remaining life cycle of the above mentioned articles (including waste generation). Environmental release during recycling of finished articles at end of life will be dependent upon the recycling methods used by waste processing companies.

PFAS emissions from the above-listed procured articles during assembly and use of A&D products in the EU are understood to be negligible. These types of finished articles are not expected to release PFAS under normal conditions of use.

The A&D industry directly uses:

- Exterior surface coatings which contain PFAS for the protection of metal alloy casings for electronic assemblies.
- Solvents which contain PFAS for cleaning of electrical components and electrical contacts.

PFAS emissions from direct use of substances and mixtures by the A&D industry is likely to be higher than for purchased articles, however potential quantities of any such emissions are unknown. Intentional releases to the environment during use of these types of product is contraindicated by product safety data sheets.

## Electronics & energy – section C, questions in relation to alternatives

Information in this section has been provided by individual companies and has been collated at A&D industry level by ASD.

In many applications, potential alternatives might have a similar performance to fluoropolymers for a particular attribute or property. However the combinations or ranges of properties required for aerospace and defence electronics and energy applications sets fluoropolymers apart from the alternatives.

For uses in fuel cells for electric aircraft, there is no alterative material, it is integral to the function of the fuel cell

**PFAS in A&D industry process:**

- Exterior surface coatings of metal alloy casings for electronic assemblies provide long term corrosion protection in extreme environments. Essential attributes:
    - Maintain chassis ground in electronic equipment.
    - Maintain equipotential bonding across systems integrated within A&D platforms thus mitigating against the damaging impact of lightning strike.
    - Increase product life.
    - Extend maintenance/inspection cycles.
- Solvents:

    - PFAS is found in solvents used for cleaning electronic components and assemblies. These solvents are particularly important for the cleaning of electrical contacts.

Alternatives for exterior surface coatings are covered in more detail in the 'Transport' section. Alcohol-based cleaners are available instead of PFAS-based solvents, however they are not as effective.

**PFAS in purchased part**

- Cable insulation:
    - High performance over the long lifetime of A&D products (can be 40+ years), particularly where reliable, high-volume data transmission in harsh environments is essential.
    - Low dielectric constant confers excellent electrical insulation.
    - Flexible, resistant to cracking/degradation when subjected to high stress environments/vibration.
    - Allows wires in wiring harnesses to slide against each other and against harness fasteners, thus reducing stress/chafing when exposed to vibration or during maintenance.
    - Resistant to high temperature environments and rapid temperature fluctuations.
    - Flame retardant.
    - UV resistant.
    - Resistant to water, oil and chemicals.
- Printed circuit boards and assemblies:
    - Low dielectric constant confers excellent electrical insulation
    - Heat resistance
    - Chemical resistance
    - Non-stick and low frictional properties
    - Resistant to water, oil and chemicals.
- Gaskets and moulded products such as fluorocarbon O-rings and seals:
    - Prevent ingress of fluids and debris over the long lifetime of A&D electronic assemblies (can be 40+ years).
    - Provide thermal stability and resistance to vibration and to chemicals that may cause deterioration in sealing properties upon contact.
- PEM Fuel cells:
    - Proton exchange membranes integral to the function of the cells

Many components that might contain PFAS are manufactured in global supply chains. Global manufacturers may choose to remove or reduce the PFAS content from products in order to access the EU market as they have done previously for other materials in response to the ROHS Directive. EU suppliers would also have to remove or reduce PFAS from manufacturing processes which would put them at a disadvantage in the global marketplace. The problem here is that the attributes conferred by PFAS are often crucial to meeting stringent A&D specifications which contain multiple requirements, whereas the requirements of many other industries are less strict.

**PFAS in supply chain process:**

- ASD understands that fluoropolymers are critical to the manufacturing processes for the following products in the supply chain:
    - Semiconductors

- High Temperature Film Capacitors:
- Electronic displays and touch screens:
- Lithium (Li) ion Batteries:
- PEM Fuel cells
- Hydrogen production technologies: electrodes or membranes increasing yield

ASD companies are downstream users of manufactured products. As such, they do not have information on the viability of PFAS alternatives for manufacturing processes. It is important to note that substantial changes to manufacturing processes often trigger a requirement to requalify the resultant product for use in A&D systems and platforms.

All of the above illustrates that a PFAS blanket restriction is likely to affect a great range of components to an unforeseeable extent for the A&D industry. These components depend upon PFAS to confer a range of attributes/functionalities. The number of changed components supplied to the A&D industry may run into thousands, perhaps hundreds of thousands. Many of these changes may not be notified to downstream users, particularly where the components are 'commercial-off-the-shelf' (COTS). Similarly, formulations may also be affected. All such changes have potential to result in the capability, reliability, longevity and safety of A&D products being degraded, with serious consequences for airline passengers and the defence capability of the EU and its allies.

Within the A&D industry a vast multitude of substitution programmes would be necessary, with many exceeding 10 years duration (based upon the existing chemicals substitution programs already in progress) and this assumes viable and available alternatives for each application. Potentially, every substituted component within an electronic assembly would have to be evaluated and/or retested in the context of the system to achieve requalification - this process would have to be repeated where substitute components are found to be unsuitable. Requalification would trigger a requirement to recertify the Platform containing the assembly. Certification is strictly controlled by regulatory bodies in both the civil aerospace and military domains. E.g., the European Aviation Safety Agency (EASA), the US Federal Aviation Administration (FAA) and their military counterparts.

A blanket ban on PFAS use in these components would also jeopardise future electric aircraft development programmes.

## Electronics & energy – section D, questions in relation to impact of legislative measures

The economic implications arising from the substitution activities described in the previous section are difficult to quantify, however they would be huge.

A huge number of products are potentially affected by a blanket PFAS restriction. Simultaneous introduction of substitutes is highly challenging. The A&D industry does not have sufficient skilled personnel to manage simultaneous introduction of substitutes. The multitude of simultaneous testing and qualification programmes necessary would be unmanageable and unaffordable.

In many cases, alternatives are unlikely to have the range of properties currently conferred by PFAS. Consequently, enforced substitution would likely erode product integrity, reliability and longevity. All of the foregoing would make it difficult for the EU aerospace and defence industry to compete in the global market, the impact upon profitability and levels of employment would be significant, and the defence capability of the EU would be eroded.

Manufacturers of A&D electronic equipment hold spare components of a tested and qualified standard for the purpose of making repairs - these could not be used in the event of a blanket restriction being imposed. Thus the impact of a blanket restriction on the A&D industry and on the defence capability of the EU and its allies would be immediate.

The loss of PFAS could also dramatically hamper the EU and aircraft industry ambitions on decarbonisation and the climate target as PFAS are, as of today, unavoidable in the hydrogen and batteries industries with the already planned ramp up until 2050 of these industries. Electrification and decarbonisation cannot happen within the targeted time frame without PFAS thus, restricting them too drastically will significantly slow down progress on the EU climate targets.

A restriction that specified cut-off concentrations of PFAS in mixtures and articles at levels that are not achievable would amount to a ban. Thus all PFAS-based mixtures and articles used by the A&D industry in electronic products would disappear from the market, thus preventing their manufacture and maintenance. As electronic products are fundamental to A&D, this would present an existential threat to the A&D industry in the EU.

Labelling products visibly with "Contains PFAS" would be the responsibility of article manufacturers and suppliers of substances and mixtures. The A&D industry could, if required, label electronic equipment assemblies with "Contains PFAS".

An obligation to report the amount of PFAS in use and respective emissions would be a costly burden to the A&D industry and global suppliers.

Provision of PFAS data to waste processors for electrical and electronic equipment would be extremely challenging and would present a significant cost burden - over and above the existing burden of meeting SCIP database obligations.

## Electronics & energy – section E, specific questions for the use

The manufacturers of EEE articles should be able to provide a greater amount of information on the PFAS content and uses for EEE as well as emissions during the manufacturing and end of life of electronic equipment and batteries.

## Transportation – section B, questions in relation to the use

ASD members manufacture commercial aircraft for transportation of passengers and cargo. Both fixed wing aircraft and helicopters.

ASD members also manufacture military platforms/vehicles. These include:

- Military aircraft, including fast jets, training aircraft, large transports and helicopters.
- Naval vessels, both surface ships and submarines.
- Land vehicles, such as tanks, weapons launchers and transportation vehicles for military personnel and munitions.

Where these military platforms/vehicles are similar to the transportation vehicles used by civilians, they are covered in this section. However it should be noted that military products must withstand more extreme conditions than their civilian counterparts and typically they must remain in service longer - for up to 50 years.

Where PFAS use is unique to military products, it is covered elsewhere in a bespoke section for 'Defence' in this consultation response.

The following PFAS uses are essential to the manufacture, maintenance and upgrade of commercial aircraft and military platforms/vehicles:

- Cleaning agents, polishes, waxes (non-industrial uses)
- Lubricants
- Metal plating & manufacturing of metal products
- TULAC (textiles, upholstery, leather, apparel and carpets)
- F-gases
- Electronics & energy

All of the above uses are covered in detail by ASD in the relevant sections of this document.

The following PFAS uses have not been fully covered elsewhere, so they are included here:

- Hydrogen
- Exterior surface coatings
- Sealing applications
- Fuel systems, hydraulic systems, cooling systems
- Machined and moulded parts
- Fluorocarbon release films.
- Fan blade wear strips for aero engines.
- Specialist cleaning fluids.
- Thermal insulation.

The A&D industry and its extensive and complex supply chains have many uses of PFAS. ASD is concerned that some uses are yet to be identified.

Many PFAS uses are in articles where a Safety Data Sheet is not available. Therefore it is difficult, sometimes impossible, for downstream users in the A&D industry to identify articles supplied in which PFAS are present, or to identify the PFAS group manufacture of articles depends upon, or to identify specific PFAS CAS numbers used in their manufacture.

Each group of PFAS substances, perhaps each substance, may have a different hazard profile. Current information indicates that some PFAS are less hazardous than others. It is acknowledged that new information on hazards arising from PFAS is continually emerging

Hence ASD is able to provide only limited data on quantities of PFAS used/emitted. As A&D products are niche/low volume, it is reasonable to conclude that the quantities will be relatively low when compared with other industries.

ASD is willing to provide new and updated information as it emerges.

## Hydrogen:

In its report "Destination 2050 - A route to net zero European aviation"[1] the aviation industry has published a pathway to net zero CO2 emissions. Hydrogen is a cornerstone of the Destination 2050 pathway and fluoropolymers are essential to provision of hydrogen as follows:

1. Commercial aircraft used on medium-range flights will be powered by direct combustion of hydrogen. According to the Fluoropolymers Product Group, fluoropolymers are integral to the functioning of electrolysers, which in turn enable the transformation of renewable energy such as wind power into green hydrogen[2].

[1] Destination 2050 - A route to net zero European aviation, page 43.
[2] Fluoropolymers and Fuel Cells: Enabling the Transformation of Hydrogen into Electricity, end of page 2.

2. Electrically powered small aircraft on short-range flights will carry hydrogen fuel cells which generate on-board electricity from hydrogen. According to the Fluoropolymers Product Group, fluoropolymers are indispensable to the electrochemical reaction which turns hydrogen and oxygen into electricity[3]. Hydrogen fuel cells are composed of an anode and a cathode separated by a proton exchange membrane (PEM). The hydrogen molecules separate into protons and electrons at the anode and the PEM relies on fluoropolymers to allow the protons to permeate through to the cathode. The electrons cannot permeate the membrane and are forced to travel through an external circuit generating an electrical current.
3. Hydrogen fuel cells may be used in hybrid-electric configurations on larger, medium range aircraft.

As this technology has only recently begun to emerge into the mainstream, ASD does not have data on quantities of PFAS used/emitted.

### Exterior surface coatings

Fluoropolymers are present in paints / top coats used to provide protection to the surface of A&D products and components. Only the formulators of these products or their suppliers are in a position to provide data, in the case they know themselves the PFAS presence in their commodities, on the total PFAS volumes in such products and PFAS emissions during manufacture.

### Sealing applications:

Fluoropolymers are present in sealants, mastics and resins, and in gaskets and moulded products such as fluorocarbon O-rings and seals. These products are widely used in aerospace and defence products.

Gaskets and moulded products are usually supplied to the A&D industry as articles, and are not therefore supplied with SDS's. ASD understands that these products are chemically stable and as such PFAS emissions are low during the use phase.

Sealants are used in aircraft:

- To seal aircraft components against moisture or fluids (e.g. fuel) as well as air, gases and air pressure differences
- To provide leak proof against water, fuel and air
- To minimise the impurities of the aircraft structure and systems as well as corrosion on In-Service aircraft (moisture cause electrochemical corrosion)
- To improve the aerodynamics (filling of cavities and grooves to minimise the noise level and air resistance)
- Fretting protection (to avoid abrasion between surfaces due to the movable aircraft structure

Aircraft Sealants are two component systems comprising of base material and hardener. When mixed, they cure to a polymeric sealant which fulfil the specifications of the customers. Due to extreme conditions (e.g. Temperature from -55 °C to +80 °C), the requirements in the Aerospace Industry are very demanding.

Surfactants are used in the hardener to disperse the curing agent. NPE was used in the past, but is restricted (REACH) since January 2021 (Authorisation requested). A re-formulated NPE-free Sealant is containing PFAS. It is currently under qualification after three years of development.

[3] Fluoropolymers and Fuel Cells: Enabling the Transformation of Hydrogen into Electricity, webpage and link.

The PFAS component was added to compensate for the loss of performance due to the NPE-exchange. In particular it is needed to fulfill a water resistance requirement.
Impacted PFAS sealant is used specifically in **Wings** as high performance sealant: for overcoat of fasteners, fillet, interfay of wing junction, gap filling, wet assembly of fasteners

### Fuel systems, hydraulic systems, cooling systems:

Fluoropolymers are present in fluid lines, hoses, pumps, valves and filters and/or the lining of these components.

Fluid lines, hoses, pumps, valves and filters are usually supplied to the A&D industry as articles, and are not therefore supplied with SDS's. ASD understands that these products are chemically stable and as such PFAS emissions are low.

### Machined and moulded parts

In A&D products, a wide range of parts are machined or moulded from fluoropolymers. Parts machined from other materials may be coated with fluoropolymers to confer required properties.

ASD understands that fluoropolymers are chemically stable. As such, PFAS emissions during machining and during the use phase are low.

### Fluorocarbon release films:

Perforated and non-perforated fluorocarbon release films are used in the manufacture of composite parts.

### Fan blade wear strips for aero engines:

PTFE fibres are incorporated in fan blade wear strips for aeroplane jet engines.

ASD understands that fluoropolymers such as PTFE are chemically stable and as such PFAS emissions in the product use phase are low.

### Specialist cleaning fluids:

Some specialist cleaning fluids used in manufacture and maintenance of A&D products contain PFAS. SDS's indicate possible release of PFAS to air and mandate no release to water.

### Thermal Insulation

Many aerospace and defence products have to be protected with a thermal insulation because of very high thermal constraints which may apply to aircraft, spacecraft, naval vessels and land vehicles. For example European Space Launchers such as Ariane 6 are fitted with Cryogenic tanks which are covered by an External Thermal Insulation (ETI) using HFCs, e.g. as a blowing agent. This protection, specifically developed for launchers, is necessary to meet national safety standards. Under the current restriction project, which includes now a very wide extensive definition of PFAS, all of the HFCs is use in the ETI would be targeted by this restriction.
Covering foils of thermal acoustic insulation may contain PFAS.

Fluoropolymers are used to encapsulate glass fibre battings in commercial aircraft. The use is due to their chemical stability against aircraft hydraulic fluid and their low flammability.

## Transportation – section C, questions in relation to alternatives

Information in this section has been provided by individual companies and has been collated at A&D industry level by ASD.

## Hydrogen:

Hydrogen itself is part of a mix of alternatives to fossil fuels used in aviation and all of the alternatives are essential to the Destination 2050 pathway. Fluoropolymers are crucial to the manufacture of green hydrogen and hydrogen fuel cells which are themselves alternative technologies. As such, viable alternatives to fluoropolymers have not been identified.

## Exterior surface coatings:

Fluoropolymers in high-performance exterior surface coatings:

- Confer long term protection from corrosion/degradation in extreme environments to increase product life and extend maintenance cycles.
- Confer resistance of the surface coating to cracking, chemicals, abrasion, heat, fire.
- Provide UV stability.
- Have non-stick properties to prevent adhesion of dirt / staining to surface coatings
- Have non-stick properties to prevent adhesion of marine growth to the hull of naval vessels. It should be noted that PFAS-based hull coatings were introduced to remove the risk of pollution from traditional anti-fouling products applied to the hull of naval vessels.

There are no drop-in alternatives suitable for current applications. A blanket PFAS restriction will force manufacturers of exterior surface coatings to reformulate their products using non-PFAS alternatives. It is the combinations or ranges of properties required for aerospace and defence applications that sets fluoropolymers apart from the alternatives. So it is likely that manufacturers will have great difficulty in ensuring reformulated products continue to meet stringent A&D industry performance specifications. Use of alternatives will likely result in reduced product life and more frequent maintenance cycles arising from reduced resistance of the surface coating to cracking, chemicals, abrasion, heat and UV light, and consequential corrosion/degradation of the underlying materials. All of this would be unacceptable to commercial and military end users of aerospace and defence products.

Increased dirt adhesion to outer surfaces of aircraft or adhesion of marine growth to the hull of naval vessels will lead to increased drag with a consequential impact on fuel consumption and emissions, thus making net zero objectives harder to meet.

Reformulated products are subject to rigorous and costly testing and qualification which (if successful) demonstrates that performance specifications continue to be met. Testing and qualification of reformulated protective coatings is usually led by A&D companies, with the support of formulators. The introduction of a reformulated surface coating can take up to three years if testing is successful, noting that the test cycle may have to be repeated until success is achieved.

## Sealing applications:

Fluoropolymers are crucial in ensuring that high-performance sealants, mastics and resins, and gaskets and moulded products:

- Provide reliable sealing over the long lifetime of A&D products (can be 40+ years) operating in hostile environments.
- Seal pressurised cockpits and cabins in aircraft subjected to rapid changes in pressure differentials, noting that the pressure differential is especially great at high altitude - thus maintaining a safe environment for crew and passengers.
- Prevent leakage of fuels, oils, coolants from high-pressure systems subject to high stress environments/vibration, extreme temperatures and rapid temperature fluctuations.

- Prevent ingress of fluids, dirt and debris to A&D products operating in hostile environments.
- Withstand exposure to fuels, engine oils, hydraulic fluids and chemicals that may cause deterioration in sealing properties upon contact.

There are no drop-in alternatives suitable for current applications. A blanket PFAS restriction will force manufacturers of sealants, mastics and resins, and gaskets and moulded products to reformulate/reengineer their products using non-PFAS alternatives. It is the combinations or ranges of properties required for aerospace and defence applications that sets fluoropolymers apart from the alternatives. So it is understood that manufacturers will have great difficulty in ensuring that reformulated products continue to meet stringent A&D industry performance specifications.

It is understood that use of alternatives will likely result in reduced product life and more frequent maintenance cycles arising from reduced resistance to deterioration in the hostile environments described above. Sealed joints are often difficult to access without extensive dismantling, hence numerous joint failures will likely lead to premature scrapping of aircraft and defence platforms. All of this would be unacceptable to commercial and military end users of aerospace and defence products.

Siloxanes may be an option in some cases. However, some of these chemicals have been recommended for inclusion in the authorisation list by ECHA so cannot be selected.

Reformulated sealants, mastics and resins are subject to rigorous and costly testing and qualification which (if successful) demonstrates that performance specifications continue to be met. Testing and qualification of sealants, mastics and resins is usually led by A&D companies, with the support of formulators. The introduction of reformulated products may take up to three years if testing is successful, noting that the testing cycle may have to be repeated until success is achieved.

Reengineered gaskets and moulded products will either be tested and supplied against industry specifications by manufacturers or supplied as 'commercial-off-the-shelf' items. Where changes to such products are significant and are notified, A&D companies may choose to undertake 'due diligence' testing of such products in the context of the system, especially where they are critical to safety. It is possible that a blanket PFAS restriction could lead to products which meet exacting A&D industry requirements disappearing from the market.

### Fuel systems, hydraulic systems, cooling systems:

Fluoropolymers are present in fluid lines, hoses, pumps, valves and filters and/or the lining of these components. Fluoropolymers confer:

- High performance over the long lifetime of A&D products (can be 40+ years).
- Resistance to permeation.
- Flexibility, resistance to cracking/degradation when subjected to high stress environments/vibration.
- Resistance to extreme temperatures and rapid temperature fluctuations.
- Resistance to water, fuels, oils, gases and chemicals.
- Flame resistance.
- UV resistance.

There are no drop-in alternatives suitable for current applications. A blanket PFAS restriction, that comes into force before A&D companies have developed and qualified alternative materials, will force critical obsolescence of these types of components for use in A&D systems in the EU. It is the combinations or ranges of properties required for aerospace and defence applications that sets fluoropolymers apart from the alternatives.  So it follows that finding comparable alternatives will be time and resource intensive.

Any alternatives used for fluid lines, hoses, pumps, valves and filters need to be able to withstand deterioration in the hostile environments that they operate within. Leakage of fuels and oils may lead to fire; leakage of hydraulic oils may lead to loss of pressure and system failure; leakage of coolants may lead to overheating, system failure and/or fire.  Reduced filter efficiency may necessitate more frequent maintenance and/or lead to premature wear and consequential failure of the affected systems.

Reengineered fluid lines, hoses, pumps, valves and filters will either be tested and supplied against industry specifications by manufacturers or supplied as 'commercial-off-the-shelf' items.  Where changes to such products are significant and are notified, A&D companies may choose to undertake 'due diligence' testing of such products in the context of the system, especially where they are critical to safety.  It is possible that a blanket PFAS restriction could lead to products which meet exacting A&D industry requirements disappearing from the market.

### Machined parts and moulded parts

A wide range of parts for A&D products are machined or moulded from fluoropolymers. Fluoropolymers confer:

- Reduced weight, leading to increased fuel efficiency and reduced emissions.
- Low frictional properties which enables moving parts to move freely without the addition of lubricants, e.g. sliding parts.
- Resistance to water, fuels, oils, gases and chemicals.
- Flame resistance.
- UV resistance.
- Reduced need to apply protective surface coatings.

Moving parts machined from other materials may be coated with fluoropolymers to confer low frictional properties.

There are no drop-in alternatives suitable for current applications.  ASD is not aware of alternative materials that have similar properties.

If machined and moulded parts could not be manufactured from fluoropolymers, different materials would have to be used.  It is highly likely that these would add unwanted weight to A&D products, thus reducing fuel efficiency.  Furthermore, moving parts would likely require lubricants which themselves may contain PFAS.

### Fluorocarbon release films:

We are not aware of available alternatives to fluorocarbon release films where they are used in our manufacturing processes.  The PFAS substances are present to prevent sticking and aid the release from moulds/tools during composite component manufacture.

Polyimide, PVF, liquid release agents may be a potential alternative to Fluorocarbon release films in some applications.  Substitution is dependent upon testing of each application and on affected manufacturing processes continuing to produce parts which meet specifications.

### Fan blade wear strips for aero engines:

PTFE fibres in fan blade wear strips enhance (low) friction performance, thus increasing engine efficiency, with consequential reductions in fuel consumption and emissions. Currently there are not alternative materials that are available for use in this application.

### Specialist cleaning fluids

Alcohol-based cleaners could possibly be used instead, though it is understood that they are not as effective. The manufacturers of cleaning fluids would be responsible for evaluating alternatives, however it is important that reformulated specialist cleaning fluids continue to meet exacting A&D industry specifications.

Should reformulated specialist cleaning fluids fail to meet exacting A&D industry specifications, then the cleaning fluids may not be as effective, the cleaning would likely take longer, thus increasing costs, and the end result may not be as good, thus compromising the quality of the end product.

### Thermal Insulation

ASD does not have information on the viability of PFAS alternatives in the manufacture/application of thermal insulation.

PEEK foils are currently used to replace the fluoropolymer cover foils for thermal acoustic insulation in new commercial aircraft projects. Cover foils for thermal acoustic insulation used on older aerospace and defence products will likely contain PFAS.

### Product approval schemes:

Prior to the introduction of PFAS alternatives within A&D companies, the alternatives have to be qualified (evaluated and tested) in the context of the system/sub-system. This process has to be repeated where the alternatives are found to be unsuitable. Once qualified, the system must be revalidated in order to maintain certification of the product (aircraft, vessel, vehicle, etc.). Certification is strictly controlled by regulatory bodies in the EU and other jurisdictions, in both the civil aerospace and military domains. Examples include the European Aviation Safety Agency (EASA), the US Federal Aviation Administration (FAA) and their military counterparts.

A&D products are subjected to some of the most aggressive environments around the world. They must operate successfully in extremes, not limited to, altitude, temperature, pressure and precipitation, while having to fulfil the highest possible technical reliability and safety requirements. To ensure aircraft safety, comprehensive airworthiness regulations[4] have been in place in the European Union (as well as around the world) for decades. These regulations require qualification of all materials and processes according to a systematic and rigorous process to meet stringent safety requirements that are ultimately subject to independent certification and approval. Such rigorous testing and qualification processes are required to assure that any changes do not compromise the integrity of the affected components or the safety of the product as a whole.

Parallel requirements[5] are in place to ensure airworthiness for defence systems in Europe. Ground and sea-based defence systems are subject to similar rigorous qualification requirements. Space systems must also meet the highest specifications for consistent reliability and performance in

[4] E.g. European Union (EU) Regulation No 216/2008 and the EASA CS-25 and EASA CS-E in the EU

[5] The European Aviation Requirements (EMARs) established by the European Defence Agency (EDA) Airworthiness Authorities (MAWA) Forum

extreme environments over many years, since repair or maintenance is practically impossible once the technology is launched.

It is important to understand that, when looking to qualify new alternatives to replace undesirable substances used in formulations and materials e.g. adhesives, sealants, resins, lubricants etc., aerospace and defence companies must ensure that the functional requirements performed by the entire formulation, as a whole, are still met. The focus when determining the necessary requirements for alternatives is not typically driven by the function of any particular constituent substance, including the substance of concern per se, but on the function of the formulation as a whole in which those substances are being used. Thus, when providing information on the technical functions that are necessary for any alternative, information that may be provided from A&D companies is often focused on the required functions for a replacement formulation rather than a replacement substance. Furthermore, this will vary according to the different OEMs, products and parts where a replacement needs to be used, even for the same formulations.

It is also important to convey that where A&D companies are progressing with alternatives development and qualification, success is not guaranteed. If alternatives, that are being progressed, fail any part of the testing criteria, substitutions will exceed any originally anticipated timeline.

To help convey the challenges involved in alternatives development and deployment for A&D uses we call your attention to a paper produced by the Global Chromates Consortium for Aerospace's (GCCA), titled Aerospace & Defence Qualification Process Impacts on Ability to Substitute Cr(VI) Substances[6].

Please note this particular paragraph of the GCCA paper:

"Aerospace and defence (A&D) products operate and carry people in extreme environments over extended timeframes, while having to fulfil extremely challenging technical, reliability, and safety requirements. To ensure the safety and reliability of aerospace products, comprehensive airworthiness regulations have been in place globally for decades. **These regulations require a systematic and rigorous framework to be in place to qualify all materials and processes to meet stringent safety requirements that are subject to independent certification and approval through EASA and other agencies requirements.** Air, ground and sea-based defence systems, and also space systems, are subject to similar rigorous qualification requirements. Changes to A&D hardware offer unique challenges that are not seen in other industries."

Although the GCCA paper was written to support hexavalent chromium Authorisation applications, the qualification and certification processes described are also applicable to substitution of other substances in A&D systems. The following illustration adapted from that paper, provides a guideline on typical timescales when each part of the alternatives development progresses to plan and without set-backs.

[6] The entire paper can be found here on the GCCA website.

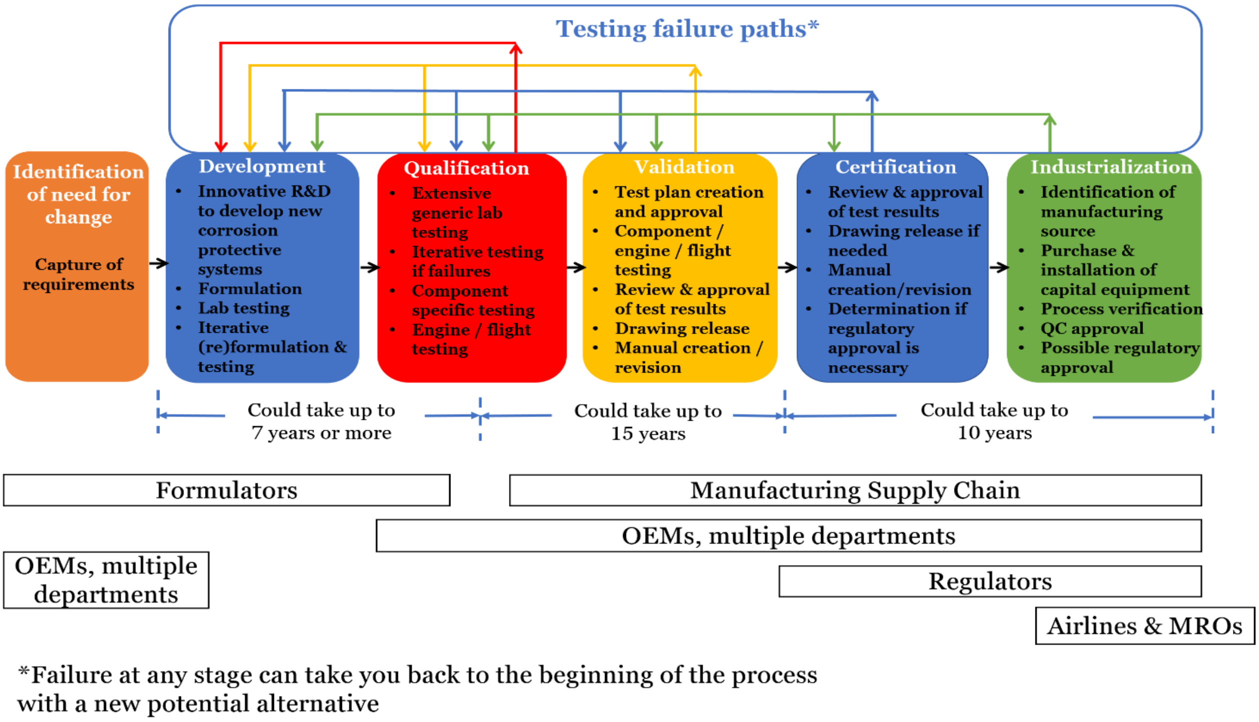


***Figure 1. Illustration of the development, qualification, validation, certification and industrialisation process required in the aerospace industry – adapted from the GCCA paper on Aerospace & Defence Qualification Process Impacts on Ability to Substitute Cr(VI) Substances[3] & Joint Analysis of Alternatives and Socio-Economic Analysis, Authorisation application 0203-02[4] .***

As also indicated in the GCCA paper, “The complex relationship between each component (in aerospace and defence systems) and its performance requirements within its own unique design parameters requires certification of each substitution individually (see Figure 2). Qualification in one particular application does not guarantee that use in another application is qualified. Every application must be individually assessed to determine that requirements are met. This process must be independently replicated across all A&D products by each A&D company. A&D products (e.g. a specific aircraft model) may be in service for 30-50 years (even longer in defence uses), requiring maintenance, repair and spare parts over their entire service lives. Any changes to these parts or processes must be fully validated and certified to ensure safety and performance are not compromised.”

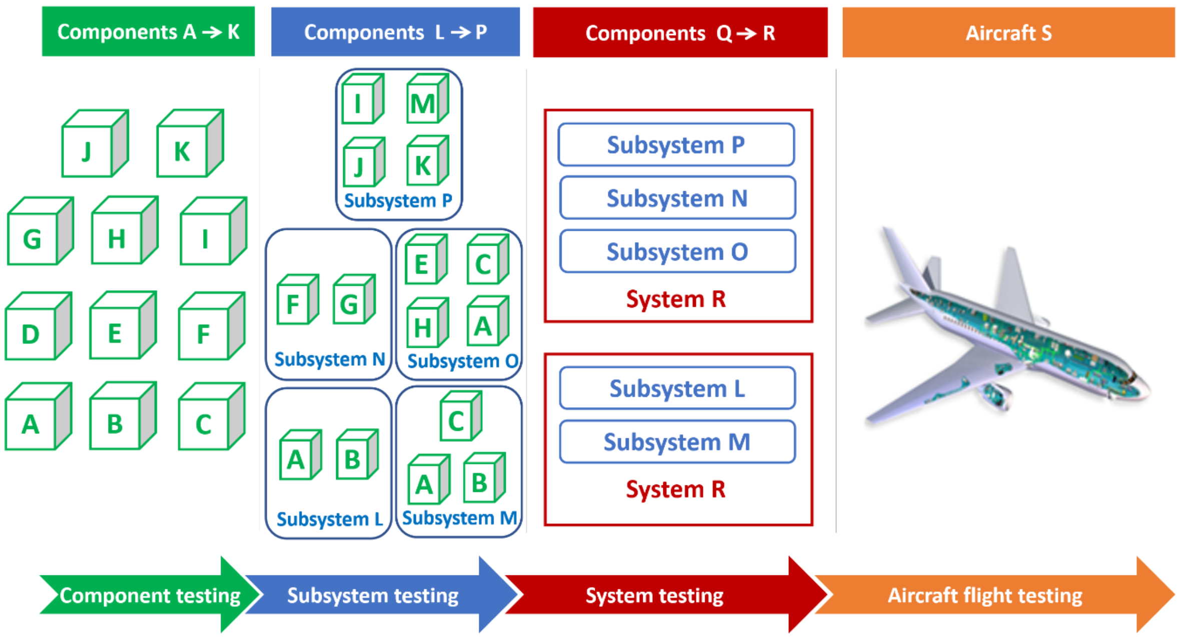


***Figure 2. Systems assessment and validation overview, reproduced from the GCCA paper on Aerospace & Defence Qualification Process Impacts on Ability to Substitute Cr(VI) Substances[3].***

In a non-use scenario (where restriction on PFAS substances use and presence in articles comes into force before A&D uses can be substituted), production and repair of the aerospace and defence products that rely on the use of PFAS substances or, as is often the case, formulations containing such substances would have to cease within the EEA. Imports of replacement and refurbished A&D parts and products that contain PFAS would not be permitted. This would, in effect, prevent the repair and maintenance of existing aircraft and defence products in the EEA and would prohibit the delivery of certain new, replacement or refurbished A&D components to the EEA. This non-use scenario would lead to the grounding of aircraft and defence platforms.

In some cases, companies may hold stocks of components containing PFAS, which are no longer being manufactured, and are retained in order to be able to repair and maintain existing aerospace and defence products throughout their service lives in the EEA. Aerospace and defence products are designed to have extremely long service lives, decades long in many cases.

If PFAS were prohibited in articles before the retirement of existing A&D products, then those products would no longer be able to be maintained in service in the EEA and any stock of PFAS-containing components would become unusable.

Please refer to Figure 3, which shows the viability of options for A&D companies in the case that a restriction for PFAS comes into force before PFAS substances are able to be removed from all affected products, parts and processes.

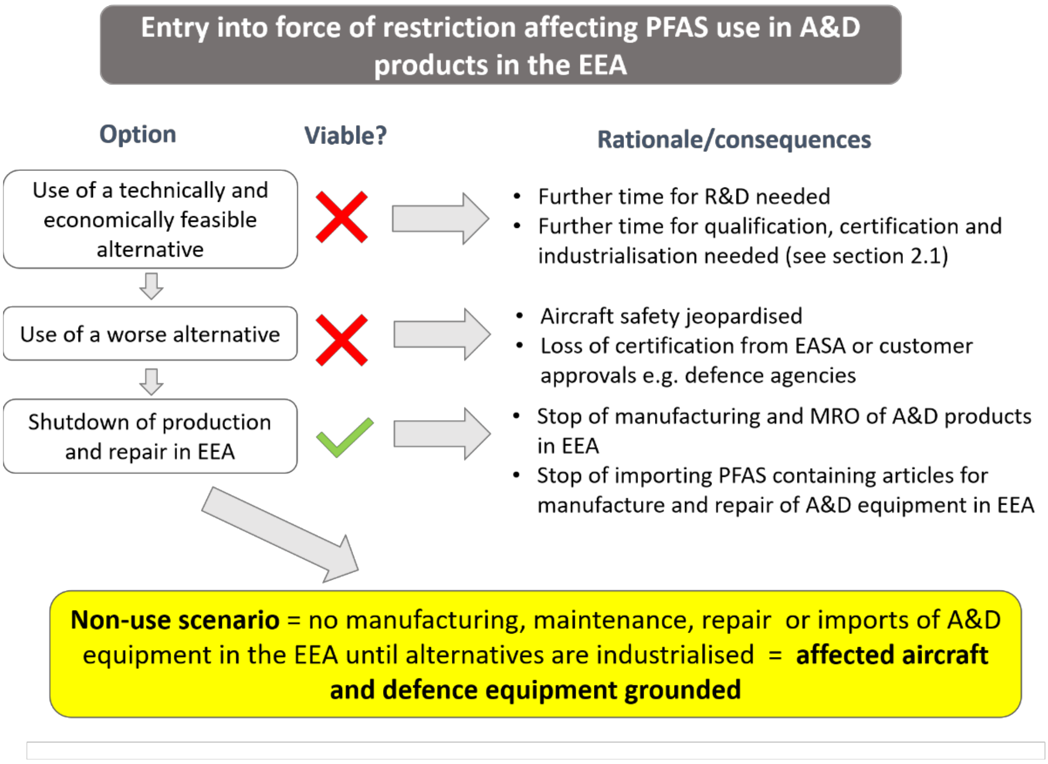


***Figure 3. Impacts of non-use scenario for A&D companies relying on PFAS in products and processes***

If PFAS substances were restricted from use in A&D products in the EEA, before all uses could be substituted, the economic impacts would be substantial. It would affect not just A&D companies, their supply chains and third-party MRO (Maintenance, Repair and Overhaul) facilities, but would also have significant impacts for customers (including airlines and defence agencies) and those who rely on the products and services provided by the A&D industry.

Economic impacts within the aerospace and defence sector would include:

- Loss of profits – OEMs, suppliers, airlines, repair and maintenance facilities, etc.
- Costs associated with unused stock disposal
- Costs for relocation of work outside of EEA – OEMs, suppliers, repair and maintenance facilities, etc.
- Penalties for failures to meet contracts (e.g., where servicing cannot be completed leading to aircraft being grounded)
- Economic consequences of commercial and freight aircraft groundings and flight cancellations

**Social and wider consequences if PFAS substances were restricted for use in A&D products before they could be substituted**

There would be interruptions to new A&D product delivery and to the maintenance and repair (servicing) of existing products, until PFAS-free alternative formulations could be developed and certified for the uses on the myriad parts and repair/maintenance schemes affected. The widespread implications for such a scenario cannot be understated and would include:

- Cease in production of A&D products within the EEA
- Cease in delivery of A&D products and spare parts to the EEA

- Inability to service and repair existing A&D products in the EEA or to import repaired and refurbished PFAS-containing components to the EEA – aircraft would be grounded, including defence fleets
- Loss of functioning A&D equipment in EEA
- Premature retiring from service of A&D equipment in EEA
- National security implications for Member States if they cannot maintain, deploy or operate affected defence products containing PFAS
- Reduced supply and increased costs of perishable goods transported by air including fruit and vegetables, fish and cut flowers.
- Price increase and reduced schedules for passenger flights and air freight
- Loss of jobs
- Closure of EEA-based facilities

Where procured articles supplied in accordance with A&D specifications are reengineered (e.g. gaskets & moulded products, fluid lines, hoses, pumps, valves and filters), requalification of the A&D systems which use them may be triggered if the change is significant. Requalification (if successful) demonstrates that the stringent performance requirements laid down in the specifications continue to be met. As described above, qualification supports certification of A&D products in the EU and other jurisdictions.

## Transportation – section D, questions in relation to impact of legislative measures

A PFAS prohibition would prevent the use of PFAS in the manufacture, operation and maintenance of A&D industry products in the EU. The use of PFAS in the manufacture of component parts/articles and formulations/mixtures along A&D supply chains in the EU would also be prevented. The many uses of PFAS by the A&D industry and its supply chains are highlighted throughout this consultation response and it can be seen that the impact of a blanket restriction would be immense.

As stated previously, it is the combinations or ranges of properties required for aerospace and defence applications that sets fluoropolymers apart from the alternatives. For this reason, it is likely that for many PFAS applications, the introduction of suitable alternatives is not possible. Thus a PFAS prohibition would threaten the very future of the industry.

A PFAS prohibition would curtail development of Hydrogen technologies and this would severely compromise the ability of the commercial aerospace industry in the EU to meet the challenging net zero objective. Again, the very future of the industry would be threatened.

A huge number of products **manufactured and assembled in-house** by ASD member companies are potentially affected by a PFAS prohibition. This will necessitate a multitude of substitution programmes which support qualification of alternatives. Simultaneous introduction of substitutes is not feasible. The A&D industry does not have sufficient skilled personnel to manage simultaneous introduction of substitutes. The multitude of simultaneous testing and qualification programmes necessary would be unmanageable and unaffordable. Thus continued certification of A&D products could not be supported.

In every case where PFAS are removed from the multitude of component parts/articles and formulations/mixtures **supplied to A&D industry specifications**, suppliers must ensure that the specifications continue to be met. This will necessitate a multitude of extensive test programmes along supply chains which will demand significant and costly resources over many years. This will increase the cost of procured items.

In cases where procured items have 'niche' uses and volumes are low, suppliers could find that it is not commercially viable to ensure that alternatives meet stringent A&D industry performance specifications, so suitable products could disappear from the market.

In the event of a PFAS prohibition, the introduction of alternatives (in cases where this is actually possible) could not be achieved in a short timeframe. Substitution programmes would take decades to complete.

Many articles that contain PFAS are made in Global supply chains and are supplied 'commercial-off-the-shelf'. Examples from throughout this consultation response include electronic components and moulded products such as 'O' rings. Global manufacturers may remove PFAS in order to access the EU market. The number of changed components supplied to the A&D industry may run into many thousands. All such changes have potential to result in the capability, reliability and safety of A&D products being degraded, with serious consequences for airline passengers and the defence capability of the EU and its allies.

Detailed impacts of a PFAS prohibition on the A&D industry are still being determined. Hence it is not possible to quantify the impact at this time in both economic and social terms. The number of product types identified as affected is already significant. The number of individual products affected is unknown, but is assumed to number many thousands, probably hundreds of thousands. This number is continually growing as new information emerges.

However it is clear that a PFAS prohibition that enters into force before successful alternatives development and substitution has taken place across the extensively affected range of parts and products, would compromise the very future of the aerospace and defence industry in the EU. This would cause consequential and significant damage to the defence capability of the EU and its allies.

A restriction that specified cut-off concentrations of PFAS in mixtures and articles at levels that are not achievable -would amount to a ban. Thus all PFAS-based mixtures and articles used by the A&D industry would disappear from the market. This would present an existential threat to the A&D industry in the EU. The European aerospace & defence industry is a major pillar of the European economy; ASD members together employed more than 890,000 people and generated a turnover of €260 billion in 2019 (ASD Fact & Figures).

An obligation to label products visibly with "Contains PFAS" would be different for every product type. Some of the issues and costs identified can be found in the remaining sections of this report.

An obligation to report the amount of PFAS in use and respective emissions would be different for every product and process. Some of the issues and costs identified can be found in the remaining sections of this report.

Specific waste management requirements with the obligation to collect, treat or recycle PFAS containing waste separately would require collection and management of significant quantities of data. The A&D industry is currently engaged in collecting and managing data to satisfy the obligation to provide data to the SCIP database under the Waste Framework Directive. The cost to industry of meeting SCIP database obligation has been calculated at 650-850 million Euros in 1 year (estimation base: **more than 1 million notifications** to be submitted by the sector to the SCiP database in 1 year requiring 3900+230 FTE`s plus IT investments). The cost of collecting and managing PFAS data may be similar. The introduction of separate waste streams would add significant extra costs as the number of waste streams could double.

## Transportation – section E, specific questions for the use

Missing PFAS applications have been included in the sections above and are listed here:

- Hydrogen
- Exterior surface coatings
- Fuel systems, hydraulic systems, cooling systems
- Machined and moulded parts
- Fluorocarbon release films.
- Fan blade wear strips for aero engines.
- Specialist cleaning fluids
- Thermal insulation

The PFAS content that is necessary in fluoro-elastomers for sealing applications, coating applications, lubricants and hydraulic fluids so that they can be used in the transportation sector cannot be accurately calculated by ASD. The A&D industry provides product performance specifications to suppliers of sealants, coatings, lubricants and hydraulic fluids which must be met by the supplier. Product SDS's may identify a % range for PFAS in such products and this could be multiplied by total product quantities across the industry. It should be noted that collecting this data would be a huge task. Furthermore, this approach would not capture data for PFAS that does not trigger a hazard classification and is not declared on a product SDS.

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## Defence – section B, questions in relation to the use

This section has been added to cover uses of PFAS that are specific to Defence. It includes:

- Defence Platforms
- Weapons, munitions and ammunition

### Multi-functional surfaces on Defence Platforms:

Fluoropolymers are essential to the manufacture and functionality of high-performance outer surfaces on current and future Defence Platforms in the Air, Naval and Land environments. These surfaces are multifunctional, however their functionality cannot be disclosed as this is classified information.

### Munitions

Fluoropolymers and PFAS substances are used in the manufacture of energetic materials and ammunition items. The manufacture of explosive materials and their incorporation into ammunition are both chemical processing, and require a wide range of process equipment which has to withstand corrosive chemicals at elevated temperatures. The seals and valves used in process equipment are required to be chemically inert having a high strength whilst retaining elasticity, and with a relatively long life when exposed to chemicals. Only polymers based on PFAS technologies can meet these requirements, and by doing so enable high safety levels to be maintained in production and manufacturing facilities through having resilient materials with a low risk of breakdown leading to contamination of energetic materials.

Certain fluoropolymers are included in energetic compositions because they provide functionality to the materials. A number of explosive compositions include fluoropolymers which act as a binder for pressed pellets, whilst the fluorine component provides enhanced oxidisation and reactivity for the explosive. Fox-7; Rowanex 3601 and other insensitive explosive compositions include fluoropolymers in their formulation. Various pyrotechnic compositions also use fluoropolymers which act as binders when pressed as pellets, but also because the unique chemistry of fluorine makes it an oxidiser which is even stronger than oxygen. Fluoropolymers have an essential use inthe manufacture of pyrotechnic flares used as anti-missile countermeasures for aircraft.

Various materials based on or including PFAS substances are also used in materials used as process aids to manufacture, and directly incorporated into ammunition. These include release agents used to prevent moulded explosives and other materials sticking to moulds; non-flammable contact cleaners used on electronic assemblies; and certain adhesives.

## Defence – section C, questions in relation to alternatives

### Multi-functional surfaces on Defence Platforms:

The range of properties conferred by fluoropolymers make them indispensable to meeting the stringent performance requirements for multifunctional surfaces used on Defence Platforms. There are no viable alternatives to fluoropolymers.

### Munitions

Currently there are no viable alternatives to the fluoropolymer based valves and seals used on equipment used in the manufacture and processing of explosives which provides the resilience and relative inertness to corrosive high temperature chemicals, and enables a high level of safety for processing of explosives and in the manufactured ammunition.

Fluoropolymer materials are used in a number of energetic compositions because of their unique chemistry. Fluorine is an extraordinarily strong oxidiser which can provide improved performance to various insensitive explosives, whilst also enabling these to be pressed into pellets for assembly into ammunition. When used in pyrotechnic flares used as aircraft defensive aids (missile decoys), the complex chemistry provides spectral output which can mimic the heat signatures of the aircraft jet exhaust. It is this unique chemistry which means that there are no viable alternatives.

The use of other PFAS chemicals in release agents and various adhesives is also important. PFAS based release agents can provide advantages over silicone based release agents in that the PFAS based materials are less liable to produce silicone contamination in undesirable parts of the ammunition. Whilst it is possible that there may be viable alternative adhesives, any changes to materials used in the processing and / or build of ammunition will have to undergo qualification to ensure compatibility with explosives and functionality in the application, which are critical requirements to prevent unintentional degradation of the energetic materials and long term safety of the ammunition over the course of its service life.

## Defence – section D, questions in relation to impact of legislative measures

### Multi-functional surfaces on Defence Platforms:

A blanket PFAS restriction would make it impossible to meet the stringent performance requirements for multifunctional surfaces used on Defence Platforms.  This would inhibit the performance of affected Defence Platforms and compromise the security of the EU and its allies.

### Munitions

It would also make it extremely difficult to impossible to manufacture ammunition without PFAS. Whilst there is a potential to use non-PFAS based seals and valves in processing, this would cause significantly increased costs due to the need for frequent process stoppage and change of materials; increased waste due to more frequent replacement of parts and a potential increase in risk to safety of the ammunition due to the enhance potential for unintended contamination of explosives in the event of mechanical failure of the seal or valves used in process equipment.

The use of PFAS as a composition material relates to the chemical characteristics of PFAS, and the fluorine atoms within them. There are no viable alternatives to those PFAS used in the compositions it is used in as they have direct function relating to performance. The pyrotechnic flares used as anti-missile countermeasures for aircraft are essential to mission capability, and PFAS polymers help produce the required spectral output to decoy missiles away from the aircraft.  As such, non-availability of PFAS for their manufacture would compromise the security of the EU and its allies.

## Fire suppression function uses -– section B, questions in relation to the use

Our industry uses PFAS for fire suppression function to protect Aircraft Engines/APU, Cargo, Lavatories and Cabin compartments from risk of permanently uncontained fire.

At the beginning of the Survey Questionnaire it is stated that the use of PFAS in firefighting foams is not part of this call for evidence.  However firefighting is included the Survey Questionnaire and associated summary reports for both F-Gas and Transport.  For avoidance of doubt, ASD wishes to emphasise the importance of continued availability of PFAS-based firefighting foams for firefighting purposes on naval vessels.

## Fire suppression function uses – section C, questions in relation to alternatives

Most Halon 1301 alternatives (HFC-125, 2-BTP, NOVEC 1230, CF3i) and all Halon1211 alternatives (2-BTP and HFC-236) are PFAS.

Assuming a non-PFAS Halon alternative is selected, a minimum of 15-20 years would be required for a complete transition.

The following steps would have to take place:

- R&D Technology assessment and validation with Airworthiness Authorities - Around 5 years.
- Technology solution development for each application (A/C) - Around 5 years.
- Technology deployment in production and flying fleet retrofit - Around 10 years.

The technical feasibility of PFAS-free alternatives listed in F-Gas use - Annex VII has not been demonstrated. None has reached a Technology Readiness Level 6 due to technical challenges (fire extinguishing performance and compliance to certification requirements, integration, toxicity,...).

The risk's profile of potential alternatives is being assessed. Notably:

- Inert Gas such as Nitrogen or CO2 – present health and safety risk of asphyxia in confined area.
- Dry chemical powder - health and safety risk is under assessment.

For fire protection using Halon and/or non-PFAS alternatives, the following approval schemes would apply:

- Fire suppression agents and equipment are generally controlled through industry standards such as NFPA, ASTM and ISO.
- Fire suppression systems shall be approved by agency such as EN, FM or UL.
- Airworthiness Authorities (FAA, EASA,...) shall validate fire extinguishing performance (called Minimum Performance Standards (MPS),
- Airworthiness Authorities (FAA, EASA,...) shall define application (A/C type) certification criteria and include it in Certification Specification (CS 25 for EASA for instance).
- Alternative agent shall be listed in US EPA SNAP List.
- Airframer OEMs shall then demonstrate and certify non-PFAS Fire Extinguishing system for each Aircraft Type sub-system (Engines / APU / Cargo / Cabin Portable Extinguishers / Lavatories) with regards to EASA CS25.

The below is a list of useful literature:

- US FAA TC Minimum Performance standard for Cargo compartment - https://www.fire.tc.faa.gov/Systems/Cargo
- US FAA TC Minimum Performance standard for Cabin Portable Extinguisher - https://www.fire.tc.faa.gov/Systems/handheld.asp
- US FAA TC Minimum Performance standard for Lavatories - https://www.fire.tc.faa.gov/Systems/LAVEX/MPS
- US FAA TC Minimum Performance standard for Engine / APU compartments - https://www.fire.tc.faa.gov/Systems/Engine

**Fire suppression (naval vessels):** While PFAS-based firefighting foams work particularly well at low-foaming levels and are capable of spreading very quickly across liquid fuel surfaces, fluorine-free foams are very dependent on a good foam quality to be effective and do not perform as well in covering large areas. Therefore, PFAS-based foams are used, for example, in sprinkler systems or whenever large fuel areas need to be quickly extinguished such as the rupture of a fuel tank on a naval vessel in combat or a crash landing of an aircraft on deck.

Film foaming is not as effective in alternatives, and efficiency is reduced by two thirds in studies. Military applications require fast and efficient extinguishing of fires, space and disposal considerations require minimum to be used, as surplus needs to be disposed of within the unique application in submarines, and a breathable atmosphere is to be maintained. The critical concentration, and the need for maintaining cleanliness and purity of the solution, is a concern.

Off ship, and internal to vessel, likely temperatures reach:

- Class A Hydrocarbon pool fire - 900deg C
- Class B Carbonaceous - 600deg C

Fluoro-containing foams maintain their foam integrity in high temperatures for longer, so their use is essential for Class A fires. Non-fluoro foams are potentially suitable for Class B fires, as the integrity of the foam is more likely to be maintained.  Non-fluoro foams could only be used in an area / system where there is no risk of a Class A fire.

Fluorine free foams do not currently meet the applicable Military specifications, therefore continued supply of PFAS-based foams which meet these specifications is required.

Is it possible that new PFAS-containing firefighting foam products are developed which contain lower quantities of PFAS than previously, whilst meeting the applicable Military specifications.  If so, it makes sense to allow such products to enter the market.

In the military context, there is an imperative for commonality across national and NATO fleets, and a need for an extinguishing foam to work on hydrocarbon fires in the shortest possible time.

Transition to fluorine-free foams on naval ships (including aircraft carriers) and submarines would not be possible until such foams were proven to meet military specifications.  Strong evidence required - no impact on crew safety, naval operations in hostile situations; no increased potential for loss of vessel, crew and hazardous artefacts on board.

The solution would be to find non-fluoro containing foams that are as effective and efficient as PFAS-based foams - there is a need to improve film integrity and durability in performance - e.g. potential additives such as surfactants.

## Fire suppression function uses– section D, questions in relation to impact of legislative measures

Should PFAS used in fire suppression be prohibited in the next 3 or even 10 years, complete transition to non-PFAS alternative (assuming a non-PFAS Halon alternative become available on the market) will not be achieved. Without exemption or derogation, Aircraft Crew members and Passengers safety could not be ensured without an on-board fire protection system. EU registered aircrafts would be then grounded with economical impacts on linked businesses such as Airports. Manufacturers in Europe will close with associated jobs loss or transfer outside of EU.  As mentioned above, assuming a non-PFAS Halon alternative is selected a minimum of 15-20 years would be required for a complete transition.

- R&D Technology assessment and validation with Airworthiness Authorities - Around 5 years.
- Technology solution development for each application (A/C) - Around 5 years.
- Technology deployment in production and flying fleet retrofit - Around 10 years.

Should the restriction specify cut-off concentrations of PFAS at levels that are lower than achievable, this would be problematic: Fire extinguishing agents are required to be used at purity levels of 99% or higher. Although PFAS agents would be considered as mixtures or articles, a maximum concentration level for PFAS of 0.1% would not allow for their use.

**Fire suppression (naval vessels):**  It is possible that new systems which utilise PFAS-based foams will not be produced - as the potential for environmental harm is understood.  This is entirely dependent upon testing, qualification and military approval of the replacement foam.  Transition is anticipated to be particularly difficult, perhaps impossible, where there is potential for Aircraft fuel fires on deck / any hydrocarbon fire.  Thus a military exemption for high performing PFAS foams would be appropriate.

A military exemption would:

- Enable EU navies to comply with the US requirement that NATO allies must use fluorinated fire-fighting foams which meet USN Spec MIL-F-24385 in order to carry out joint operations with USN.
- Support continued manufacture and supply of fluorinated fire-fighting foams to EU / NATO navies.
- Prevent operational difficulties when EU, USN and UK RN vessels operate in EU waters.

The naval sector transition period should continue until all of the following are complete:

- The US DoD 'alternative' non-fluoro Specification is published. Publication date is uncertain, with a forecast of 2023.
- Fluorine free foam which meets the new specification is available.

NATO MoD programmes to introduce fluorine free foam, vessel by vessel, are complete.