

Aerospace, Security and Defence Industries Association of Europe (ASD) COMMENTS ON THE ANNEX XV RESTRICTION REPORT FOR PER- AND POLYFLUOROALKYL SUBSTANCES (PFAS)

Reference: ECHA Public Consultation on the Annex XV restriction report of 22 March 2023 for Per- and polyfluoroalkyl substances (PFASs)¹

This is the joint contribution of the Aerospace, Security and Defence Industries Association of Europe (ASD) – to the ECHA Public Consultation on the Annex XV restriction report of 22 March 2023 for PFAS.

We are submitting detailed information specifically for Q6 including case studies to illustrate PFAS usage by this sector.

¹ Available at <https://echa.europa.eu/restrictions-under-consideration/-/substance-rev/72301/term>.

1 Summary

Who we are: ASD is the voice of European Aeronautics, Space, Security and Defence Industries, directly and indirectly representing around 3,000 companies. It has 22 major European companies as direct members and 23 National Associations active in 18 European countries. ASD members together employed 879,000 people and generated a turnover of €238 billion in 2021. See our webpage for more details: <https://www.asd-europe.org/>.

In this document, we submit our input to Q6. We provide information on identified uses of PFAS chemicals in A&D products, the types of PFAS and our assessment of how these uses have been considered by the dossier submitters in the proposed restriction and the extent to which they are in scope of proposed/potential derogations.

Table 1 gives details of the uses reported by ASD members with details of the PFAS type and a best guess assessment of which of the application areas described in the restriction report they may be assigned to. For each reported use, we then assessed whether they may be in scope of a proposed/potential derogation (details given in Annex 1). From this assessment, we see that while some of the A&D uses were assessed, a very significant number of uses were not assessed and not unsurprisingly are also not covered by any derogation. We also see that in principle, some of our uses were assessed but the dossier submitters did not include them in the proposed/potential derogations.

In terms of the derogation periods given in the proposed restriction, we also see that the maximum time period is 12 years. In the assessment of available alternatives for the uses assessed (Annex E of the restriction report), we can also see that the dossier submitters did not consider the specificities of our sector when determining the time needed for substitution.

In this report, we provide details of these specificities (chapter 2.2) and show that when they are taken into account, the impact risk option proposed (RO2) would be catastrophic both for our sector and the wider functioning of the EEA in terms of aviation and defence capability (chapter 2.3).

PFAS chemicals and in particular fluoropolymers are integral to the production, operation and MRO of A&D products. A given product may have many 1000's of PFAS containing parts integrated into the components, sub-systems, systems, etc. that make up the product. The driver for their use is their high performance in harsh/extreme operating conditions that underpin the safety and reliability of A&D products. Due to the formal quality management processes in place to ensure safety and reliability, substitution is lengthy even when potential alternatives are available. There are no potential alternatives available that can fulfil the performance requirements. Maintenance of in-service A&D products must also be done with spare parts as per the original approved design over the entire product service. Depending on the product, this can be 40+ years (e.g. aircraft) or longer (e.g. naval vessel). Changes in the production of the spare parts would trigger the need for requalification and recertification and likely redesign before the part could be taken into use. This is lengthy and it can also be that redesign is not technically feasible.

Due to the ubiquity of PFAS (primarily fluoropolymers) in the production, operation and MRO of A&D products, the scale of the substitution requirement that would be triggered by the proposed restriction has no precedent. The dossier submitters' assessment did not consider the specificities of the A&D sector and the derogations as given are inadequate both in coverage and duration. Due to the complexity of A&D products and the formal quality management systems in place, non-availability of even a limited number of parts will stop production of new products and scheduled maintenance of in-service products. This

means that the impact of the restriction would be felt already 18 months after the entry into force as all uses are not covered by a derogation. The impact would be quite simply catastrophic. The restriction as proposed does not have a plausible non-use scenario when our sector is included.

We ask the dossier submit to revise their proposal to include our sector; specifically

- Exclude fluoropolymers (and the precursor chemicals necessary for their manufacture) from the scope of the restriction given their ubiquity in A&D products and the absence of alternatives that fulfil the performance requirements for reliability and safety
- Include a sector derogation for the use of PFAS chemicals necessary for the production and operation of A&D products with a review clause to allow for an extension/renewal of the derogation if needed due to the non-availability of suitable alternatives
- Exclude the use of PFAS chemicals on their own, in formulations and in articles that are necessary for the MRO of existing products
- Include a time-unlimited derogation for specific PFAS chemicals used fire suppression systems (see case study 5 in Annex 2)

We also note that the reporting requirements on manufacturers and importers of PFAS or PFAS containing articles as well as formulators of PFAS containing mixtures relying on derogations (paragraphs 7 & 8) did not consider the specificities of our sector. Due to both the complexity of our products and our global supply chains (see chapter 2.2), it is not possible to collect, compile and report the information required under paragraph 7 within 18 months of the entry into force. The site specific management plans requirements given in paragraph 8 also cannot be implemented within 18 months of entry into force as the users will be need to collect information from all tiers of their supply chain and map PFAS in the 1000's of parts, components, systems etc. that make up A&D products. At least 5 to 10 years would be needed to be compliant with such requirements.

In addition, we highlight that the restriction refers to ppb levels in articles (paragraph 2) – the challenges associated with complying with the requirement were not considered by the dossier submitters as apriori to verify this, we would need to test all articles. This is not feasible for A&D products as 1000's of parts/components would need to be tested. In addition, standard test methods are not available for the range of articles that would need testing with this level of detection.

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List of abbreviations

2-BTP	Bromotrifluoropropene
A&D	Aerospace And Defence
ADCR	Aerospace And Defence Chromates Reauthorisation (REACH authorisation consortium)
AoA	Analysis Of Alternatives
APU	Auxiliary Power Unit
ASD	Aerospace, Security And Defence Industries Association Of Europe
CBRNE	Chemical, Biological, Radiological, Nuclear, And High Yield Explosives
Cr(VI)	Hexavalent Chromium
CRES	Corrosion Resistant Steel
EASA	European Aviation Safety Agency
ECHA	European Chemicals Agency
EEA	European Economic Area
EoL	End Of Life
ESA	European Space Agency
ETFE	Ethylene Tetrafluoroethylene
EU	European Union
FAA	Us Federal Aviation Administration
FEP	Fluorinated Ethylene Propylene
FEPM	Tetrafluoroethylene Propylene
FFKM	Perfluorelastomers
F-Gas	Fluorinated Gas
FKM	Family Of Fluorocarbon-Based Fluoroelastomer Materials
FMQ, FVMQ	Fluorosilicone Rubber
FP	Fluoropolymer
FPG	Fluoropolymers Product Group
GCCA	Global Chromates Consortium For Aerospace (REACH authorisation consortium)
Halon 1211	Bromochlorodifluoromethane
Halon 1301	Bromotrifluoromethane
HFC	Hydrofluorocarbons
HFC R-134a	1,1,1,2-Tetrafluoroethane
HFC-125	Pentafluoroethane
HFC-236	Hexafluoropropane
HFE	Hydrofluoroether
MEA	More Electric Aircraft - A Term For Next Generation Aircraft Power
MoD	Ministry Of Defence
MRL	Manufacturing Readiness Level (1-10); Market Acceptance Readiness Level (11-15)
MRO	Maintenance Repair & Overhaul
NASA	National Aeronautics And Space Administration (US)
NOVEC 1230	Perfluoro(2-Methyl-3-Pentanone)
ODS	Ozone Depleting Substances
OEM	Original Equipment Manufacturer

PCB	Printed Circuit Board
PEBHF	Phosphate-Ester Based Hydraulic Fluids
PEMFC	Proton-Exchange Membrane Fuel Cells
PFA	Perfluoroalkoxy Alkane
PFAE	Perfluoroalkylether
PFAS	<u>Per-</u> And <u>Poly</u> <u>fluoro</u> <u>alkyl</u> <u>S</u> ubstance
PFPE	Perfluoropolyether
PSI	Pounds Per Squire Inch
PTFE	Polytetrafluoroethylene
PVDF	Polyvinylidene Fluoride
PVF	Polyvinyl Fluoride
R-1234yf	2,3,3,3-Tetrafluoropropene
REACH	Registration, Evaluation, Authorisation And Restriction Of Chemicals (Regulation (EC) No 1907/2006)
RO	Restriction Option
SEA	Socio-Economic Analysis
TFE	Tetrafluoroethylene
TRL	Technology Readiness Level
TULAC	Textiles, Upholstery, Leather, Apparel And Carpet
U.S.	United States
UK	United Kingdom
US DoD	US Department Of Defence

2 Overview of PFAS usage by the A&D sector

2.1 Use identification and assessment of derogation suitability

As soon as the restriction proposal was available on the ECHA website, ASD members initiated new activity to identify any further PFAS uses and to understand the impact of the proposed restriction on their sector and the extent of coverage of the proposed (5a-5t, 6a-6f) and potential (5u-5ee, 6h-6o) derogations. As outlined in our reply to Q2, PFAS chemicals are integral to the production, operation and MRO of A&D products. For example, a given product (e.g. a commercial airliner) will contain many 1000's of individual fluoropolymer parts/components integrated to subsystems, systems and assemblies.

A questionnaire with pre-defined questions was circulated between ASD members, with fields for free text answers. ASD members completed the questionnaires based on their current knowledge of where PFAS chemicals are used in the products and supply chains. Due to the limited time available, it was not possible to complete an exhaustive supply chain investigation. The aim was to collect a sector-wide first understanding of uses and to map coverage by the proposed and potential derogations as a first step in determining the impact of the proposed restriction. This exercise is not intended to be exhaustive or definitive. It was done solely in the scope of the restriction proposal and considering the applications identified by the dossier submitters (Annex A to the restriction dossier).

The questionnaire had fields to report uses by "application area/main use", the type of PFAS used and their understanding of whether each identified use may be covered by a proposed/potential derogation. ASD members reported uses in the "application area/main use" fields according to their products.

The completed questionnaires from each member were compiled to yield a wide dataset covering uses of ASD members and their supply chains. Duplicates for "application area/main use" were merged. An external contractor used expert judgement to assign reported uses to the use categories defined by the dossiers' submitters in Annex A of the proposed restriction dossier. The dataset was then used to extract details of the types of PFAS chemicals reported for each application area/main area. The contractor used expert judgement to categorise the PFAS reported in use by ASD members to particular groups; fluoropolymers, fluorinated gases, unspecified PFAS, fluorinated alkene or fluorinated organic fluids). The assignment of the reported PFAS to a PFAS type is given in Annex 1. The reported PFAS for each application area were grouped by types given in Table 1. The responses to the questionnaire depend on the products made by the member (e.g., aircraft, engines, landing gear, defence systems). There are many commonalities between the products since fluoropolymer PFAS are ubiquitous material for seals, gaskets, sleeves, tubing, cables, hosing, bearings, bushings and as components of lubricants, sealants and hydraulic fluids.

From Table 1, it can be seen that a very extensive set of application areas/main areas have been reported across the sector and that many of these cannot be assigned to a restriction use category included in Annex A by the dossier submitters. These are reported as "miscellaneous" in the Table. It can also be seen that fluoropolymers are the most common PFAS type. Note that the assignment of an A&D reported use to a restriction use category was a best guess based on current understanding of Annex A of the restriction report. The sub-uses given in Annex A for "transport" are not extensive and "defence industry" sub-uses are not given.

Some uses which have been categorised under "Applications of fluorinated gases" use 2-bromo-3,3,3-trifluoroprop-1-ene (CAS 1514-82-5, EC 627-872-0), which is a liquid at room temperature and pressure,

but due to its low boiling point and high vapour pressure, is considered a gas in use. The fluorinated alkene reported was TFE (tetrafluoroethylene, CAS 116-14-3, EC 204-126-9). It is expected that this will be in the polymeric form in its final use but was reported separately by ASD members.

Table 1. Alignment of use categories as stated by the dossier submitter (Annex A) with those reported by ASD members for each PFAS type

Possible restriction Use Category (& sub-use) (Annex A)	Sub use identified by ASD members	Fluoropolymer	Fluorinated Alkene (non polymeric)	Fluorinated organic fluids (non polymeric)	Fluorinated gases	Unspecified PFAS
Applications of fluorinated gases	Cooling agents			x		
	Refrigerants			x	x	
	Refrigerants for air conditioning in military vehicles				x	
	Handheld fire extinguishers			x		
	Lavatory fire extinguishing systems				x	
	Cargo fire extinguishing systems			x		
	Engine and APU fire extinguishing systems			x	x	
	Fire extinguishers			x		
	Anti-corrosion products				x	
Transport* (Body-, hull- and fuselage construction)	Fire resistant bulkhead	x				
	Cellular materials	x				
	Housing	x				
	Radomes	x				
	Welding					x
Applications of fluorinated gases; solvents (Cleaning agents)	Specialist cleaning fluids			x		x
	Cleaning fluids				x	
	Cleaning agents			x		
	Cleaning solvents			x		
	Contact cleaners			x		
	Degreasing solvents			x		
	Precision cleaners			x		
Transport* (Coating and finishings)	Fan blade wear strips	x				
	Anti-slip paint	x				
	Abrasion resistant coatings	x				
	Varnish for electronics	x				
	Electrical coil varnish	x				
	Coatings	x				
	Paints	x				x
	Varnish	x				

Possible restriction Use Category (& sub-use) (Annex A)	Sub use identified by ASD members	Fluoropolymer	Fluorinated Alkene (non polymeric)	Fluorinated organic fluids (non polymeric)	Fluorinated gases	Unspecified PFAS
	Lacquers					x
	Chemically resistant coatings	x				
	Anti-foul paints					x
Electronics and semiconductors	Cable insulation	x	x			
	Electronic displays and touch screens	x				x
	Semiconductors					x
	Vapor phase soldering	x		x		
	Cables	x				
	Soldering	x				
	Protection sleeves					x
	Batteries	x				x
	Printed circuit boards	x				x
	Connectors	x				
	Optical fibre accessories	x				
	Harness insulation	x				
	Shrink sleeves	x				
	Components					x
	Lead-free soldering					x
	High frequency connectors	x				
	Coaxial cables	x				
	Dielectrics	x				
	Soldering fluxing agent	x				
	Sleeves	x				
	Flexible sleeves	x				
	Solder sleeves	x				x
	Conformal coatings	x				
	Boots	x				
	Tubing	x				
	Electronics					x
	Metal-plated wires	x				
	Loom guides	x				
	Looms	x				
	Pin carriers	x				
Energy sector	Proton exchange membrane (PEM)	x				
	Covering foils	x				

Possible restriction Use Category (& sub-use) (Annex A)	Sub use identified by ASD members	Fluoropolymer	Fluorinated Alkene (non polymeric)	Fluorinated organic fluids (non polymeric)	Fluorinated gases	Unspecified PFAS
Food contact materials and packaging** (Foils ²)	Foil heaters	x				
	Identification tape	x				
	Wrap for engine casings	x				
Food contact materials and packaging	Potable water systems					x
Transport* (Hydraulic fluids)	Hydraulic fluids	x		x		x
	Anti-corrosion liquids (hydraulics)			x		
Laboratory equipment	Diagnostic tests	x				
	Calibration of measurement instruments	x		x		x
	Calibration standard	x				
	Chemical detectors for military applications	x				
Lubricants	High temperature greases	x		X		
	Release agents	x		X	x	x
	Dry film lubricants	x		x		
	Perforated and non-perforated fluorocarbon release films					x
	Ammunition release agents	x				
	Bearings	x				
	Bushings	x				x
	Piston bearings		x			
	Thread lubricants	x				
	Lubricating oils	x				
	Lubricants	x		x		
	Anti-friction coatings	x		x		
	Solid lubricants	x				
	Self-lubricating coatings	x		x		x
	Chemically resistant greases	x				
	Greases for military applications	x				
	Greases	x	x			
	Release foils	x				
	Moulding	x				
	LVDT lubricants	x				

² See reply #8.1 in the ECHA Q&A from the webinar available at https://echa.europa.eu/documents/10162/2156610/230405_upfas_webinar_qa_ds_en.pdf

Possible restriction Use Category (& sub-use) (Annex A)	Sub use identified by ASD members	Fluoropolymer	Fluorinated Alkene (non polymeric)	Fluorinated organic fluids (non polymeric)	Fluorinated gases	Unspecified PFAS
	PTFE sheet for cabin emergency trap sealing	x				
	Sliding pads	x				
	PTFE and graphite filled polyamideimides	x				
Metal plating and manufacture of metal products	Nickel PTFE coating	x				
	Metal coatings					x
	Lamellar zinc surface treatments					x
	Metal plating	x				
	Lamellar zinc plating	x				
Pyrotechnics	Plastic bonded energetic material	x				
	Igniters	x				
	Relays	x				
Transport* (Sealing applications)	Seals	x		x		x
	Sealants	x				
	Adhesives	x				x
	O-rings	x				
	Gaskets	x				
	Backup rings	x				
	Tapes	x				
	Insulation tapes	x				
	Pressure-sensitive tapes	x				
	Adhesive sheets	x				
	Adhesive fabrics	x				
	Grommets	x				
	Hydraulic system seals	x				
	Slipping rings	x				
	Drive train seals	x				x
	Interlay sealants	x				
	High temperature sealants	x				
	Overcoating	x				
	Aircraft window gaskets	x				
	Wedge	x				
	Adhesive tapes	x				
	Pellet and strip locking	x				
	Bellows	x				

Possible restriction Use Category (& sub-use) (Annex A)	Sub use identified by ASD members	Fluoropolymer	Fluorinated Alkene (non polymeric)	Fluorinated organic fluids (non polymeric)	Fluorinated gases	Unspecified PFAS
	Valve seats	x				
	Grand plates (washer)	x				
	Shutters	x				
	Collar trim	x				
	Primary ring adapters	x				
	Washers	x				
TULAC	Anti-g suits	x				
	Cover vehicle seats					x
	Fire resistant glass cloth	x				
	Coated Fabrics for Rafts or Canopy					x
	Camouflage nets	x				
	Lacing ties	x				
	Coated yarns	x				
	Yarns	x				
Miscellaneous (not assignable)	Tank liners	x				
	Thermal insulation	x				x
	Filters	x				
	Pipes	x				
	Hoses	x				
	3D-Printing agents					x
	Heat transfer fluids					x
	Polyimide plastic					x
	Hydraulic hoses	x				
	Pumping rings	x				
	Tooling	x				
	Membranes	x				
	Oil level accessories	x				
	Half shells for anti-rotation coils	x				
	Cushion clamps	x				
	Mechanical parts	x				
	Rubber mats					x
	High performance polymeric membrane (filter)	x				
	Anti-vibration parts	x				
	Cable ties	x				
	Carriers	x				

Possible restriction Use Category (& sub-use) (Annex A)	Sub use identified by ASD members	Fluoropolymer	Fluorinated Alkene (non polymeric)	Fluorinated organic fluids (non polymeric)	Fluorinated gases	Unspecified PFAS
	Duct oil	x				
	Dyes	x				
	Elastomeric components	x				
	Extruded profiles	x				
	Flex	x				
	Friction devices		x			
	Fuel hose assemblies	x				
	HAD process surface treatments					x
	Holders	x				
	Liners	x				
	Markings	x				
	Fuel tank membranes	x				
	Oil hose assemblies	x				
	Packing	x				
	Pin holders	x				
	Critical foam packaging	x				
	Plastic for interiors					x
	Pneumatic assemblies	x				
	Rubber strips	x				
	Shock absorbers	x				
	Site glass	x				
	Special rubbers	x				
	Low friction thermoplastics	x				
	Process equipment	x				x
	Heat Transfer fluids (polymeric)	x				
	Heat transfer fluids for brazing furnace			x		

* "transport" does not cover many defence and security products (weapons, munitions, launchers)

** The assignment was a best guess focussing on "packaging" – details in Annex A are quite limited

Derogation assessment: Information on possible derogation coverage was then extracted from the dataset. In this context, "coverage" solely means that the contractor could make a link between the reported use and a derogation (i.e. the use may be in scope of the derogation). The contractor used the information reported by ASD members in their completed questionnaires and expert judgement based on the content of the dossier and the Q&As from the ECHA webinar. Expert judgement/best guess was used to assign each application area as "unassessed" or "assessed/partially assessed" by the dossier submitter and to determine where applications could perhaps fall under a proposed/potential derogation.

Note that as the dossier submitters did not include aerospace, defence and security as application areas in their assessment, coverage is very limited and open to interpretation.

Details of the derogation assessment are given in Annex 1. In terms of A&D areas assessed by the dossier submitters and possibly covered by a proposed derogation, 5-k, 5-m and 5-s were the most assigned (see Table 15). Of the ASD application areas considered to be “partially assessed” by the dossier submitters, the potential derogation 6-o “transport” was the more assigned by the contractor (see Table 16). Note that this is using a very wide interpretation of “transport” – many defence and security uses are not “transport” and they will not be covered. For two ASD application areas that were assessed by the dossier submitters, release agents and release foils, it is open to interpretation if they are covered by the proposed derogation 5-s “lubricant”. The contractor assigned these two applications separately as “5-s?” – see Table 17. However, a **significant number of ASD application areas** were considered to be **either fully or partially assessed** by the dossier submitters but **not assignable to either a proposed/potential derogation** (see Table 18). A **significant number of ASD application areas** were **not assessed** by the dossier submitters and are mostly **not assignable to a proposed or potential derogation** (see Table 19 (red)).

From this investigation into ASD member uses, ASD has further confirmed that PFAS chemicals are ubiquitous in the production, operation and MRO of A&D products. Fluoropolymers are the most widely reported PFAS type as articles (seals, cables, etc.), integrated into articles (paints, coatings, sealants, etc.) or components of mixtures (e.g. lubricants, cleaning agents) across all A&D products. When assessing identified ASD member uses of PFAS against the scope of the proposed/potential derogations, it is clear that there is insufficient coverage for the vast majority of its application areas.

From the use and derogation assessment, it is clear that if the restriction (RO2) came into force as proposed, the impact on the sector would be significant and would already be apparent within the 18 month transition period, since ca. half of the PFAS uses identified to date would not be covered at all by either a proposed or potential derogation. For those uses that could be covered by a proposed/potential derogation, and assuming these uses could even viably continue in the absence of the non-covered uses, the A&D sector would need to rely on a scattered and incomplete set of derogations, with expiry dates that do not consider the challenges and specificities for developing and introducing alternatives in the sector.

Such a situation, where some A&D uses are not derogated for and others are sporadically covered by multiple non-A&D specific derogations with short (12 years and less) expiry periods would lead to non-use scenarios being realised. Even if one PFAS-reliant component or formulation, critical to manufacture or MRO of an A&D product is no longer available (e.g. due to lack of clear derogation), the product manufacture and in-service support would cease. Taking civilian aviation as an example, this would mean grounding of aircraft. We see that this has not been considered by the dossier submitters.

In terms of derogation periods, particularly for fluoropolymers (which may never be replaced with less ‘persistent/resilient’ alternatives), 5 or even 12 years is inadequate for the A&D sector, even if there were potential alternatives available, due to the strict qualification and certification requirements that have to be met before a new alternative can be safely introduced and the long product service lives together with the associated need for spare parts/legacy spare parts to be available for decades. It would take decades for a full phase out if suitable alternatives could even be developed. The substitution requirement would impact thousands of parts, components, sub-systems etc. in all A&D products on a scale that has no precedent for this sector.

2.2 Specificities of ASD products

As outlined in our reply to Q1, PFAS chemicals are used in the production, operation, and maintenance of A&D products and/or in the manufacture of component parts (articles), sub-assemblies and formulations (mixtures) in A&D supply chains. This means that the impact of the restriction needs to consider production, operation and MRO activities.

2.2.1 High performance in harsh/extreme operating conditions is a key requirement for safety and reliability of A&D products

From our use identification to date, it is already clear that PFAS chemicals are ubiquitous in A&D products. Fluoropolymers in particular are integrated at every level of the supply chain relating to the production, use and maintenance, repair and overhaul (MRO) of A&D products. Due to their unique combination of properties (chemical inertness, thermal stability over a wide temperature range, non-stick and low friction properties, electrical insulation, weather and UV resistance, high resistance to corrosive liquids and gases,, mechanical strength and durability) they are used in seals, sealants, gaskets, lubricants, bearings, bushings, etc. the parts, components and systems that make up A&D products. The drivers for their ubiquitous use stem from their high performance in harsh/extreme operation environments that underpin the safety and reliability of A&D products. They have been integrated into A&D products due to their performance and an A&D product will have 1000's of PFAS containing parts integrated into components and systems. There are formal quality management systems in place to qualify and certify/approve A&D production, operation and MRO. This means that once a product is approved, there are formal change management protocols that must be followed for any change. This means that a substitution requirement to change all current PFAS containing parts has to follow the quality management systems in place to ensure continued safety and reliability of A&D products.

2.2.2 Complexity in terms of number of parts

A&D products are generally very complex assemblies of parts, components, sub-systems and systems. For example, a single product such as a tank or air defence system contains many thousands of parts, utilising an exceptionally wide range of materials and technologies in the engines, structure, wheels, radio communications, controls, fuel system, lubrication systems, hydraulic systems, munitions, CBRNE protection, etc.. Hydraulic systems will have PFAS containing hydraulic fluids, hoses, seals, gaskets, filters and cables. In an aircraft such hydraulic systems are then used in braking systems, landing gear, wing flaps, flight-control surfaces, engine pumps, air turbines, and many other area. A single major platform such as a ship or aircraft can have millions of parts, many of which are complex assemblies. Figure 1 illustrates that products like commercial aircraft are assembled from parts that are themselves made up of thousands of parts. It has been estimated that around 400,000 - 500,000 PFAS-containing components are likely to be present in a smaller short-haul commercial aircraft, whilst in larger aircraft the number of PFAS-containing components will likely be in excess of 1 million.

2.2.3 Illustrative examples of the diversity of A&D uses of PFAS in a diversity of A&D products

20 case studies are given in Annex 2 illustrating the use of PFAS in A&D products, and providing a thorough explanation on the reasons/ needs and the status of alternatives. These examples are not exhaustive and many other uses of PFAS chemicals are also still required. Some highlights are given below.

For example, a **commercial airliner** will have many thousands of integrated fluoropolymer seals, gaskets, sealants, coatings, cables, connectors in its gas turbine engines, landing gear, fuel systems, brake systems and electronic systems. Fluoropolymer seals are used in various critical applications within gas turbine engines, such as sealing combustion chambers, fuel systems, lubrication systems, hydraulic systems, and other high-temperature and high-pressure components. The specific choice of fluoroelastomer seal

depends on the operating conditions, fluid compatibility, and temperature requirements of the engine component (see case studies 3, 14). **Gas turbines engines** in turn have applications in a very broad range of fields – the major ones are aviation, oil and gas, marine propulsion, power generation and industrial applications. PFAS containing lubricants and hydraulic fluids are integral to the functioning of safety critical components like aircraft gas turbines (jet engines), including actuators, flight control systems and landing gear systems, maritime gas turbine, combustion engines (see case studies 7, 14) .

Lubricants are another example. Fluoropolymers are very widely used as lubricants for bearings, valves, actuators, regulators, gears and gearboxes, gear chains, mechanical devices (like hatch opening) and fasteners in general. **Electronic systems** also have integrated fluoropolymer components due to their inertness, light weight, mechanical strength, and durability (see case study 18). **Energy sources** like Li-ion batteries and hydrogen fuel cells also have integrated fluoropolymer components (see case study 6).

Non-polymeric PFAS are used in the operation of A&D products. For example, commercial airplanes, military vehicles, naval vessels including aircraft carriers and submarines use **clean agent fire suppression systems**. Clean fire suppression systems are designed to rapidly extinguish the fire without leaving residues that damage equipment or cause harm to humans breathing them in. PFAS gases have generally replaced or are about to replace halon as the fire suppression agent. Halon was banned under the F-gas Regulation and Ozone Depleting Substances (ODS) regulations. It was also banned for non-essential uses since 2003 and banned for essential uses by 2040. For aircraft fire extinguishers systems and other A&D uses, the replacement of halon (as required by the Montreal Protocol and associated regulations) has been staged over time, some systems being already addressed/retrofitted, some others on track for approval in 2024 - in most of the cases, the halon replacements are PFAS chemicals (see case study 5).

PFAS chemicals are also used as heat-transfer fluids in **refrigerant systems**. For example, in defence platforms, including jet fighters, surveillance platforms, transports, helicopters, naval ships, submarines and land vehicles, they are used in weapon systems to cool high output electrical and electronic equipment in addition to air conditioning, general equipment cooling and food preservation. In commercial aircraft, refrigerant systems are used for cabin air conditioning, avionics cooling, galley cooling, cargo hold cooling and equipment cooling (see case study 4).

Other PFAS chemicals are used in operation and maintenance activities to modify surfaces to repel rain and dirt. For example, they are used as rain repellent agents in fluids applied to windscreens in aircraft, military aircraft canopies, defence platforms like aircraft carriers, etc. They impart water repellence to windscreen surfaces ensuring good visibility under all weather conditions. They are also used in cleaning fluids to prevent rainwater sticking to surfaces leading to ice formation at high altitudes and changes to the weight and balance of the aircraft during flight. Another example of their use is in the technical textiles coating mainly used in the land defence vehicles and tanks, aircrafts, etc. for their fire and smog resistance properties and as water and oil repellence at the same time.

More details are given in Section 2.3.

2.2.4 Very long service lives and availability of spare parts and materials for operation and MRO

Products typically have decades long service lives meaning that a continuous supply of parts and material must be available for their operation and also in maintenance, repair and overhaul (MRO) until the end of service life. The latter also particularly relates to ships and submarines including for lay-up prior to decommissioning. All spare parts and materials are generally required to be as per the original design specification in all key attributes including physical, chemical, surface wear, life, reliability and compatibility with adjacent materials and components.

2.2.5 Complex multi-tiered supply chains

Due to the complexity of the products, each OEM will deal with hundreds of suppliers for each product/platform type. For some suppliers, production will be based on customer (OEM) drawings. Others will have their own designs and supply chains using a variety of custom and off-the-shelf commercial components. A simplified two region supply chain diagram is given in Figure 2 to illustrate the complex interrelationships and many levels of the global supply chain.



Figure 1. Illustration of the complexity of A&D products (adapted from Figure 8 in the ASD Sectoral Guidance for WFD/SCIP implementation³)

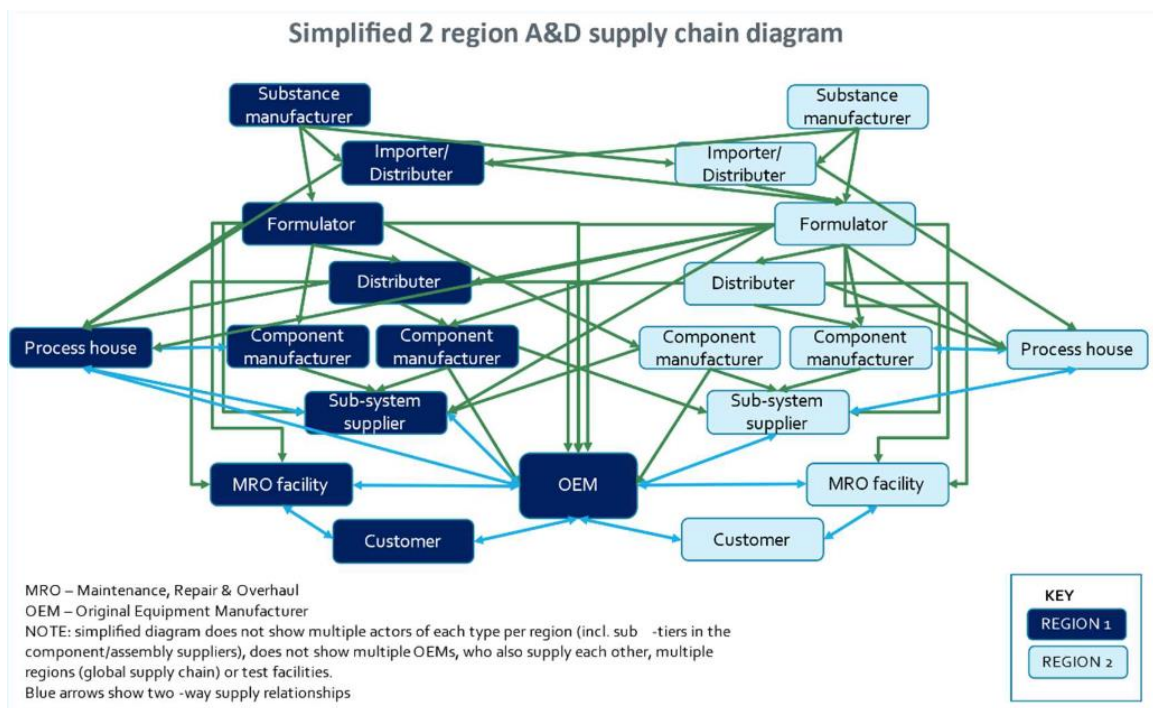


Figure 2. Simplified 2 region A&D supply chain showing the interdependences between the different tiers (reproduced with permission from the ADCR authorisation applications⁴ for CrVIs for the A&D sector)

³ ASD Sectoral Guidance for WFD/SCIP implementation available at <https://www.asd-europe.org/sites/default/files/2022-08/ASD%20Sectoral%20Guidance%20for%20WFD-SCIP%20implementation0505.pdf>

⁴ ADCR application for authorisation for continued use of hexavalent chromates; Application ID 0327-01 "Chemical conversion coating using chromium trioxide, sodium dichromate and/or potassium dichromate in aerospace and defence industry and its supply chains" available on the ECHA website at <https://echa.europa.eu/en/applications-for-authorisation-consultation/-/substance-rev/74108/term>

2.2.6 Formal quality management systems in place to ensure safety and reliability of A&D products

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. Formal quality management systems are in place to ensure safety and reliability of A&D products throughout their service lives. For example, to ensure aircraft safety, comprehensive airworthiness regulations⁵ 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 requirements⁶ are in place to ensure airworthiness for defence systems in Europe. Ground and sea-based defence systems are subject to similar rigorous qualification requirements. They operate in extreme environments over many years. In the defence sector, many national, European and NATO standards are obligatory and must be reached to be compliant with the NATO requirements settled by the allies in the international agreements. Space systems must also meet the highest specifications for consistent reliability and performance in extreme environments over many years, since repair or maintenance is practically impossible once the technology is launched.

This means that every alternative for an existing use must be successfully qualified (evaluated and tested) in the context of the whole system/sub-system. This has to be demonstrated for every existing use to be replaced, even if the alternative is the same. Once qualified, the system must be revalidated 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 (European Aviation Safety Agency (EASA), the US Federal Aviation Administration (FAA) and their military counterparts).

Alternatives can only start to be used once they have successfully passed the qualification and certification stages. This means that substitution is a lengthy process. The specificities of the substitution process for the A&D sector are described in detail in the ADCR authorisation applications – see for example chapter 3.1.2 of the AoA-SEA report of the application requesting authorisation for continued use of hexavalent chromates in conversion coatings⁴.

The scale of the substitution effort that would be required, if new materials are ever developed to replace PFAS (but in particular fluoropolymers), has no precedent. Thousands of formulations, parts, components, systems etc. across all A&D products would be affected.

Note that one of the challenges is to find suitable substitutes that fit with the existing product design. These are more or less frozen as they are tied to the type certification, making substitution technically and/or economically impractical. The “form, fit, function” requirements, that alternatives have to comply with, may mean that a complete redesign could be needed, which may in turn impact on product characteristics such as weight and adversely impact environmental performance. Retrofitting in-service

⁵ E.g. European Union (EU) Regulation No 216/2008 and the EASA CS-25 and EASA CS-E in the EU

⁶ The European Aviation Requirements (EMARs) established by the European Defence Agency (EDA) Airworthiness Authorities (MAWA) Forum

products also has temporal, logistical & economic challenges. For example, one OEM has design responsibility for a customer fleet of 12000 in-service civilian aircraft.

2.3 A&D uses of PFAS chemicals (Missing uses (Q6))

Based on the use mapping reported in section 2.1, ASD see that the specificities of their A&D sector have not been considered by the dossier submitters (variety of different A&D products concerned, number of parts and products concerned, strict qualification/certification requirements, long service life requiring parts to be available for decades, complex supply chains). To be clear, the potential derogation “transport” (6-o) is not adequate for the A&D sector as not all uses would be covered and the time limit of 12 years is insufficient.

For this reason, ASD provide information on A&D sector uses of PFAS in its reply to Q6 and request A&D to be considered as a sector in its own right, when determining derogations.

2.3.1 Tonnage and emissions – PFAS uses by the A&D sector (ECHA Q6a)

ASD members are typically OEMs and system integrators and the PFAS will generally be used by the members but also throughout their upstream suppliers (parts, components, systems, sub-systems providers), service providers (MRO providers) and customers (airline companies, defence forces and their service providers). It is therefore very challenging to estimate likely tonnages and emissions.

Types of PFAS: Based on the identification of PFAS uses by ASD members to date, polymeric PFAS are the most widely used PFAS type and are integrated to the parts and components that are ultimately assembled into the A&D products. Ca. 80 % of the reported uses (by count) given in Table 1 refer to polymeric PFAS and most refer to articles. As downstream users of fluoropolymers, ASD members do not have access to emissions data relating to their manufacture and end-of-life (EoL). We refer the dossier submitters to information submitted by the Fluoropolymers Product Group (FPG)⁷ on manufacture and to the Conversion report on fluoropolymer waste¹¹. The remaining 20 % of reported uses cover all non-polymeric PFAS.

Intentional release during use phase: For emissions, ASD have no reliable estimates at this time. Looking at the types of PFAS and where they are used in practice, ASD can differentiate between those where there is intentional release during the use and those where there is not and it is clear that there are only a few cases with intentional releases.

For polymeric PFAS integrated to parts/components in seals, gaskets, cables, sleeves, tubing, linings, and similar, there is no intentional release to the environment during use. The inertness and durability of polymeric PFAS is the driver for their use in these kinds of products.

For non-polymeric PFAS, there will be intentional release where that is intrinsic to the functioning of the system (e.g., as the fire suppression agent on the rare occasions they are used for purposes of safety (confirmed or suspected fire), this has been estimated to be ca. 4 tons per year (with +3% increase – i.e. ca. 0.150 metric tonnes - as per forecasted fleet growth – see case study 5) and no intentional release for uses as refrigerants, heat transfer fluids and hydraulic fluids.

Manufacturing stage: Due to the length and complexity of supply chains for the many parts affected it is not possible to provide additional information at this time regarding emissions during parts manufacture.

⁷ Fluoropolymer Product Group (FPG) website available at <https://fluoropolymers.plasticseurope.org/index.php/about-us>

We refer the dossier submitters to the comments submitted by the FPG (#6418) on “*Health and Safety Directive (OHS) together with the implementation of responsible manufacturing and EoL risk-management practices*” for the position of the manufacturers. Our understanding is that for fluoropolymers in particular where there is no expected release during service life, it could be considered that any risks in the manufacturing and waste phases be addressed through the Industrial Emissions Directive and occupational health and safety measures.

A supplier of fluoropolymer seals and other parts for aerospace engines shared their estimates for emissions from the manufacture of their fluoropolymer parts used in aerospace engines at their site. The emissions are very low (< 0.3 kg /year to water and negligible to air during manufacture). These emissions can be effectively regulated under the Industrial Emissions Directive (see comments submitted by DuPont⁸).

Table 2. Preliminary estimates for breakdown of PFAS use by type and potential for emission during use from the use assessment

	Polymeric PFAS	Non-polymeric PFAS
% of PFAS type in A&D uses (estimate*)	Ca. 80 %	Ca. 20 %
Intentional releases to the environment during use	No, for most uses where the polymer is integrated to a part/component– there is no release for the service life of the part.	Yes, for some uses where release is a required function (fire suppression – see details in case study 5 in Annex 2 No, for other uses (e.g., refrigerant systems with leak controls)

* by count from the preliminary use mapping done – see Table 1

Emissions at end-of-life stage: Emissions depend on the type of PFAS and the specific use. The following details are based on civil aviation practices. Similar processes are anticipated in military equipment such as military aircraft in such cases where there is end of life disposal. It should be noted that the end-of-life management of military equipment is a highly sensitive subject for national security reasons and no information is provided on that in this report.

End-of-life A&D products e.g. aircraft, defence vehicles are valuable assets due to the parts and materials contained even after service life measured in decades. See for example the information on recycling of specific aircraft on OEM websites⁹ and providers who specialise in aircraft recycling.¹⁰ Dismantling includes decontamination/depollution steps to separate out hazardous waste including all chemicals and fluids which are then sent to appropriate hazardous waste treatment facilities. Some of these will include PFAS. As shown in the sectoral use mapping (Table 1), fluoropolymers are the dominant PFAS type and are generally integrated in articles such as seals, O-rings, fluid systems, cables and structures, etc.. As outlined in the Conversio report on fluoropolymer waste, the focus of aircraft dismantlers and recyclers is to extract valuable and reusable parts as well as recovery of metal fractions such as skeleton and cladding.

⁸ Socio-Economic Impact Assessment for the use of PFAS within the Aerospace Supply Chain, Final Report prepared for DuPont by RPA, submitted via the webform on 09.08.2023

⁹ <https://aircraft.airbus.com/en/newsroom/news/2022-11-end-of-life-reusing-recycling-rethinking>

¹⁰ <https://www.tarmacaerosave.aero/aircraft-recycling>

Non-recyclable materials are mainly incinerated for energy recovery operations. Only a small share of plastics, incl. a small share FP materials, is landfilled, e.g., in the UK or in France.¹¹

Aircraft storage, recycling and disposal is a specialised activity and is managed as a service.

Land defence vehicles storage, recycling and disposal is a specialised activity and is managed as a service with MoDs.

Emissions at end-of-life from the decommissioning of fire suppression equipment are extremely low as most of the agent is recovered and reused to service other equipment.

2.3.2 Key functionalities driving the use of PFAS chemicals in A&D products (ECHA Q6b)

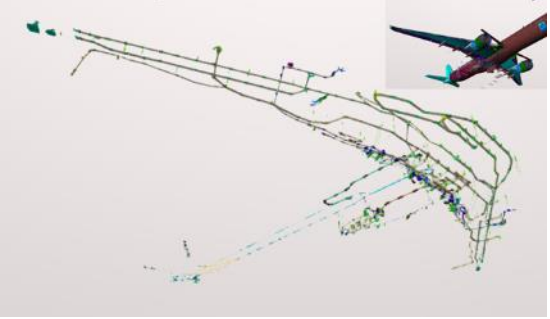
The key functionalities will depend on the driver for using the PFAS chemical in parts, components, sub-systems, assemblies and products. ASD members differentiated between polymeric PFAS and non-polymeric PFAS in their description of key functionalities requirements. Depending on the A&D product, their key functionalities are determined by the operating environment and conditions of use of the affected formulation or article within a product.

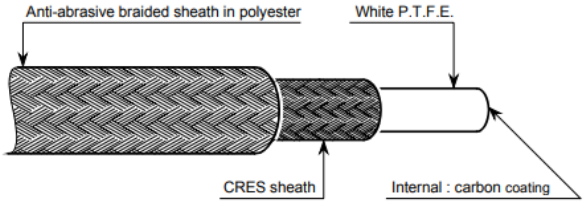
To illustrate the diversity and complexity of PFAS use across A&D products, some examples are given in Table 3. (typical fluoropolymer articles), Table 4 (formulations containing fluoropolymers) and Table 5 (non-fluoropolymer uses). As A&D products were generally not considered by the dossier submitters in their assessment, the examples aim to explain the where and why for PFAS usage.

¹¹ Fluoropolymer waste in Europe 2020, End-of-life (EOL) analysis of fluoropolymer applications, products and associated waste streams Conversio report 2022-07-19 available at <https://www.ft.dk/samling/20222/almdel/euu/spm/49/svar/1951975/2698345.pdf>

REACH PFAS Restriction Proposal

Table 3. Overview of typical fluoropolymer parts used in the production and MRO of A&D products, the drivers for the use and examples

Common fluoropolymer components	Description	Driver for why it is made from a fluoropolymer	Examples of fluoropolymer parts integrated to components/systems
Bearings and Bushings	Parts in mechanical systems that allow free rotation between a shaft and surrounding structure with minimal axial or radial movement.	- Higher thermal capabilities; - Reduced friction and wear, - life extension and performance i.e., lower friction less power losses Bearings in aircraft control levers are given an illustrative example. In an aircraft environment, where heat and chemical resistance as well as excellent wear characteristics are required, PTFE containing bearings or PTFE containing films are used at the interfaces of moving parts where low friction is required and other methods such as lubricants which require associated regular maintenance are not feasible. For example, the flap lever controls the high-lift system during take-off and landing. In addition to various sensors in the wings and redundant computer systems, the high-lift system is controlled manually by the pilot. The necessary, so-called Flaps Lever is situated in the cockpit and is the man-machine interface of the system. The Flaps lever is mounted in its pivot point in bearing shells, containing polytetrafluoroethylene (PTFE) thus to minimize friction of the bearing. Due to the fact that the adhesive and the gliding friction are equally low with PTFE, the so-called stick-slip-effect is prevented, which is crucial for precise operation of the Flaps lever by the pilot.	 Use of PTFE bearings in aircraft control lever These parts are used at every intentionally moving interface. In aircraft this includes, flaps, slats, rudders, ailerons, doors, landing gear, fire escapes, switches, levers etc. In other products, these includes drive trains, turrets, anchorage and mooring systems, missile loading systems, cargo management, cranes. Exact material choices depend on operating conditions. See case Table 11. 12 and case study 8 in Annex 2.
Hydraulic hoses	Flexible pipes that allow transfer pressure through an incompressible fluid, with minimal expansion or flexing under extremely high fluid pressures	Performances related to aging (aeronautical requirement related to lifetime) - large range of temperature (-55°C to 232°C) - large range of pressure: full vacuum to 10 000 PSI - Compatibility with almost all fluid (fuel, hydraulic, ...) - Compatibility with oxygen system (breathable) - mechanical performance mix: flexibility & tensile/ pressure properties - All specifications (standard and customer) require PTFE for hose construction As a specific example from the aviation sector, hoses in the aircraft are used to contain and convey hydraulic fluids, oils, fuel, greases, lubricants, anti-icing and de-icing agents, cleaning agents, oxygen, extinguishing agents and multiple other flight safety critical substances.	 Schematic of aircraft fuel and hydraulic systems

Common fluoropolymer components	Description	Driver for why it is made from a fluoropolymer	Examples of fluoropolymer parts integrated to components/systems
		Hydraulic hose lines act as links to ensure the transmission of energy in hydraulic systems. If they fail, the entire system is affected and machine failures are the result. Certification co-dependencies: as of today certification requirements make it so hydraulic fluids are phosphate ester based for fire resistance. As a result, hydraulic hoses must be resistant to phosphate ester.	 Schematic of CRES (corrosion resistant steel) hose material structure/layers Every hydraulic system has integrated hydraulic hoses. Hydraulic controls are used for high-force mechanical actuation for wing and rudder controls, thrust reverser movement, landing gear, gun turret and torpedo operating systems, crane and mooring systems. See Table 11 and case study 2 in Annex 2.
Seals (including O-rings and gaskets)	Gasket: Packing material between two relatively static surfaces to prevent leakage. O-Ring: A circular seal or gasket preventing liquids or gases from mixing or escaping to atmosphere	Seals: Use in aggressive environment: fluids (e.g. engine oil), space (extreme temperature and pressure) Gaskets: Chemical resistance (oils, greases, fuels) Thermal resistance (205°C / continuous) Resistance to ozone and oxygen For example, fluorocarbon and PTFE seals used in multiples parts of gas turbines. There are no alternatives that met the temperature and material compatibility requirements. Fluorocarbon and fluorosilicone seals are standard for fuel system sealing. There are no alternatives that have temperature and compatibility capability. Inability to use fluorocarbon seals would additionally prevent the use of sustainable fuels where the biggest compatibility challenges exist. Aircraft and other A&D products are required to operate in a wide temperature range of -56 to 80°C, in some areas the temperature may go up 220°C (engine fuel feed lines and recirculation). Seals and sealing solutions have to be suitable for use under these extreme temperatures. In particular, fuel seals and fittings must remain pliable at the coolest temperatures, to cope with flexure in the airframe from air movements and aircraft manoeuvres to avoid leaks. They also need to be oxygen, ozone, fuel and	 Photos of O-rings and parts with fitted seals

Common fluoropolymer components	Description	Driver for why it is made from a fluoropolymer		Examples of fluoropolymer parts integrated to components/systems
		oil resistant. Due to very specific technical requirements and extreme operating conditions, there are only two fluorinated rubbers which can offer the properties and characteristics needed to be used for aircraft seals and sealings solutions: Fluorinated silicones (FMQ) and fluorinated carbon rubbers (FKM). All the main groups of fluorinated rubbers possess very enhanced properties over traditional oil resistant rubbers, the key ones being the high resistance to swelling and mechanical strength. Fluorinated silicone rubbers (FKM) have a very extended temperature range -45 to +225°C and consequently extreme resistance to long term oxidation, aging and perishing.		Seals are used in gas turbines compressors and turbines to separate primary gas flows and cooling air, in air bleed valves, oil pumps, fuel pumps, oil and fuel filters, fuel delivery systems, fuel and oil temperature or pressure transducers, every fuel or oil pipe joint, shut-off valves, control valves, gearboxes. Across aircraft systems, seals are used through the hydraulic system including hydraulic pumps, pipe joints, filters, actuators for landing gear, flaps, rudders and ailerons. Seals are found around cargo doors and passenger doors, windows, electrical connectors, access panels. In other applications seals are used to protect all kinds of marine systems from sea water entry, and for the integrity of all manner of systems including fuel, lubrication, and hydraulic systems and to protect electronic and other systems from corrosion. See Table 11 and case study 3 in Annex 2
Sleeves	A protective tube that fits over a wire, pipe or other part to protect it from abrasion or to prevent electrical short circuits.	Shrink sleeves: - Heat and chemical resistance; - Insulation - Dielectric properties - Thermal resistance - Fire resistance - Mechanical protection - Chemical resistance	Sleeves: - Excellent mechanical strength and toughness, stiffness, - high dielectric strength, - abrasion resistance, - creep resistance, - high purity, - chemical inertness, - low flammability & low moisture absorption.	Sleeves in electrical wiring provide insulation and protection for individual wires in electrical joints. Electrical and electronic systems are everywhere in modern A&D equipment, with many thousands of electrical joints per product system. Sleeves may also be used around oil or fuel pipes wherever there is a risk of rubbing and abrasion to protect against leaks or fire.
Sealants, adhesives and tapes	Adhesives and sealants stick to surfaces and may be used for a range of purposes including prevention of fluid	Sealants: PFAS contribute to the high temperature stability and fuel resistance (high chemical stability) of fluorocarbon sealants. Adhesives: High Strength, Chemical, thermal, water, and electrical resistance (insulating and dielectric properties), low coefficient of friction, chemically inert, high wearability and adhesion strength, cohesion (drip-resistant)		These products may be used in complex assemblies at joints or mating surfaces where there is a risk of air or fluid leaks and where disassembly is not needed, including in electronic assemblies, fuselage structures and wing structures.

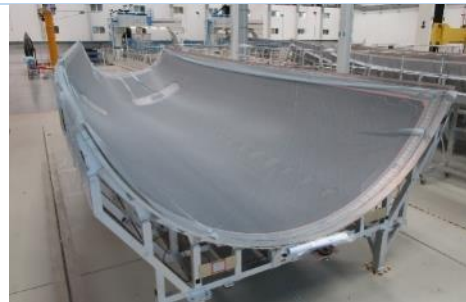
Common fluoropolymer components	Description	Driver for why it is made from a fluoropolymer	Examples of fluoropolymer parts integrated to components/systems
	leakage between parts and mating surfaces. Tapes comprise a surface material together with an adhesive to provide a protective surface.	Tapes: protect parts from dust and aggressive chemicals (e.g., lubricants, fuels, electrolytes) thus ensuring functionality and reducing service intervals; prevent leakage, resistant against heat, pressure and corrosive chemicals and also have a low friction coefficient For A&D products, 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/extreme environments. - Withstand exposure to fuels, engine oils, hydraulic fluids and chemicals that may cause deterioration in sealing properties upon contact. For example, sealants are used to seal airframes, panels, and other structures both in civil and military aircraft. Aerospace sealants have a significant impact on airframe functionality, operational performance, and maintainability. Tapes increase aircraft surface life because they effectively protect aircraft panels from vibration, corrosion, aggressive fluids, and more.	See Table 11 and case study 3 in Annex 2.
Cables and connectors	Electrical cables together with electrical connectors which connect electronic devices with each other and to key sensors and actuators.	Cable insulation: Combination of safety requirements: - temperature resistance (55°C to 260°C); - chemical resistance; - Resistant to fungal attack - mechanical resistance (abrasion, cut-through); - flexibility; - excellent dielectric properties; - arc tracking resistance;	Cables provide a nervous system-like network of reliable signal transmission within all A&D products to control communications, safety, and mission critical systems, such as flight controls, radar, and survivability equipment (depending on the product). For example, a single aircraft, satellite, or vehicle will have numerous cables and cable assemblies, each with unique performance requirements based on its specific use in a complex system.

Common fluoropolymer components	Description	Driver for why it is made from a fluoropolymer	Examples of fluoropolymer parts integrated to components/systems
		- flame Retardant Co-axial cables: - Resistance to soldering operations; - good resistance to solvents; - low moisture absorption; - uniform electrical properties over frequency For examples, specifically for cables in civilian airliners, ca. 50 000 km of cable are mounted each year in aircrafts by one OEM. All of these cables contain PFAS. More than 95 % of this volume (up to 49 000 km) are specified by the European standards EN2267-009, EN2267-010 and EN2714-013. Those specifications require the cables to be able to operate in temperatures between -55°C and 260°C. Fluoropolymers, and especially PTFE is the only currently known material to be able to operate efficiently cable insulation and flexibility in those temperature ranges during the whole lifecycle of the aircraft (40 years and up). Cables also need to be resistant to external contamination in case of failure of another system (fuel for example). Failure in the electrical system could lead to severe consequences and those requirements are thus essential to be met for safety and certification of the Aircraft.	 As a specific example, aircraft signal, power wires and cables systems are used all over the aircraft. The schematic shows the complex and wide electrical structure of the aircraft (engines are excluded in the schematic). Electrical system include communications, flight controls, engine controls, land controls, radars, weapon systems, power supplies, entertainment systems, lighting, flight recording systems ("black box"), telemetry and sensing systems, actuators. See Table 11 and case study 1 in Annex 2.

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Table 4. Common polymeric PFAS containing mixtures used in the production, operation and MRO of A&D products, the drivers for the use and examples

Common fluoropolymer containing mixtures	description	Driver for why fluoropolymers are included	Examples of A&D uses
Lubricants	Materials and liquids which reduce friction between rubbing surfaces	Temperature resilience; chemical inertness; very low friction coefficient; resistance to harsh environment; Low outgassing; Lubricant operating with oxygen - Inert to oxygen; Key functions relate to the lubricant as a whole, not just to the PFAS component and include temperature stability and lifetime. It must retain its coefficient of friction over the full temperature range. Many components use these products to ensure that safety critical features are maintained. In A&D products, lubricants are used in production, operation and MRO to prevent sticking of surfaces in all use conditions. Aerospace applications have some of the most demanding requirements when it comes to lubrication. Compared to automotive applications, for example, the temperature ranges where a single lubricant must perform are considerably broader. Military aerospace applications can involve even greater extremes, in addition to other requirements, such as long storage life. Component failures in aerospace applications can be catastrophic, not only in terms of the capital costs of the parts themselves, but also because of the ancillary costs of repair and safety risks they engender.	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. See Table 11 and case study 10 in Annex 2.
Coatings	A coating that modifies the surface to give specific properties e.g. non-stick, corrosion resistance, abrasion resistance	Surface modification to prevent foreign particles sticking to the surface in all conditions of use For example, the requirements for coatings used in military aircraft systems, specifically in protecting aircraft parts, radomes and leading edges from abrasion and rain erosion during flight, are highly demanding. Operating in mission environments characterized by supersonic speeds, high altitudes, rain, UV-radiation and friction-induced high temperatures, military aircraft face significant challenges. Sprayable coatings are essential for providing effective protection against rain erosion and abrasion, aerodynamic heating, thermal flash exposure, and weathering. PFAS, particularly in the form of FKM (fluoroelastomers) and PTFE (polytetrafluoroethylene), play a critical role in meeting the functional requirements of these coatings. They possess unique properties such as heat resistance exceeding 200°C, wear resistance, lubricating properties, elasticity for shock absorption, and excellent aircraft fluid resistance, making them indispensable for military aircraft applications.	 naval carrier with a radome Weather-resistant structures, marine systems subject to salt water attack, hydraulic pumps and actuators. See Table 11. 1 and case studies 11 and 19 in Annex 2

Release films		In defence products, for example the surface protection system used in rail launchers is essential to their performance and longevity. The current state-of-the-art solution involves hard anodizing-based protection with a PTFE sealing to reduce wear. This combination provides a range of exceptional properties that are critical to meeting the demanding requirements of rail launcher applications.	
	Release films allow for the removal from the composite part of other process materials such as breather fabric and flow media.	ETFE, PTFE, and FEP-based mold release films play a vital role in aircraft and aerospace craft manufacture, offering the cleanest, most consistent release performance possible. The molding of composite structures is essential in improving the ratio of strength-to-weight and resistance to corrosion and fatigue. For example PTFE coated fibreglass fabric is used in various composite manufacturing processes. It is applied directly to the mold and product allowing for an easy and clean release after the curing process of aircraft composite.	 Photo of aircraft composite part with release film Composite parts are superior to traditional metals, including aluminum, due to higher strength, lower weight, and excellent resistance to flex fatigue and exposure to environmental extremes such as heat, cold, humidity, and pressurization. Release films are used in the manufacture of aircraft composited components like helicopter rotor blades, satcom and weather radomes, structural components like tail sectors, wire harness protective insulation.
Pyrotechnic mixtures	Pyrotechnics play a crucial role in defence by providing various effects, including illumination, signalling, and smoke generation	Fluoropolymers are used in pyrotechnic flares as their complex chemistry provides spectral output which can mimic the heat signatures of the aircraft jet exhaust.	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. The fluoride ions from the PFAS increase the brightness of the signal, to reach the specific illuminating effect.
Energetic materials	An energetic material, often referred to as an explosive	Certain fluoropolymers are included in energetic compositions because they provide functionality to the materials. A number of explosive compositions include	Polymer-bonded explosives in military weapons and munitions (see case study 20 in Annex 2)

material, is a substance that contains a large amount of stored energy that can be released rapidly in the form of an explosion. These materials are designed to release this energy when subjected to certain stimuli such as heat, shock, friction, or electrical impulses. Energetic materials are used in various applications, including military and industrial uses, mining and propulsion systems.

fluoropolymers which act as a binder for pressed pellets,-the high-density coating enables an effective energy transfer within the explosive material. The chemical stability of the binder also ensures dimensional stability and performance of the explosive composition over time.

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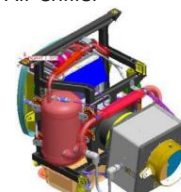
Table 5. Uses of non-polymeric PFAS in A&D products, the drivers for the use and examples

Non-polymeric PFAS uses	Description	Driver for PFAS use	Examples of A&D uses
Hydraulic fluids	Incompressible liquids which transfer force through hoses to actuators driving flight surfaces or other mechanisms, operating at high pressure.	- Anti-corrosion; - temperature resilience; - chemical stability; An example case study for aviation related hydraulic systems is given in the appendix and summarised in Table 11. Aviation hydraulic systems are used to control many parts of an aircraft. This includes the aircraft brakes and landing gear, the movement of flight control surfaces, pitch and yaw to move the aircraft up, down, left, and right, and parts of the wings for controlling lift and speed. All these systems are operated and lubricated by a common oil, which is a fire-resistant phosphate-ester based hydraulic fluid (PEBHF). PEBHFs are hydraulic system lubricants based on the esters of phosphoric acid. They have been the exclusive hydraulic fluid used for commercial aircraft for many decades because of their unique combination of fire resistance and low-temperature performance. The fire resistance properties are required to provide aircraft and passenger safety. The low-temperature performance properties are needed to ensure trouble-free operation of aircraft hydraulic systems, such as steering, under cold atmospheric conditions. Because of their chemical and electrical properties, phosphate ester fluids in high-pressure hydraulic systems without the use of a corrosion inhibitor additive can lead to rapid electrochemical erosion and ultimately failure of precision hydraulic system components, disrupting aircraft control. To prevent these failure modes, corrosion inhibitors for PEBHFs must increase the electrical conductivity of the phosphate ester fluid by dissociating into ionic charge carriers. The use of fluorinated compounds decreases the association energy of the ions and permits this to happen. Critically, the erosion inhibitor must be stable under harsh service conditions. Non-fluorinated erosion inhibitors were attempted many decades ago, and all	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. The diagram is titled 'SCHEMATIC REPRESENTATION OF PROGRESSION OF ELECTROCORROSIVE WEAR IN AN AIRCRAFT SERVOVALVE'. It shows a cross-section of a servovalve with an orifice, spool, and land. The orifice is labeled '3000 psi' and the land is labeled '20 psi'. The spool is labeled 'Spool'. Below the main diagram are three circular diagrams showing the progression of wear. The first circle is labeled 'Fluid Velocity' and shows 'High' and 'Low' regions. The second circle is labeled 'Streaming Potential' and shows 'High' and 'Low' regions. The third circle is labeled 'Wall Current' and shows 'Fe²⁺' and 'Fe³⁺' ions. The diagrams illustrate how wear progresses from the orifice to the land, leading to a decrease in fluid velocity and streaming potential, and an increase in wall current.

See case Table 11 and case study 7 in Annex 2

Non-polymeric PFAS uses	Description	Driver for PFAS use	Examples of A&D uses
		showed poor performance even in older, less severe system designs. Over 200 alternatives to PFAS have been tested in PEBHFs over 3 decades, and all have had challenges in one or more areas. To date, no potential replacement has been identified.	
Fire suppression clean agent	A clean agent is a gaseous fire suppressant that is electrically non-conducting and that does not leave a residue upon evaporation. This is ideal when protecting high value items like historical artifacts or sensitive electronic equipment. The umbrella term “clean agents” includes both halocarbon agents and inert gas agents. ¹²	Fire suppression without residues (which can damage equipment in ways that can compromise safety); Chemical stability; Fire suppression at low concentration - Safe to breathe in - replacement for halon Fire extinguishers in aircraft are given as an example. Aircraft fire extinguisher systems are currently composed of build-in systems protecting four areas: - propulsion system (engines) - auxiliary power unit (APU – small gas turbine and aimed at providing energy for function other than propulsion) - cargo - cabin lavatories, plus, cabin & cockpit areas that are fitted with portable fire extinguishers The fire suppression agents have been HFCs regulated under Ozone Regulation and Montreal Protocol and substitution efforts to phase out banned HFCs has been ongoing for decades. However all substitutes are PFAS chemicals as the only alternatives that fulfil the level of safety required for airworthiness.	 Cockpit fire extinguisher Fire extinguishers are used in aircraft cockpit/passenger areas, cargo holds, and around engines and auxiliary power units. They are also used in Submarine / ship use due to confined spaces? See case Table 11 and case study 5 in Annex 2.
Refrigerant agent	Heat transfer fluids, or refrigerants, are used in refrigerant systems to absorb heat in the evaporator, release heat in the condenser, and facilitate the heat exchange process between various components. They undergo phase changes from gas to liquid and vice	- chemically inert; - non-flammable; - high dielectric strength and electrical resistivity; - evaporate without leaving residues;	

¹² <https://www.gaseousfireextinguishers.com/>

Non-polymeric PFAS uses	Description	Driver for PFAS use	Examples of A&D uses
	versa, allowing for efficient heat transfer and enabling the cooling or heating effect desired in the system	- broad operating temperature range; As a specific example of an A&D use, use in aircraft cooling systems is included as an illustrative case study (Table 11) HFC refrigerants are used in equipment specifically designed for use on aircraft installations and have an operation envelope to meet high safety and reliability standards. A basic principle of aircraft systems design is to avoid by design any event that could impose a risk to the safe operation of the aircraft. HFC refrigerant R-134a, which is used on aircraft, is non-toxic, non-flammable and thus intrinsically safe. Airworthiness certification of equipment is based on non-flammability classification of the refrigerant.	Galley Cooling - Air Chiller  Supplemental Cooling -Vapor Cycle Refrigeration Unit See case Table 11 and case study 4 in Annex 2.

Examples of key functionalities for specific A&D uses are given in Table 6, Table 7 and Table 8 together with information on the availability of alternatives. The details are taken from case studies given in Appendix 1 and from information available from suppliers (see summaries in Table 11). Due to their unique combination of properties that make them ideally suited to uses in harsh environments with high reliability requirements, there are generally no suitable alternatives available for fluoropolymer uses. Prior to this restriction proposal, there was no concern relating to the use of fluoropolymers in A&D and no driver to develop substitutes apart from their high costs. For non-polymer PFAS uses in fire suppression systems and refrigerants, PFAS chemicals substitute earlier HFC gases that are regulated under the Montreal Protocol and Ozone Regulation. However due to the qualification and certification requirements and the long service life of A&D products, substitution is still ongoing.

Details of what substitution would involve in practice in terms of identification of alternatives, qualification and certification are given in the next section.

2.3.3 Companies/parties in the sector impacted by the proposed restriction (ECHA Q6c)

A&D supply chains are complex and multi-tiered. The proposed restriction impacts hundreds of thousands of parts and components at all tiers of the supply chain, since if a qualified part is not available, it has a knock-on effect for each subsequent tier upstream. The non-availability of qualified parts would impact production of new products and maintenance of existing products in the EEA. It would also impact A&D customers from commercial airlines to Ministries of Defence in terms of the operability of A&D products in the EEA and their maintenance in terms of availability of spare parts and legacy spare parts. It would impact 3rd party MRO service providers who would not be able to source components containing PFAS in the EU. It would impact air transport (passengers, cargo) and the operational readiness of EEA defence forces as products and spare parts would not be available in the EEA and would also not be able to be sourced from outside the EEA.

Table 6. General key functionalities of polymeric PFAS and examples for specific uses

Polymeric PFAS	General	Seal in a gas turbine engine	Cable insulation in A&D products	Valves & seals in the manufacture of explosives	Printed circuit boards and assemblies integrated into electronic systems	Coating for the radome housing communication and weather antenna
Key functionalities	Durable, stable and mechanically strong in harsh conditions in a variety of sectors including but not limited to automotive, aerospace, environmental controls, energy production and storage, and electronics, stable in air, water, sunlight, chemicals and microbes; Chemically inert, Non-wetting, non-stick, and highly resistant to temperature, fire and weather	Provide thermal stability and resistance to vibration and to chemicals that may cause deterioration in sealing properties upon contact. e.g., PTFE lip seal Tight sealing, even under high pressure in excess of 35 Bar; Ability to run at temperatures far above or below elastomer rubber lip seals (with typical temperature ranges from -53 °C to 232 °C); Elastomer coatings on the seal's outer diameter make for easy installation without damaging mating hardware; Available in custom designs and a wide range of sizes and materials; Inert to most chemicals; Withstands high speed between moving surfaces in excess of 35 metres per second;	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.	Be chemically inert having a high strength whilst retaining elasticity, and with a relatively long life when exposed to chemicals	Low dielectric constant confers excellent electrical insulation; Heat resistance; Chemical resistance; Non-stick and low frictional properties; Resistant to water, oil and chemicals; See case study 18 in Annex 2.	Transparency to radio waves at relevant wavelengths; Weather resistance: Electrical insulation; Mechanical strength and durability; Chemical resistance. Specific example: Active Phased Array Radar in Naval applications operate in harsh and challenging environmental conditions. To protect the array, a radome is required that protects the radar system and withstands all environmental loads while also being transparent for X-band microwaves. The short wavelengths of X-band are needed for high resolution imaging for target identification. These short wavelengths require specific radome materials. See case study 19 in Annex 2.

Polymeric PFAS	General	Seal in a gas turbine engine	Cable insulation in A&D products	Valves & seals in the manufacture of explosives	Printed circuit boards and assemblies integrated into electronic systems	Coating for the radome housing communication and weather antenna
		Low friction and ability to address rotating equipment and vibration for longer life; Compatible with most lubricants and able to run in dry or abrasive media.	Resistant to water, oil and chemicals;			The only material that combines these conflicting properties is a fibre reinforced fabric with PTFE.
Availability of alternatives	There are no general alternative for fluoropolymers that have a comparable range of key functionalities. Note it is uncertain if alternatives can ultimately be innovated that would not be equally “persistent” as durability and inertness are technical performance requirements for operation in harsh/extreme conditions of use to ensure safety and reliability of A&D products.	There are no alternatives that fulfil the performance requirements. See Table 11. and case study 3 in Annex 2. The requirements for the A&D sector were not considered by the dossier submitters in the assessment of alternatives (Table E.113 in Annex E) under the “transport” use.	Currently no alternatives are available or known to be able to operate under the harsh conditions and over such a long lifecycle. See case Table 11. and case study 1 in Annex 2 This use (Annex A) and the availability of alternatives (Annex E) was not considered by the dossier submitters in their assessment.	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. See case Table 11 and case study 11 in Annex 2 This use and the availability of alternatives was not considered by the dossier submitters in their assessment (Annex A and Annex E).	There are no alternatives available that have the range of properties required for applications with high performance requirements in terms of safety and reliability. The requirements for the A&D sector were not considered by the dossier submitter in the assessment of alternatives (Table E.218 in Annex E)	No alternatives available with the range of properties needed. For the specific example of naval carriers, due to the environment and reliability requirements, materials in naval radar construction have to undergo and pass extensive qualification and testing. No alternative to PTFE coated fiber reinforced fabric is available to date for X-band radome material with required phased array radar performance which meets Naval environmental requirements. This use (Annex A) and the availability of alternatives (Annex E) was not considered by the dossier

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Polymeric PFAS	General	Seal in a gas turbine engine	Cable insulation in A&D products	Valves & seals in the manufacture of explosives	Printed circuit boards and assemblies integrated into electronic systems	Coating for the radome housing communication and weather antenna
						submitters in their assessment.

Table 7. General key functionalities of non-polymeric PFAS uses in fire suppression and refrigerants with examples for specific uses

PFAS-gases	General	Aircraft fire suppression systems in 4 areas (engines, auxiliary power unit, cargo, cabin lavatories plus cabin & cockpit areas that are fitted with portable fire extinguishers)	Refrigerant HFC R-134a in aircraft installations	Heat Transfer Fluid Galden® HT in supplemental cooling system aircraft
Key functionalities	Chemically inert over a broad range; non-flammable; evaporates without leaving residues; Broad operating temperature range; Safe for humans to breathe at the concentrations used; Dielectric properties	Fire suppression without residues (which can damage equipment in ways that can compromise safety); Chemical stability; Fire suppression at low concentration - Safe to breathe in - replacement for halon Certified for use on aircraft according to airworthiness regulations See case study 5 in Annex 2	HFC refrigerant R-134a, which is used on aircraft, is non-toxic, non-flammable and thus intrinsically safe. Airworthiness certification of equipment is based on non-flammability classification of the refrigerant. Certified for use on aircraft according to airworthiness regulations See case study 4 in Annex 2	Galden® HT is used as heat transfer fluid in order to remove heat from the galleys and avionics. The physical properties of Galden® HT, being non-flammable, non-conductive and non-toxic in this application, make it intrinsically safe for use on aircraft applications. Certified for use on aircraft according to airworthiness regulations See case study 4 in Annex 2.
Availability of alternatives	Substitution for HFCs covered by the F-gas regulation has been ongoing for more than 20 years – however many of the substitutes are PFAS	PFAS are alternatives for Halon 1301. Halon 1301 (Bromotrifluoromethane) is the most effective fire extinguishing agent, but because of its high ozone depleting potential, the production of Halon 1301 was banned in 1994 as part of the Montreal Protocol. Most Halon 1301 alternatives (HFC-125 (Pentafluoroethane), 2-BTP (bromotrifluoropropene), NOVEC 1230 (Perfluoro(2-methyl-3-pentanone), CF3i	Alternatives for R-134a are available in the market for stationary and domestic applications as well as for vehicles and ground transport. These alternatives are either HFC (e.g. R-1234yf), natural (flammable) fluids like propane, isobutane, or Carbon Dioxide (CO2). These are not currently suitable for aerospace / aircraft applications. Replacing the current refrigerant is extremely difficult in the short and mid-term refrigerant	Alternatives for use on aircraft are available. In fact, Galden® HT is not used anymore, in new aircraft types. For example in the A350 system a water-based Propylene-Water Glycol mixture is used, mainly due to weight reasons. However, additional design precautions are needed mainly due to the electrical conductivity, which could result in a risk in the case of leakages.

PFAS-gases	General	Aircraft fire suppression systems in 4 areas (engines, auxiliary power unit, cargo, cabin lavatories plus cabin & cockpit areas that are fitted with portable fire extinguishers)	Refrigerant HFC R-134a in aircraft installations	Heat Transfer Fluid Galden® HT in supplemental cooling system aircraft
		(Trifluoroiodomethane)) and all Halon1211 (Bromochlorodifluoromethane) alternatives (2-BTP and HFC-236 (Hexafluoropropane)) are PFAS. Assuming a non-PFAS Halon alternative is selected, a minimum of 15-20 years would be required for a complete transition. See Table 11. and case study 5 in Annex 2 The alternatives listed in Appendix E.2 to Annex E are not suitable for these uses.	on certified aircraft as no suitable refrigerants are on the market that have the same behaviour in terms of physical properties, e.g., are neither toxic nor flammable. It is technically possible to design, develop and build new equipment using natural refrigerants like propane and isobutane. However, the OEM needs to demonstrate the same safety level as today considering the flammability classification of the equipment. It may be possible that additional design precautions or means need to be installed on aircraft to enable safe operation of the equipment. This includes ventilation of installation areas, protection of electrical equipment, or relocation of the equipment. See Table 11 and case study 4 in Annex 2. The alternatives listed in Appendix E.2 to Annex E are not suitable for these uses.	Replacing Galden® HT on in-service aircraft is not possible, since extensive changes are needed on the equipment. If it can not be used, in-service aircraft will be grounded. See Table 11 and case study 4 in Annex 2 The alternatives listed in Appendix E.2 to Annex E of the restriction report are not suitable for these uses.

Table 8. General key functionalities of other non-polymeric PFAS and examples for specific uses

	Component of hydraulic fluid in aircraft hydraulic systems
Key functionalities	Corrosion inhibition in all conditions of use; fire resistant Aviation hydraulic systems are used to control many parts of an aircraft. This includes the aircraft brakes and landing gear, the movement of flight control surfaces, pitch and yaw to move the aircraft up, down, left, and right, and parts of the wings for controlling lift and speed. All these systems are operated and lubricated by a common oil, which is a fire-resistant phosphate-ester based hydraulic fluid (PEBHF). PEBHFs are hydraulic system lubricants based on the esters of phosphoric acid. They have been the exclusive hydraulic fluid used for commercial aircraft for many decades because of their unique combination of fire resistance and low-temperature performance. The fire resistance properties are required to provide aircraft and passenger safety. The low-temperature performance properties are needed to ensure trouble-free operation of aircraft hydraulic systems, such as steering, under cold atmospheric conditions.
Availability of alternatives	Over 200 alternatives to PFAS have been tested in PEBHFs over 3 decades, and all have had challenges in one or more areas. To date, no potential replacement chemistry has been identified with adequate stability to survive in phosphate esters in aircraft service. See Table 11 and case study 7 in Annex 2 Table E.133 in Annex E states that there are no non-PFAS alternatives available and that more than 10 years are needed for substitution. However, the assessment did not consider the specificities of the A&D sector.

2.3.4 Availability of suitable alternatives to PFAS chemicals in the A&D sector (ECHA Q6d)

PFAS chemicals are integral to the production, operation and MRO of A&D products due to their high performance in harsh/extreme operating conditions that underpin the safety and reliability of A&D products. Their high performance stems from their unique combination of properties and there are generally no suitable alternatives available that fulfil the performance requirements. Due to the formal quality management systems in place to ensure product safety, alternatives that fulfil the performance requirements would need to be identified and then taken through the strict qualification and approval processes before taking them into use. Scheduled maintenance and repair also requires the availability of spare parts that are produced as per the approved product over its entire service life. This can be decades depending on the product (e.g. 40+ for an aircraft, 40+ for a naval vessel). Any changes in the production of the spare parts also need to follow a requalification and recertification process before they can be taken into use. A redesign is likely to be needed meaning it is very lengthy as it would involve retrofitting all in-service products.

One of the key challenges with this proposed restriction is the scale of the substitution requirement it would trigger. As can be seen from the Tables above, fluoropolymers in particular are ubiquitous in A&D products. Substitution efforts would need to be balanced against all other ongoing R&D activities and substance replacement workstreams. It would also impact ongoing activities like the transition from internal combustion engines to hydrogen, as fluoropolymers are integral to the hydrogen transition (see contribution from Hydrogen Europe¹³) and MEA (more electric aircraft). Additionally fluoropolymers are necessary for the transition to sustainable aviation fuel, which would also be impacted.

The dossier submitters included an analysis of alternatives for the application areas and sub-uses they considered in their assessment. Defence and security was not included in their assessment and defence use are not generally covered in Annex A or Annex E of the dossier or if they are covered (e.g. lubricants), the specificities of defence products were not considered in the availability of alternatives or the time

¹³ https://hydrogeneurope.eu/wp-content/uploads/2023/02/Hydrogen-Europe-position-paper-on-PFAS-ban_v12_FINAL.pdf

needed for substitution. For other A&D products, a limited number of uses could be under the scope of “transport”. However, the dossier submitters concluded for uses under “transport “ in Table E.121 in Annex E

[...] that a 12 year derogation could be appropriate for PFAS use in transport (including automotive, aircraft, rail, marine, and aerospace industries) where the substances are affecting the proper functioning related to the safety of transport vehicles, and affecting the safety of operators, passengers or goods. Shorter transition periods would not reflect the current state of the industry with respect to PFAS use, with many uses having no satisfactory identified alternatives at the present time.

In light of the broad use scope and the weak evidence base to narrow down the scope for a derogation, such a derogation is not proposed at this point but marked for reconsideration. A derogation might be proposed at a later stage if additional information on (e.g.) the rationale for continued PFAS use in specific applications and the quantities of PFAS used in those applications is provided. [...]

We highlight that the dossier submitters did not consider the specificities of our sector where there are no alternatives that fulfil the performance requirements needed for safety and reliability of A&D products. 12 years is not adequate to develop new materials and subsequently phase out all the uses of fluoropolymers in A&D products. Noting that it is not currently foreseen that alternatives, that are not also considered persistent, may ever be found for fluoropolymer applications, since reliability/durability is a primary reason they are used in A&D applications.

Taking lubricants and hydraulic fluids that are ubiquitous in A&D products as illustrative examples, reformulation requires identification of alternatives that fulfil the performance requirements for **each use**. The testing of each lubricant and fluid, followed by qualification and certification for use across each application in all A&D products may take from 3 to 10+ years per formulation, depending on complexity, **after** a reformulated alternative has been developed by formulators. 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. In ASD’s earlier submission in the call for evidence in 2021, an ASD member 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.

Taking an example of ongoing substitution efforts, the A&D sector has been working for more than 30 years to replace hexavalent chromium compounds. The challenges faced with alternatives development for this sector was summarised by the Global Chromates Consortium for Aerospace (GCCA)¹⁴ as follows (related to their application for authorisation to continue use of these chemicals after the given sunset dates):

“Aerospace and defence 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

¹⁴ “Aerospace & Defence Qualification Process Impacts on Ability to Substitute Cr(VI) Substances” from Global Chromates Consortium for Aerospace (GCCA) available at <https://www.ramboll.com/-/media/files/reh/GCCAerospaceDefenceQualificationProcessImpactsonAbilitytoSubstituteCrVSubstanceswhitepaper>

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 Aerospace and Defence hardware offer unique challenges that are not seen in other industries.”

The illustration given in Figure 3 (adapted from the GCCA paper¹⁴ in the ADCR authorisation applications⁴) provides a simplified overview of alternatives development steps and typical timelines. Note that as PFAS chemicals, in particular fluoropolymers, are ubiquitous in A&D products, **the substitution challenge is far more complex as substitution impacts multiple chemicals, multiple parts integrated into multiple components that are in turn integrated into the sub-systems and systems that make up the products.** An illustration of the testing requirements going from components to subsystems to systems from the ADCR authorisation application reports⁴ is given in Figure 4.

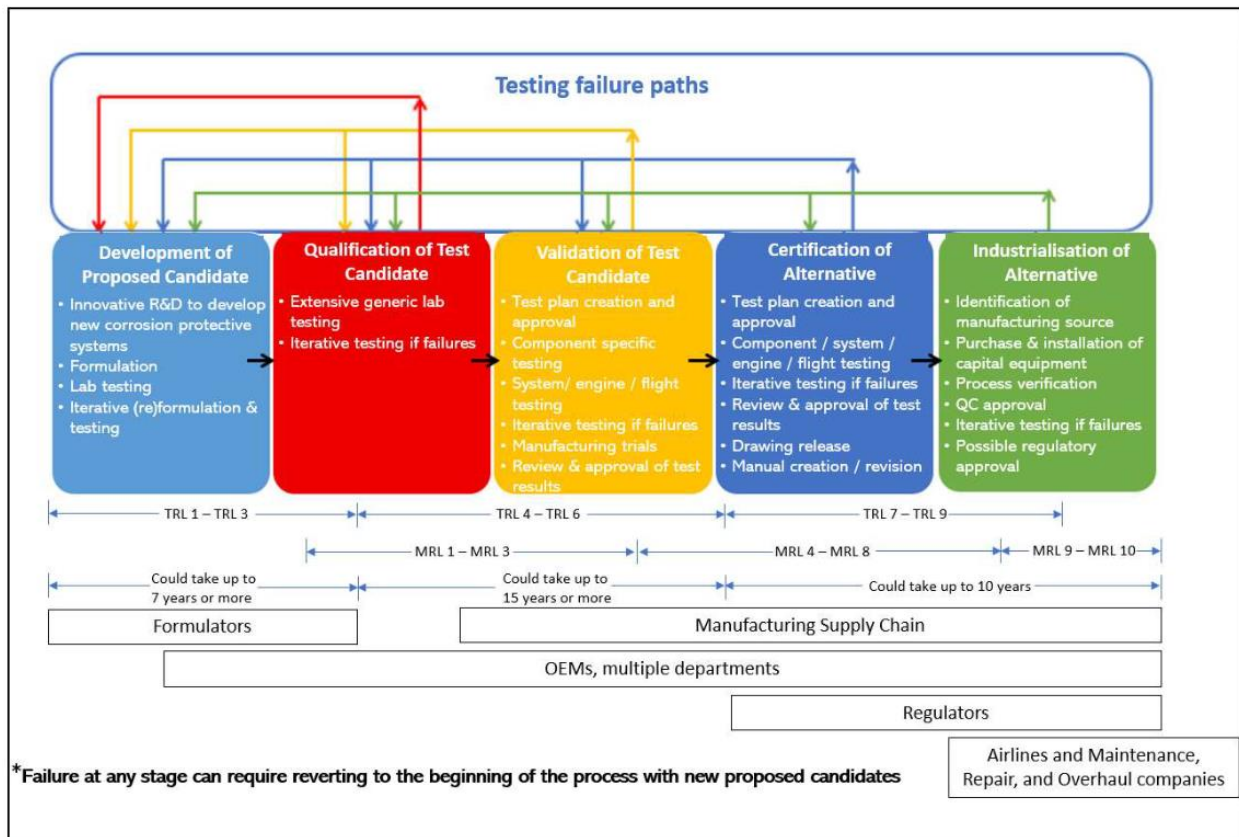


Figure 3. Schematic showing the key phases of the substitution process; Typical TRLs and MRLs associated with each stage, and the entities involved in each stage, are also shown. Note that failure of a proposed candidate at any stage can result in a return to a preceding stage including TRL 1. Note that failures may not become apparent until a late stage in the process. – adapted from the GCCA paper on Aerospace & Defence Qualification Process Impacts on Ability to Substitute Cr(VI) Substances & Joint Analysis of Alternatives and Socio-Economic Analysis, Authorisation application 0203-0242 (reproduced from ADCR authorisation application⁴)

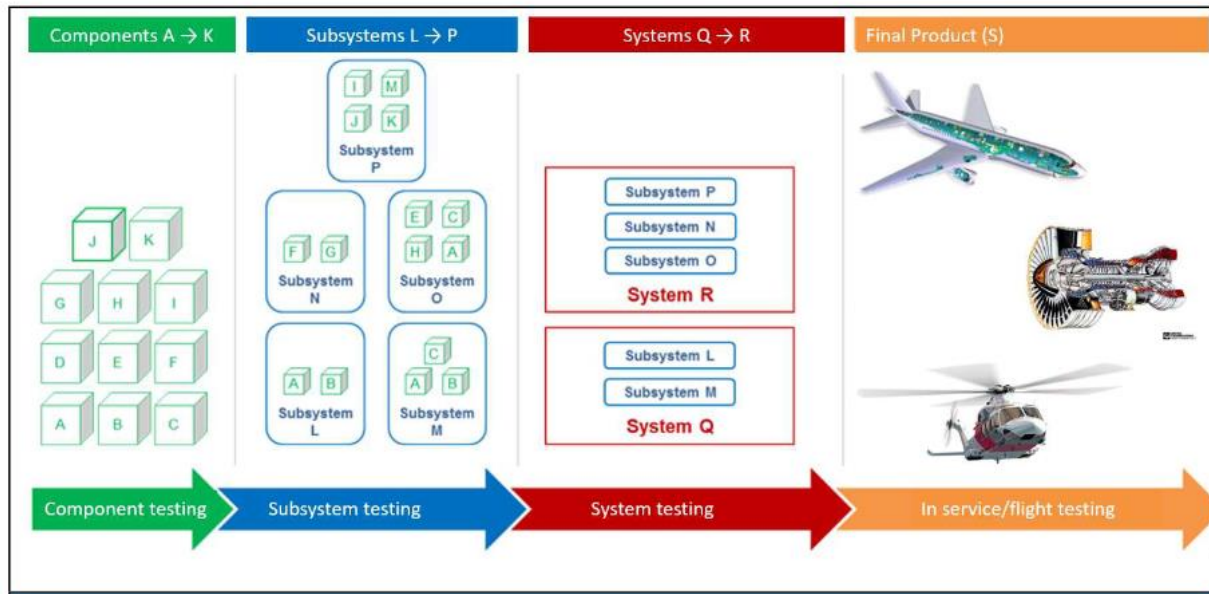


Figure 4. Assessment requirements in the implementation of alternatives (reproduced from the ADCR authorisation application⁴ and based on the GCCA paper on "Aerospace & Defence Qualification Process Impacts on Ability to Substitute Cr(VI) Substances"¹⁴

When looking to qualify new alternatives to replace undesirable substances used in formulations and materials e.g., adhesives, sealants, resins, lubricants etc., A&D companies must ensure that the functional requirements performed by the formulation are met. The focus when determining the necessary requirements for alternatives is not typically driven by the function of any individual constituent substance per se, but on the function of the formulation as a whole in which those substances are being used (for the case where PFAS is a component of a formulation).

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. A schematic illustration of the path to successful reformulation of a formulation certified for use in commercial aircraft from the ADCR 2023 authorisation application⁴ for A&D uses of Cr(VI) compounds is given in Figure 5.

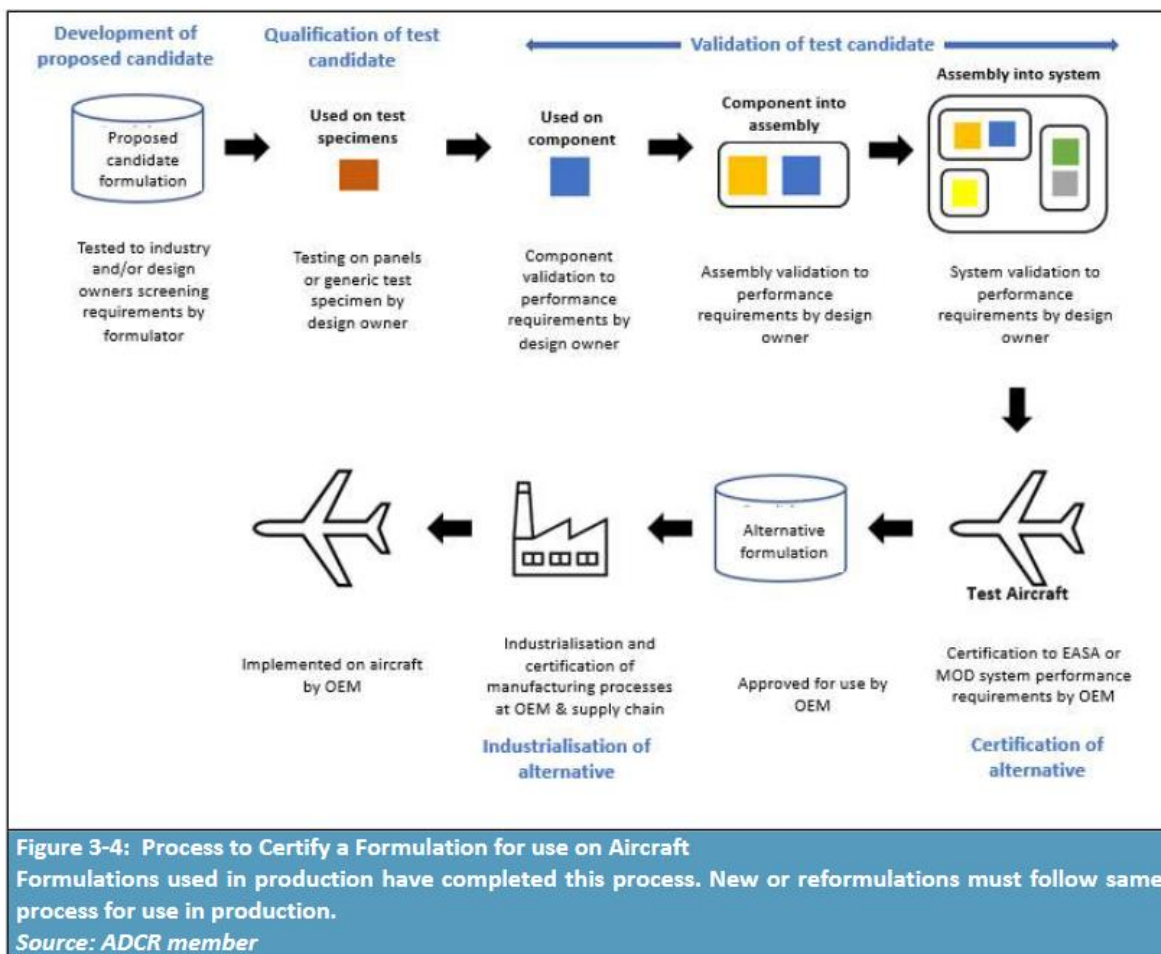


Figure 5. Overview from the ADCR authorisation application⁴ illustrating the complexity of reformulation must consider the overall functioning of the formulation and not solely the component substituted.

Note that with alternatives development and qualification, success is not guaranteed. If alternatives fail any part of the testing criteria, the process restarts, substitution timelines will exceed any originally anticipated timeline. Resource constraints can prevent testing/trialling multiple alternatives simultaneously (since whilst the cost/resource is less for performing multiple trials than if done separately, it is still higher than if one trial is done and it works)

An additional aspect specific to the A&D sector is the long lifetime of the products. This means that spare parts made according to the approvals in place at the time an A&D product was certified must be used in MRO, unless a replacement is qualified and certified under an exhaustive and robust process. This means that spare parts must be available for decades and also legacy spare parts must be available to support operation after the aircraft ends production. This also means storage facilities for such spares must be in place (and of adequate environmental/ cleanliness standards and maintain suitable QC standards). Non-availability of a sufficient number of spare parts means that the aircraft is grounded. The ADCR consortium authorisation applications for continued use of CrVI for various surface treatments illustrate the impact of the non-availability of parts on the ability to produce an aircraft⁴ (see Figure 6).

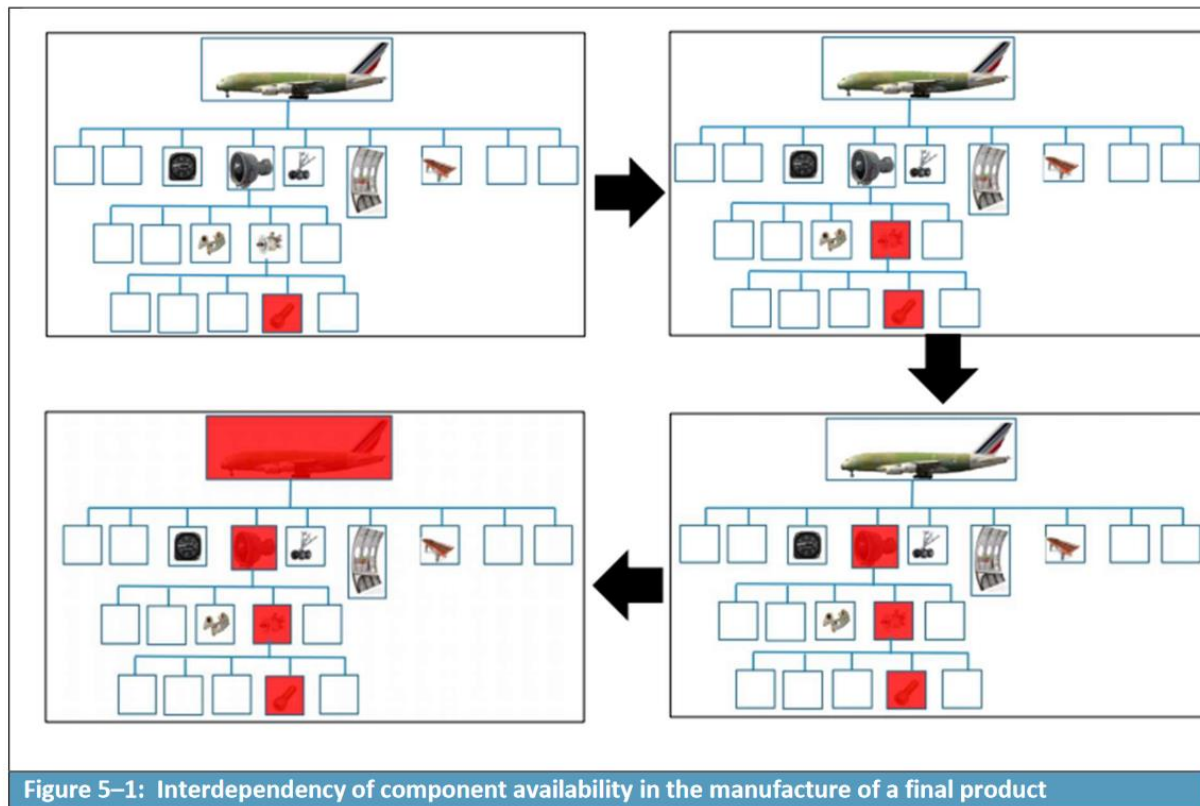


Figure 6. Schematic from an ADCR authorisation submission (March 2023) illustrating the interdependency of component availability in the manufacture of the final A&D product (in this case, a commercial airliner)⁴

2.3.4.1 Frameworks to understand the “readiness” of an alternative for commercial deployment and market acceptance

To ensure a common understanding of the path to commercial deployment of a new technology, ASD share details on the frameworks that are used to describe the stages and milestones involved. Evidence of successful lab scale results does not imply ultimate successful field testing or commercial deployment. Commercial deployment in turn does not imply market acceptance.

Technology readiness levels (TRLs 1-9) give a framework to describe the stages from “proof of concept” to successful industrial deployment. These were developed by NASA for the space program in the 1970’s and are now integrated into EU funding programs since the 2014 Horizon 2020 program¹⁵. **Manufacturing Readiness Levels**¹⁶ (MRLs 1-10) are also widely used with assessments of innovation readiness and are designed to assess the maturity of a given technology, system, subsystem, or component from a manufacturing perspective. They were developed by the US Department of Defence (DoD) to assist decision-makers (at all levels) with a common understanding of the relative maturity (and attendant risks) associated with manufacturing technologies, products, and processes being considered to meet DoD requirements. Manufacturing readiness and technology readiness go hand-in-hand. In conjunction with TRLs, MRLs are key measures that define risk when technology or process is matured and transitioned to commercial production.

¹⁵Horizon Europe NCP Portal, TRL Guidance notes available at <https://horizoneuropencppportal.eu/store/trl-assessment>

¹⁶ Manufacturing Readiness Level Definitions available at <https://acqnotes.com/acqnote/careerfields/manufacturing-readiness-levelmanufact>

Note that this framework applies for each and every application.

Table 9. Technology Readiness Levels (source EU Commission H2020 programme)¹⁷

G. Technology readiness levels (TRL)

Where a topic description refers to a TRL, the following definitions apply, unless otherwise specified:

- TRL 1 – basic principles observed
- TRL 2 – technology concept formulated
- TRL 3 – experimental proof of concept
- TRL 4 – technology validated in lab
- TRL 5 – technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
- TRL 7 – system prototype demonstration in operational environment
- TRL 8 – system complete and qualified
- TRL 9 – actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

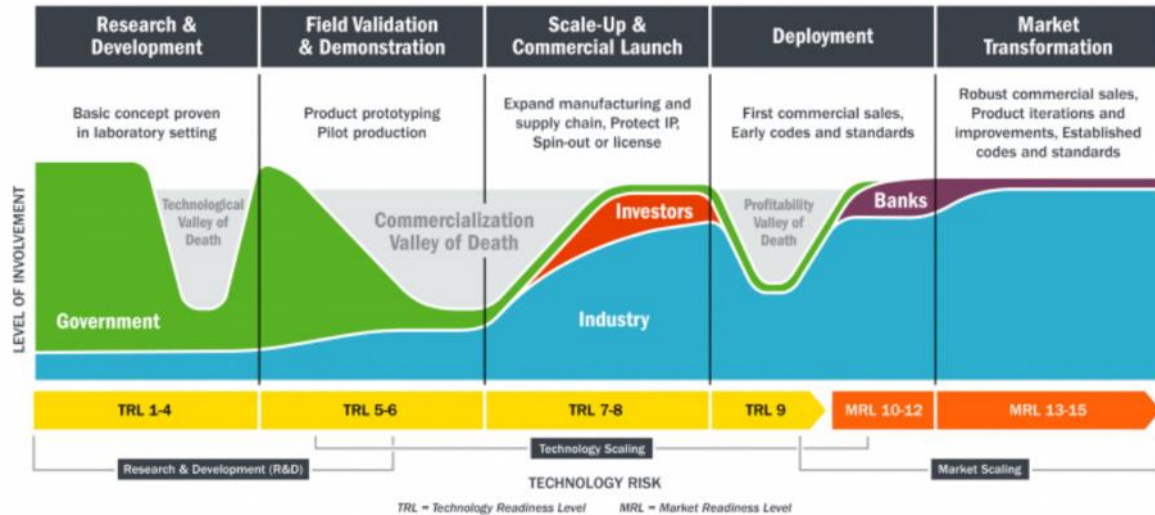
Table 10. MRL frameworks developed for the assessment of the readiness of an innovation for commercial deployment (TRL) and the readiness in terms of actual manufacturing in commercial production (reproduced from ¹⁶)

MRL	Definition
1	Manufacturing Feasibility Assessed
2	Manufacturing Concepts Defined
3	Manufacturing Concepts Developed
4	Capability to produce the technology in a laboratory environment.
5	Capability to produce prototype components in a production relevant environment.
6	Capability to produce a prototype system or subsystem in a production relevant environment.
7	Capability to produce systems, subsystems or components in a production representative environment.
8	Pilot line capability demonstrated. Ready to begin low rate production.
9	Low Rate Production demonstrated. Capability in place to begin Full Rate Production.
10	Full Rate Production demonstrated and lean production practices in place.

More recently, “**Market Readiness Levels (MRLs 10-15)**” have also been introduced by the US DoD to take into account that market transformation is also staged. The stages and milestones that need to be achieved to move from R&D to commercial production to market acceptance are illustrated in Figure 7.

¹⁷ Technology Readiness Levels [taken from H2020](https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf) work programme available at https://ec.europa.eu/research/participants/data/ref/h2020/wp/2014_2015/annexes/h2020-wp1415-annex-g-trl_en.pdf

These frameworks illustrate that commercial deployment and market transformation is staged.



Tech-to Market Process: Technology readiness is commonly measured on a nine-point scale referred to as Technology Readiness Level (TRL). TRLs are used to consistently identify technology development stages across technology types. Market Readiness Levels (MRLs) refer to the readiness of a market to accept and adopt a new technology.

Figure 7. Visualisation of the path from innovation to market that also considers “Market readiness Levels” (from <https://www.energy.gov/eere/buildings/technology-market>)

Examples of specific PFAS uses in A&D products are given in Annex 2 to highlight the particular challenges faced with substitution. Summaries are given in Table 11. Note the use cases are intended to be illustrative on the PFAS use, the availability of alternatives for that specific use and derogation assessment as per the proposed restriction text. They are not intended to be exhaustive.

The examples may refer to a specific product. The assessment of which derogation may be assigned to the use is specific to the product. For example, hosing in aircraft (case study 2 in Annex 2) may be covered by 6-o but this does not imply that 6-o is generally applicable to all hosing uses in all A&D products.

Table 11. Use cases illustrating where PFAS chemicals are used, the availability of alternatives and possible derogation coverage

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
1	Aircraft signal, power wires and cables	Aircraft –all operating systems for power and communication - Electrical wiring insulation given as a specific example	Fluoropolymers	Some coverage under 6-o (12 years)	Aircraft signal, power wires and cables systems are used all over the aircraft. fluoropolymers are used in a variety of different components: cables, connectors, sleeves, conduits, shrinkable elements, connector back-shells, modules, contacts, lugs, pressure seals, tying devices, tapes, optic fibre cables and more complex elements such as electromechanical devices There are no alternatives available to replace fluoropolymers for these uses. Research, development, and implementation of alternatives could take more than a decade and require several different solutions to be developed in parallel, which would put a substantial strain on resources and is not realistic. It is uncertain if alternatives can ultimately be innovated that would not be equally “persistent” as durability and inertness are technical performance requirements. The potential derogation for “transport” (6-o) (fluoropolymers and perfluorethers) would in principle cover these uses - however the time period (12 years) is inadequate as there is no alternative available meaning that new insulation materials will need to be innovated and that substitution will be lengthy. In addition, 12 years is not adequate for MRO of existing aircraft for existing aircraft that have lifetimes of 40+ years. For these reasons, ASD highlight that the derogations are not adequate either in coverage or duration.	See case studies submitted by W.L. Gore & Associates (#6286 and 6301) and Dupont⁸ for more detailed information on specific products. The dossier submitter did not consider defence or security related uses and these would not be covered by 6-o.

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
2	Hydraulic, oil, air, water (waster), bleed air and fuel hose assemblies in aircraft	Aircraft hose assemblies	Fluoropolymers	Some coverage under 6-o (12 years)	Hoses in the aircraft are used to contain and convey hydraulic fluids, oils, fuel, greases, lubricants, anti-icing and de-icing agents, cleaning agents, oxygen, extinguishing agents and multiple other flight safety critical substances. Those media are either hazardous, toxic, flammable, corrosive and/or reactive. They need to be contained and conveyed in the safest way achievable whilst also meeting the high level of performance necessary to achieve improved rigorous fuel efficiency and sustainability requirements. Different materials can be used to meet the required functions, certification and safety requirements of the products. In each case, hoses are protected with a PTFE liner to protect them from the aggressive media durably during the long lifecycle of the aircraft (40+ years). PTFE fulfils the chemical compatibility, chemical inactivity/resistance requirements meanwhile its longevity makes it viable for as long as the lifespan of the aircraft. There are no alternatives available to replace fluoropolymers for these uses and it is uncertain if alternatives can ultimately be innovated that would not be equally “persistent” as durability and inertness are technical performance requirements. The potential derogation for “transport” (6-o) (fluoropolymers and perfluorethers) would in principle cover these uses - however the time period (12 years) is inadequate as there is no alternative available meaning that new hosing materials will need to be innovated and that substitution will be lengthy. In addition, 12 years is not adequate for MRO of existing aircraft for existing aircraft that have lifetimes of 40+ years. For these reasons, ASD highlight that the derogations are not adequate either in coverage or duration.	The dossier submitter did not consider defence or security related uses and these would not be covered by 6-o.
3	Sealing solutions and seals in aircraft fuel lines	Aircraft - mostly fuel systems	Fluoropolymers	Some coverage under 6-o (12 years)	Aircraft are required to operate in a wide temperature range of -56 to 80°C. For equipment the temperature may exceed 200°C (some areas higher than 220 °C), for example for engine fuel feed and recirculation lines. Seals and sealing solutions must be suitable for use under these extreme temperatures. Fuel seals and fittings must remain pliable at the lowest temperatures, to cope with flexure in the airframe from air movements and aircraft manoeuvres to avoid leaks. They also need to be chemically resistant to oxygen, ozone, fuel and oil. Due to these very specific technical requirements and extreme operating conditions, there are only two fluorinated rubbers which can offer the properties and characteristics needed to be used for aircraft seals and sealings solutions: fluorinated silicones (FMQ) and fluorinated carbon rubbers (FKM). For high-speed seals, the anti-	See case studies submitted by W.L. Gore & Associates (#6286 and 6301 and Dupont⁸ for more detailed information on specific products. ASD support the position of the European sealing association – see their case study on the use of

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
					extrusion rings contain PTFE. PTFE is needed to prevent O-ring extrusion and permit the use of seals in higher pressure settings (up to 1000 psi) which is essential in the aerospace industry. In a typical aircraft nearly all fuel seals will be affected, as well as majority of the landing gear struts. There are no alternatives available to replace fluoropolymers for these uses and it is possible that alternatives, that are not also considered persistent, will ever be found for such applications where durability/reliability under harsh conditions is a requirement. The potential derogation for “transport” (6-o) (fluoropolymers and perfluoroethers) would in principle cover these uses - however the time period (12 years) is inadequate as there is no alternative available meaning that new insulation materials will need to be innovated and that substitution will be lengthy. In addition, 12 years is not adequate for MRO of existing aircraft for existing aircraft that have lifetimes of 40+ years. For these reasons, ASD highlight that the derogations are not adequate either in coverage or duration.	fluoroelastomer sealing elements in gas turbine engines.¹⁸ The dossier submitter did not consider defence or security related uses and these would not be covered by 6-o.

¹⁸European Sealing Association (ESA) position statement relative to the European proposal for PFAS regulation in relation with the Sealing Industry available at <https://www.esaknowledgebase.com/wp-content/uploads/2022/03/ESA-Position-Statement-on-proposed-PFAS-regulation-March-2022-1.pdf>

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
4	Heat transfer fluids & refrigerants	Aircraft – cooling systems	Perfluorocarbons Perfluoroethers	Some coverage under 5-i (12 years), 5-p and 5-q (5 years); Military vehicles: 5-dd (12 years)	Refrigerants and heat transfer fluids are used in equipment specifically designed for use on aircraft installations to meet high safety and reliability standards. Refrigerant HFC R-134a is used in aircraft cooling systems. Replacing the current refrigerant in the short and mid-term on certified aircraft is extremely difficult as no suitable refrigerants are on the market that have the same behaviour in terms of physical properties, e.g., are neither toxic nor flammable. Heat Transfer Fluid Galden® HT is used as heat transfer fluid in order to remove heat from the galleys and avionics. Alternatives for use on aircraft are available and Galden® HT is not used in new aircraft. Replacing Galden® HT on in-service aircraft is difficult since extensive changes are needed on the equipment. There is no alternative solution without redesigning the equipment, mainly the pumps of the system. For refrigerants and heat transfer fluids used in aircraft cooling systems, it will take at least 12 years for substitution in new aircraft. For MRO of existing aircraft, certified equipment needs to be available up to the end of product range life. Based on the derogation mapping done since the dossier was made available on the ECHA website, it is our understanding that this is not directly covered by either a proposed or potential derogation. Potential derogation 5-dd is specific to military aircraft but not civilian. The proposed derogation 5-i for refilling and maintaining existing HVACR equipment does not cover production and there is some coverage under 5-q depending on the interpretation of “transport refrigeration”. ASD highlight that the derogations are not adequate either in coverage or duration. To avoid catastrophic effects on aircraft production and MRO of existing aircraft 18 months after the entry into force, ASD request a derogation for these uses with a review clause and to limit the scope to their use in new products and exclude existing products due to recertification requirements.	
5	Fire suppression – substitutes for halon in aircraft fire suppression systems	Aircraft – fire safety systems	2-BTP (C ₃ H ₂ BrF ₃) HFC-236fa ([CF ₃] ₂ CH ₂) Verdagent® (blend of 2-BTP)	5-m (12 years)	Fire events have always been considered as one of the most severe threats for aviation, leading industry to develop fire protection systems since the early/mid 1900s. Development of the associated safety level has been supported by the airworthiness authorities that have set up minimum standard to be reached/demonstrated and mandated it through their respective certification standards. extinguishing agents, but because of	ASD supports the position of Halon Alternatives Research Corporation (HARC) (#4457)

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
			(C3H2BrF3) and CO2)		their high ozone depleting potential, their production was banned in 1994 as part of the Montreal Protocol with limited exceptions for critical applications such as “aviation, military and police use” and subject to phase out deadlines (Annex VI to the Ozone Regulation). However, most Halon 1301 alternatives (HFC-125 (Pentafluoroethane), 2-BTP (bromotrifluoropropene), NOVEC 1230 (Perfluoro(2-methyl-3-pentanone), CF3i (Trifluoriodomethane)) are PFAS chemicals. All Halon 1211 (Bromochlorodifluoromethane) alternatives (2BTP and HFC-236 (Hexafluoropropane)) are PFAS chemicals. These chemicals are substitutes to Halon (1301/1211) in aircraft safety devices (fire extinguishing systems) currently regulated under the Ozone Regulation. The proposed restriction therefore impacts ongoing substitution to comply with other regulations. There are no other alternatives available to Halon 1310 and 1211 for these specific applications. The identification of these 3 chemicals as suitable alternatives to Halon took decades. The use is covered by the proposed derogation 5-m “<i>clean fire suppressing agents where current alternatives damage the assets to be protected or pose a risk to human health</i>”. However, the duration period is not adequate for time needed to identify, qualify, (re)certify alternatives in the systems. There is also no review clause meaning that use must cease upon expiry of the derogation period. This would mean a cease in aircraft production and grounding of existing aircraft due to lack of certified fire systems. MRO for existing aircraft will require availability of certified systems or re-certified systems with alternatives. ASD highlight that the derogation is not adequate in duration. They ask the dossier submitters to consider the ongoing substitution efforts, the absence of suitable alternatives and the low emissions from this use. In line with the position of the Halon Alternatives Research Corporation (HARC) , ASD request the following: reconsider the time limit and proposed a time-unlimited derogation.	
6	Hydrogen fuel cell (PEMFC)	Aeronautical energy systems	Fluoropolymers	6-e (5 years)	Hydrogen fuelled proton-exchange member fuel cells (PEMFC) provide electrical power generated via electrolysis of air and hydrogen. This technology enables both CO2-free and NOx-free operation of hydrogen fuelled aerospace aircraft/vehicles within the EEA. For	ASD support the position of Hydrogen Council ¹⁹

¹⁹ Position paper from the Hydrogen council on PFAS published 31.7.2023 <https://hydrogencouncil.com/wp-content/uploads/2023/07/Hydrogen-Council-White-Paper-PFAS.pdf>

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
					example, aircraft are expected to use hydrogen fuel cells to create electrical power that complements the modified gas-turbine engines, resulting in a highly efficient hybrid-electric propulsion system. Fluoropolymers are integral to the production, operation and safety of PEMFCs. They are integral to membranes, gas diffusion layer, microporous layers, electrodes; sealants; bonding fasteners; Housing for electrical components. There are no alternatives available and time limited derogations are not adequate. Aeronautical uses of PEMFCs have exceptionally high requirements for safety, stability and durability. Currently the only materials that fulfil these requirements are fluoropolymers. For the above reasons ASD highlight that the derogations are not adequate either in coverage or duration. Alternative risk management options are requested (e.g. exception from the restriction until such time as alternatives are available, other legislation to limit emissions and recover materials at the end of life).	
7	Hydraulic fluids (anti-corrosion agent in fire-resistant phosphate-ester based hydraulic fluid)	Aviation hydraulic systems	Potassium decafluoro(pentafluoroethyl) cyclohexanesulphonate	5-o (12 years)	Fire-resistant phosphate-ester based hydraulic fluids (PEBHF) are used in sealed hydraulic fluid systems within passenger, commercial, and most military aircraft. Due to electrochemical erosion (a unique form of corrosion), Potassium decafluoro(pentafluoroethyl)cyclohexanesulphonate (CAS 67584-42-3) has been included as a corrosion inhibitor in PEBHFs since the 1970s and continues to be used today. To date, despite significant effort and investment, there are no alternatives available for these uses. It is possible that over the course of the derogation period, an inferior chemistry could be identified and brought forward as an alternative which may provide partial protection. However, any associated reduction in safety and reliable operation would be considered unacceptable for these critical aircraft systems. The proposed derogation: “5.o Additives to hydraulic fluids for antierosion/anti-corrosion in hydraulic systems (incl. control valves) in aircraft and aerospace industry” gives a derogation period of 12 years. However based on current research and state of the art for this technology, 12 years will not be adequate since it cannot be predicted if alternatives will be successfully deployed in a given timeframe. In addition, 12 years is not adequate for MRO of existing aircraft for existing aircraft that have lifetimes of 40+ years.	ASD supports Exxon Mobil’s submission to the public consultation. See also case study 15 in Annex 2

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
					For the above reasons ASD highlight that the derogations are not adequate either in coverage or duration and request the following: - Introduce a review clause in the current derogation for this use - Reconsider the time limit and the conditions of the restriction - Exclude existing products from the scope	
8	Aircraft electro-mechanical equipment	Internal bearings in aircraft control levers – Flaps lever give as an example	Fluoropolymers (PTFE)	6-o (12 years)	The flaps lever for the high-lift system in an aircraft's cockpit is a crucial control that enables the pilot to manage the position of high-lift devices on the wings. These devices, including flaps and slats, are essential for optimizing lift and control during takeoff and landing, and proper control of these devices is fundamental for safe and efficient flight operations. PTFE containing bearings or PTFE containing films are used at the interfaces of moving parts where low friction is required and other methods such as lubricants with associated regular maintenance are not feasible. Alternatives are not available and due to qualification and certification requirements, substitution will be lengthy in new products. For existing products, the re-certification requirements is not likely to be economically feasible. The potential derogation for “transport” (6-o) (fluoropolymers and perfluorethers) would in principle cover these uses - however the time period (12 years) is inadequate as there is no alternative available meaning that new materials will need to be innovated and that substitution will be lengthy. In addition, 12 years is not adequate for MRO of existing aircraft for existing aircraft that have lifetimes of 40+ years. For these reasons, ASD highlight that the derogations are not adequate either in coverage or duration. Alternative risk management options are requested.	See case study 15 for other examples.
9	Guidance section of missile systems	Defence systems	PFAS components of specialist lubricants	Possible coverage under 5-s (12 years); Otherwise no coverage	The Guidance Section is the brain of the missile. It communicates with the aircraft, acquires and tracks the target, performs guidance and autopilot functions. The Guidance Section uses special oils and greases which contain PFAS. Two example use cases given. Neither has available alternatives. This use is possibly covered by proposed derogation 5-s “<i>lubricants where the use takes place under harsh conditions or the use is needed for the safe functioning and safety of equipment</i>” depending on the interpretation of “harsh conditions” and “safe functioning	Defence uses were not assessed by the dossier submitters.

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
					/safety of equipment". The derogation period of 12 years is not adequate as it is uncertain if alternatives will be identified and qualified by the expiry of the period. If qualified alternatives are not available, it will impact the operational readiness of defence systems. ASD highlight that the derogations are not adequate either in coverage or duration. Alternative risk management options are requested.	
10	Surface coating - defence systems	Defence systems: Rail launchers for submunition	Fluoropolymers (PTFE)	Possible coverage under 5-s (12 years); Otherwise no coverage	Rail launchers serve a vital role in various sectors, including defence and aerospace. They are specifically designed for launching projectiles at high speeds, making them crucial for missions that require precision, accuracy, and reliability. These launchers operate in extreme conditions and therefore are subject to significant stresses and challenges. The surface protection system used in rail launchers is essential to their performance and longevity. The current state-of-the-art solution involves hard anodizing-based protection with a PTFE sealing to reduce wear. This combination provides a range of exceptional properties that are critical to meeting the demanding requirements of rail launcher applications. There are no alternatives available and R&D needs to be initiated for new materials. The unique properties and performance of fluoropolymers (PTFE), are indispensable in meeting the stringent requirements of military aircraft systems. Until feasible alternatives are available or in development, derogations are vital to ensure the safety, effectiveness, and readiness of military aircraft as well as to avoid unnecessary burdens on operational capabilities. Note it is uncertain if alternatives can ultimately be innovated that would not be equally "persistent" as durability and inertness are technical performance requirements for operation in harsh/extreme conditions of use to ensure safety and reliability of the system. This use is possibly covered by proposed derogation 5-s "lubricants where the use takes place under harsh conditions, or the use is needed for the safe functioning and safety of equipment". The derogation period of 12 years is not adequate as it is uncertain if alternatives will be identified and qualified by the expiry of the period. If qualified alternatives are not available, it will impact the operational readiness of defence systems. In addition, 12 years is not adequate for MRO of existing aircraft for existing systems. For these reasons, ASD highlight that the derogations are not adequate either in coverage or duration. Alternative risk management options are requested.	Defence uses were not assessed by the dossier submitters.

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
11	Erosion resistant coatings, abrasion resistant coatings – A&D products	Airframe: Areas subject to abrasion and erosion (e.g. leading edges, flap / slat mechanisms)	Fluoropolymers (PTFE, KFM)	6-o (12 years)	The requirements for coatings used in military aircraft systems, specifically in protecting aircraft parts such as radomes and leading edges from abrasion and rain erosion during flight, are highly demanding. Operation of military aircraft face significant challenges in mission environments characterized by supersonic speeds, high altitude, rain, UV-radiation and friction-induced high temperatures. Sprayable coatings are essential for providing effective protection against rain erosion and abrasion, aerodynamic heating, thermal flash exposure, and weathering. There are no alternatives available that have the performance properties in coatings used in military aircraft systems, specifically in protecting aircraft parts such as radomes and leading edges from abrasion and rain erosion during flight. Operating in mission environments characterized by supersonic speeds, high altitudes, rain, UV-radiation and friction-induced high temperatures, military aircraft face significant challenges. Note it is uncertain if alternatives can ultimately be innovated that would not be equally “persistent” as durability and inertness are technical performance requirements for the harsh/extreme conditions of end-use to ensure safety and reliability of the product. This use is possibly covered by proposed derogation 5-s “lubricants where the use takes place under harsh conditions, or the use is needed for the safe functioning and safety of equipment” depending on the interpretation of “lubricant” by the dossier submitter – see ECHA Q&A from the webinar. The derogation period of 12 years is not adequate as it is uncertain if alternatives will be identified and qualified by the expiry of the period. If qualified alternatives are not available, it will impact the operational readiness of defence systems. This means that use would need to stop for production of new rail launchers and maintenance/repair of existing launchers. ASD highlight that the derogations are not adequate either in coverage or duration. Alternative risk management options are requested.	Defence or security uses were not assessed by the dossier submitters and are not covered by 6-o.
12	Aircraft engine uses	Bearings and bushings in a high pressure compressor	Fluoropolymers (PTFE)	6-o (12 years)	Fluoropolymers are very widely used in aero-engines in the form of sockets, gaskets, wedges or wear strips. For example, PTFE is used in engine components such as bearings and bushings. As a specific example, PTFE bearing and bushings are used in the high-pressure (HP) compressor of the engine. A high-pressure compressor in an aircraft engine plays a crucial role in preparing the incoming air for combustion by compressing it to a higher pressure. This compression leads to more efficient and powerful combustion, which	See also case study 8

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
					in turn generates the thrust needed to propel the aircraft forward. The function of the bearings and bushings is to improve the rotation and position of the blade for HP compressor in engines. There are no alternatives available to PTFE that fulfil the technical performance requirements (friction properties, mechanical properties, temperature resistance over a wide temperature range, chemical resistance) in the bearings and bushings. This means that R&D programs need to be started to first innovate new materials with no certainty that suitable alternatives will be identified. Once alternatives are identified, it would need to be qualified and then certified for use in the aircraft engine. For existing products, redesign would be needed for new materials and recertification. In this case, as hundreds of components in an engine have to be replaced, it would be necessary to have an alternative for each component before launching the re-certification process for the redesigned whole engine. Note it is uncertain if alternatives can ultimately be innovated that would not be equally “persistent” as durability and inertness are technical performance requirements for the harsh/extreme conditions of end-use to ensure safety and reliability of the product. The potential derogation for “transport” (6-o) (fluoropolymers and perfluorethers) would in principle cover these uses - however the time period (12 years) is inadequate as there is no alternative available meaning that new materials will need to be innovated and that substitution will be lengthy. In addition, 12 years is not adequate for MRO of existing aircraft for existing aircraft that have lifetimes of 40+ years. For these reasons, ASD highlight that the derogations are not adequate either in coverage or duration. Alternative risk management options are requested.	
13	Sealing systems and greases for extreme mobility & extreme environment suspension systems –	Suspension systems for military-specific vehicles	Fluoropolymers (FKM, PTFE, FFKM, PFPE)	Possible coverage under 6-o (12 years). Dubious whether “Transport” cover all necessary	An armored vehicle is a type of military or security vehicle that is specifically designed and built to provide protection to its occupants from various threats such as ballistic projectiles, explosives, and small arms fire. Armored vehicles have reinforced armor plating, typically made of steel or composite materials, that shields the occupants from bullets, shrapnel, and other forms of attack. Despite their added weight from armor, armored vehicles are usually equipped with powerful engines and robust suspension systems to maintain mobility on various terrains. There are no alternatives available to replace PTFE, FKM, FFKM and PFPE parts and greases that are used in the suspension systems. There are currently no promising R&D programs to guarantee possible 1:1 substitution. Key characteristics that	Defence or security uses were not assessed by the dossier submitters.

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
	defence products			military vehicles (for example, self-propelled or towed artillery)	prevent the possible use of other materials include the wide temperature range the systems are required to withstand (from -46°C in order to fulfil NATO Standards for arctic vehicles to operating temperatures in off-road mobility of over 200°C without degradation), low friction coefficient, compatibility with main NATO standard fluids and chemical inertness. Note it is uncertain if alternatives can ultimately be innovated that would not be equally “persistent” as durability and inertness are technical performance requirements for the harsh/extreme conditions of end-use to ensure safety and reliability of the product. The proposed 12-year derogation is considered insufficient due not only to the lack of current substitute availability which would require R&D programmes lasting more than 12-years in order to develop sealing, guiding, and bearing systems which have passed all related certifications (MIL-STD, Def-Stan), but also due to the long life of the vehicles themselves (over 40 years) which renders MRO impossible for existing vehicles with a 12-year derogation as proposed. Another key point is the consideration of “transport” wherein it is unclear that all military vehicles are included. While certain vehicles such as 4x4s and trucks are certain to be included, other vehicles such as combat systems or artillery system have a very doubtful fit in this category. For these reasons, ASD highlight that the derogations are not adequate either in coverage or duration. Alternative risk management options are requested	
14	Chemical, Biological, Radiological, Nuclear, and high yield Explosives (CBRNE) detection equipment	Security and defence	Fluoropolymers and pefluoroelastomers	Not covered	CBRNE is an acronym for Chemical, Biological, Radiological, Nuclear, and high yield Explosives. These types of weapons have the ability to create both mass casualties as well as mass disruption of society. CBRNE threat detection equipment plays a key role in ensuring the safety of military forces and help protect civilians. Current CBRNE detection technologies are strongly reliant on PFAS due to the bespoke specificities they require. There are no alternatives available. These uses are not covered by any proposed or potential derogation. This means that the use of fluoropolymers in the production of CBRNE detection equipment must stop 18 months after the entry into force of the restriction. Imports of components would also stop meaning that MRO would also stop. This would have the consequence that the industry	Defence or security uses were not assessed by the dossier submitters.

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#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
					would not be able to produce or maintain this equipment meaning that security and defence forces would be unable to detect potential CRBNE threats. This is not a plausible scenario. ASD highlight that the restriction as currently proposed does not have a plausible non-use scenario for these uses. Alternative risk management options are requested.	
15	Aircraft landing gear	Seals & hoses, hydraulic fluids, paints & coatings, insulation (cables and systems)	Fluoropolymers, Specific non-polymeric PFAS as additives for anti corrosion,	6-o (12 years) 5-o (12 years)	Aircraft landing gear and its actuation system are critical components that facilitate the safe takeoff, landing, and taxiing of an aircraft. Manufacturers must ensure that the strict requirements of aviation sector in terms of safety and durability are met. Components like seals and hoses, hydraulic fluids, paints and coatings and isolation material all contain PFAS. There are no alternatives available that fulfil the technical performance requirements for parts/components of landing gear and actuation systems. The potential derogation for “transport” (6-o) (fluoropolymers and perfluorethers) would in principle cover seals, hoses, insulation uses - however the time period (12 years) is inadequate as there is no alternative available meaning that new materials will need to be innovated and that substitution will be lengthy. In addition, 12 years is not adequate for MRO of existing aircraft for existing aircraft that have lifetimes of 40+ years. Hydraulic fluid use would be covered by “5.o Additives to hydraulic fluids for antierosion/anti-corrosion in hydraulic systems (incl. control valves) in aircraft and aerospace industry”. However, the derogation period of 12 years will not be adequate-since it cannot be predicted if alternatives will be successfully deployed in a given timeframe. In addition, 12 years is not adequate for MRO of existing aircraft for existing aircraft. Note it is uncertain if alternatives can ultimately be innovated that would not be equally “persistent” as durability and inertness are technical performance requirements for the harsh/extreme conditions of end-use to ensure safety and reliability of the product. ASD highlight that the derogations are not adequate either in coverage or duration. Alternative risk management options are requested.	See also case studies 1-3 and 7
16	SMArt artillery ammunition – defence systems	Defence - PTFE surface coating for shell gliding properties	Fluoropolymers (PTFE)	Not covered	A 155 mm SMArt (Submunition Area Denial Artillery) shell is a type of artillery ammunition used primarily for long-range artillery systems. It is a sophisticated artillery round that is capable of releasing submunitions equipped with sensors and guidance systems. PTFE surface coatings are used in the shells to reduce friction. The coating plays a crucial role in	See also case study 10 and 20.

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
		under conditions of fire			the reliable functioning of the end product, even under the most extreme operating conditions (-33 °C to +52 °C). The special sliding properties of the surface coating guarantee error-free mechanical interaction of the components that are briefly subjected to the highest loads during operation. There are no alternatives available. Note it is uncertain if alternatives can be ultimately innovated that would not be equally “persistent” as durability and inertness are technical performance requirements for the harsh/extreme conditions of end-use to ensure safety and reliability of the product. The use of PFAS in artillery ammunition is not covered by any proposed or potential derogations as the dossier submitters did not consider defence uses in their assessment. This means that 18 months after the restriction enters into force, production of the shell would stop. Imports would also stop. Supply would rely on shells in stock with no possibility of restocking once the supply is used up. This would have a security implications as these weapons systems could not be used. This has not been considered by the dossier submitters. This is not a plausible scenario. ASD highlight that the restriction as currently proposed does not have a plausible non-use scenario for these uses. Alternative risk management options are requested.	Defence or security uses were not assessed by the dossier submitters.
17	ePTFE microporous membranes to protect equipment from the effects of pressure and humidity changes	Defence	Fluoropolymers (ePTFE)	not covered	ePTFE (expanded polytetrafluoroethylene) microporous membranes are versatile materials with a unique porous structure. They are used to protect equipment from pressure variations and humidity by serving as effective barriers that control the exchange of gases and moisture between the equipment's interior and the external environment. See details in Annex 2 (confidential)	Defence or security uses were not assessed by the dossier submitters.
18	Fluoropolymers in electronic, optical and microwave equipment	Defence	Fluoropolymers	No coverage	The main products containing fluoropolymers used in electronic, optical and microwave equipment are: - printed circuit boards (PCBs) - connectors and accessories (SMA, SMB, SMP, N, etc.)	Defence or security uses were not assessed by the dossier submitters.

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
					- coaxial cables - optical cable sheaths - seals - waterproof membranes, - electronic and microwave functions, in the form of ready-to-use components such as amplifiers, dividers, circulators, etc. See details in Annex 2 (confidential)	
19	Use of PTFE in a radome for a naval multi-function radar	Defence	Fluoropolymers	Not covered	A radome on a naval vessel is a protective enclosure or cover that houses and shields radar antennas and other sensitive electronic equipment from the harsh marine environment while allowing electromagnetic signals, including radar signals, to pass through with minimal loss or distortion. See details in Annex 2 (confidential)	Defence or security uses were not assessed by the dossier submitters.
21	Fluoropolymer bonded explosives	Defence	Fluoropolymer (FPM)	Not covered	Polymer-Bonded Explosives (PBX) are a type of explosive material in which explosive particles or crystals are dispersed within a polymer matrix or binder. Fluoropolymers are used in PBX in military weapons and munitions. The chemical stability of fluoropolymer binders ensures dimensional stability and performance of the explosive composition over time. Degradation of the binder due to ageing (caused by processes such as hydrolysis, oxidation, rearrangement, chemical reaction with surrounding materials, etc.) increases the sensitivity of the explosive composition over time, resulting in unpredictable behavior that poses a safety risk. There are no alternatives available. The time required to identify alternatives and requalify the munitions and weapons is significantly longer than the time proposed for the restriction to become effective (18 month after entry into force). It is uncertain if alternatives can be identified. It would also take a considerable amount of time to industrialize the manufacturing process and increase production to meet demand. Given the unique properties of fluoropolymer-bonded explosives, there may not be a one-to-one equivalent. If R&D efforts are not able to identify alternatives, the entire explosive trains will have to be redesigned and qualified.	See case studies 10 and 16 Defence or security uses were not assessed by the dossier submitters.

#	Specific use case	Application area described in the case study	Type of PFAS	Possible derogation coverage	Key points	Other relevant information
					These uses are not covered by any proposed or potential derogation. This means that the use of fluoropolymers in the production of the concerned weapons and munitions must stop 18 months after the entry into force of the restriction. Imports of the concerned weapons and munitions would also stop. The proposed restriction would cripple the ability to supply armed forces as needed, which would reduce the defence capabilities of Member States as ammunition stocks would likely be depleted long before alternatives are available. This is not a plausible scenario. ASD highlight that the restriction as currently proposed does not have a plausible non-use scenario for these uses. Alternative risk management options are requested.	

2.3.5 Non-use scenario & socio-economic impact of the current restriction proposal (ECHA Q6g)

The impact of the proposed restriction would be exceptionally severe on the A&D sector.

With Restriction Option 1 (RO1) where all PFAS chemicals are banned with no derogations, the economic impacts would be severe and detrimental to the functioning of the EEA both in terms aviation (passenger, cargo, military) and national and European Defence and security.

With RO2 (all PFAS chemicals are banned with time limited derogations for uses by specific sectors/applications), the impact will depend on the eventual coverage of the derogations for uses of PFAS chemicals needed for the production, operation and MRO of A&D products. If the derogation coverage is not complete and/or the expiry periods are not sufficient, the impact could be as severe as RO1. It would affect A&D companies, their supply chains, third-party MRO facilities, customers (including airlines and defence agencies) and those who rely on the products and services provided by the A&D industry. Our use identification and potential/proposed derogation assessment further demonstrates that coverage for A&D uses is not well considered or provided for currently.

In this section, we discuss non-use scenarios for the aviation and defence sectors and consider the impact on the non-availability of qualified parts/components etc. when the restriction comes into force and derogations expire. To provide an appreciation for quantification of the anticipated SEA impacts, we refer to the recent authorisation applications submitted by the A&D sector for the continued use of a limited number of hexavalent chromium compounds CrVI for a limited number of surface treatment of parts/components in the production, operation and MRO of A&D products.⁴ We referred to their socio-economic impact assessment to get an illustrative understanding of the wider economic consequences of non-use scenarios. However, it must be recognised that impacts would be even greater, since import of PFAS-containing articles would be prohibited and so any non-use scenario allowing for continued import of articles manufactured outside the EEA, could not be considered in the case of PFAS. For RO2, neither use nor import is allowed. The impacts are summarised in Table 12.

Table 12. Non-use scenario when qualified and certified alternatives are not available for A&D products and the wider economic impact

	Non-use scenario when qualified and certified alternatives are not available (RO1 or RO2 with incomplete/non-aligned derogations)
Aviation	• Production of aircraft/and or aircraft equipment in the EEA stopped • Imports of aircraft to the EEA is stopped (as import of an article containing PFAS is not allowed) • Operation of aircraft and components, including spares containing PFAS components would not be stopped for existing aircraft in use at the time of expiry or other aircraft 'visiting' the EEA • Scheduled maintenance operation activities involving replacing PFAS components in the EU stopped and relocated outside the EEA, only where possible • Aircraft requiring repairs/replacement PFAS parts effectively 'grounded' in the EEA. • Premature retirement of aircraft that can no longer be maintained or repaired. • Operation activities involving PFAS stopped in the EEA (e.g., safety critical window cleaning fluid) • Impacts to production of aviation products in other regions including UK and US, where customers are currently reliant on EU based manufacture or assembly of certain components (global supply chain)

Defence (non-aviation uses)	• Production of defence products stopped in the EEA • All imports of defence products and components, including spares to the EU stopped • Defence equipment requiring repair/replacement parts effectively 'grounded' • Scheduled maintenance of defence assets that require the use of PFAS-containing parts shifted outside the EEA only where possible (in most cases this will not be possible due to security considerations for defence applications) • Premature retirement of defence equipment that can no longer be serviced/repaired • Operation of existing defence products containing PFAS would not be stopped – but production, maintenance and repair would shift outside the EEA only where possible (in most cases this will not be possible due to security considerations for defence applications) • Impact production of defence products in other regions including UK and US, where reliant on EU based manufacture or assembly of certain components (global supply chain)
Wider economic impacts	• Cease in both production and import of A&D products within the EEA • Cease in delivery of spare parts to the EEA (leading to reliance on offshore maintenance services for A&D products used in the EEA) only where possible (in most cases this will not be possible due to security considerations for defence applications) • 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 (with direct impact on national security) • No new A&D products could be imported or produced in the EEA • Loss of functioning A&D equipment in EEA • Premature retiring from service of A&D equipment in EEA • The EEA neither develops innovative new PFAS-reliant products nor benefits from those developed outside the EEA • Remaining existing products reach end of service life and cannot be replaced • EEA aviation sector no longer viable • MoDs cannot procure defence systems • National security is compromised as operational readiness is not possible • Passenger and cargo air transfer relies on depleting and aging stock with all MRO scheduled to be done outside the EEA (leading to increased costs) • Airlines cease business as costs are too high and cannot be passed on to passengers or by increased freight charges • Massive loss of jobs across multiple sectors that rely on the A&D sector • Closure of EEA-based facilities • Loss of strategic innovation and technology development in the EEA

The economic impacts would include:

- Loss of profits – OEMs, suppliers, airlines, repair and maintenance facilities, etc.
- Business closures and lost jobs
- Costs associated with unused stock disposal
- Costs for relocation of work outside of EEA – OEMs, suppliers, repair and maintenance facilities, etc. (only in cases where this is even possible)
- 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
- Market distortion for aviation services (no EEA based airline companies)
- The EEA ceases to have functioning aviation and defence capabilities due to its inability to procure new products or maintain existing products

- Market distortion of global innovation and technology development to favour locations outside the EEA

The wider consequences are given in the Table above. The consequences would be catastrophic and are not plausible. The EEA would cease to have functioning aviation and defence capabilities as production and MRO would all need to be done outside the EEA. Imports would not be possible. All technology development, innovation, investment etc. would move outside the EU and the European defence would rely on other military countries (US, China, others) or must be stopped. This is simply not a plausible scenario.

The 2023 ADCR submission for chromate re-authorisation for the A&D supply chain assessed the economic impact of the non-availability of conversion coatings based on hexavalent chromium compounds on A&D companies²⁰. The non-use scenario is similar since without conversion coatings, a significant proportion of production and all MRO activities would cease in the EEA. Whilst the conversion coating non-use scenario allows for relocation and import of articles back to the EU, in the case of PFAS, any relocation of activities would only be able to serve non-EU markets and so the actual realised impacts for the PFAS case would be much more severe. Table 13 gives quantitative estimates for the impact on A&D companies (in the context of the 12 year review period applied for and a 4 % depreciation (UK figures included due to an equivalent authorisation requirement under UK REACH, but there would also be some impact on this market due to UK dependencies on EU-based production of parts)). The non-use scenario in this case would mean that all production and MRO relocates giving a higher impact.

²⁰ ADCR application for authorisation for continued use of hexavalent chromates; Application ID 0327-01 “Chemical conversion coating using chromium trioxide, sodium dichromate and/or potassium dichromate in aerospace and defence industry and its supply chains” available on the ECHA website at <https://echa.europa.eu/en/applications-for-authorisation-consultation/-/substance-rev/74108/term>

Table 13. Extract from the ADCR submission⁴ for the re-authorisation of CrVI based conversion coatings in the A&D supply chain giving the impact on A&D companies

Table 5-8: Summary of economic impacts under the non-use scenario (12 years, @ 4%)		
Economic operator	Quantitative	Qualitative
Applicants	Not assessed	Lost profits to applicants in both the EEA and UK are assessed in the Formulation SEA
A&D companies	- Lost operating surplus EEA: €29.6 – 70.5 billion over 12 years (€3.1 – 7.5 billion over one year) - Lost operating surplus UK: €4.7 – 28.0 billion (€0.5 – 2.9 billion over one year)	Relocation costs, disruption to manufacturing base and future contracts, impacts on supply chain coherence, impacts on future growth in the EEA and UK sectors, loss of skilled workforce, impacts on R&D (and potential to deliver new more sustainable technologies)
Competitors	Not anticipated due to sectoral coverage of the application	Not anticipated due to sectoral coverage of the application
Customers and wider economic effects	Not assessed	- Impacts on airlines, air passengers, customers, cargo and emergency services, and thus society as a whole - Impacts on military forces' operation capacity and mission readiness - Lost output/value added multiplier effects due to impacts on civil aviation and loss of defence sector spending - Loss of spin-off effects – innovation and new technologies

The authorisation application reports also considered related aspects; the impact on military forces and companies acting as suppliers to the military forces. It was not considered plausible that the EEA defence forces would rely entirely on non-EEA suppliers, and it was considered that use would continue via defence exemptions. Obsolescence risk was also considered as if solely defence uses are allowed, many suppliers would not have sufficient turnover to remain profitable.

The report highlighted the contribution the defence sector makes to the EEA economy:

“Companies in the European defence sector represent a turnover of nearly €100 billion and make a major contribution to the wider economy. The sector directly employs more than 500,000 people of which more than 50% are highly skilled. The industry also generates an estimated further 1.2 million jobs indirectly. In addition, investments in the defence sector have a significant economic multiplier effect in terms of creation of spin-offs and technology transfers to other sectors, as well as the creation of jobs.”

The report highlighted that this multiplier effect would be lost if companies relocate outside the EEA.

Based on the sector wide quantitative assessment done for the same sector for a very limited number of coatings and where imports are not restricted, it can be seen that impact of the non-use scenario is severe. In this case, due to the number of chemicals within scope and the ubiquity of their use in the production, operation and MRO of A&D products, the impact of RO2 would be catastrophic. RO2 would shut down production of new products, stop MRO of existing products, stop the import of products, components, parts etc. The wider economic consequences go beyond lost jobs but would in effect stop all EEA based production of A&D products, stop their imports, stop MRO of existing products, stop import of

components, parts etc. Taking civilian aviation as an example, this would mean that aircraft could fly in the EU but could not be produced, serviced or imported in the EEA. Taking national security as an example, existing defence products (aircraft, naval vessels, land vehicles, munitions, weapons) could be operated but not serviced due to lack of spare parts. Existing stocks once depleted could not be replenished. New products/parts could neither be produced nor imported in the EEA. Defence forces would be unable to respond to security threats. These non-use scenarios are not plausible.

ASD ask that the dossier submitters revise their proposal and propose more appropriate and proportionate regulatory risk management measures that explicitly take the specificities of the A&D sector into account and the wider aspects on the functioning of the EEA.



Appendices

Annex 1. Assignment of the specific PFAS reported by ASD members in their questionnaires to PFAS types for the use and derogation assessment

Table 14. Details of the assignment of PFAS reported by ASD members to PFAS types for the use and derogation mapping (see Tables 1, Tables 15-19)

Type of PFAS	Abbreviation	Trade Name(s)	Chemical Name	EC No	CAS No
Fluoropolymer	PFPE		1-Propene, 1,1,2,3,3,3-hexafluoro-, oxidized, polymd.	615-044-1	69991-67-9
	ECTFE		poly(ethene-co-chlorotrifluoroethene); poly(1-chloro-1,2,2-trifluorobutane-1,4-diyl)	polymer	25101-45-5
	ETFE	Tefzel	poly(ethene-co-tetrafluoroethene); ethylene tetrefluoroethylene	polymer	25038-71-5
		Ethene, 1,1,2,2-tetrafluoro-, oxidized, polymd	Ethene, 1,1,2,2-tetrafluoro-, oxidized, polymd; fomblin m15 pfpe	polymer	69991-61-3
	FEP	Teflon FEP; Neoflon FEP; Dyneon FEP	fluorinated ethylene propylene; Tetrafluoroethylene-hexafluoropropene copolymer; Fluorinated ethene propene copolymer	polymer	25067-11-2
	FEPM		Tetrafluoroethylene propylene copolymer	polymer	unknown
	FFKM	Kalrez, Technoflon PFR; Dyneon PFE; DAI-EL GA; Chemraz	perfluoroelastomeric compounds	polymer	multiple
	FKM	Viton, Viton E	family of fluorocarbon-based fluoroelastomer materials	polymer	multiple
		Fluoropolymers	unspecified fluoropolymers	unknown	unknown
		fluorosilicone	fluorosilicone rubber	polymer	unknown
	FPM	Viton	family of fluorocarbon-based fluoroelastomer materials	polymer	multiple

	FVMQ		fluorovinylmethylsiloxane rubber; fluorosilicone rubber	polymer	unknown
		Nafion	Perfluorosulphonic acid-PTFE copolymer	polymer	66796-30-3
		Nedox	(range of surface coating products)	polymer	multiple
		NOVEC 1700 (active)	Fluorinated acrylate polymer	polymer	unknown
	PCTFE		Polychlorotrifluoroethylene	polymer	9003-83-9
			Perfluoroalkane sulfonyl (meth)acrylate polymers	polymer	unknown
			Perfluorocarbon elastomer	polymer	unknown
		Perfluoroelastomer	Perfluoroelastomer	polymer	unknown
	PFA		perfluoroalkoxyl polymer	polymer	unknown
	PFPE	Krytox	perfluoropolyether	polymer	unknown
	PTFE	Teflon; Arlon; Avalon; Turcon; Formulations containing PTFE include: Alexol Stabox; Magnalube G; Microflon M2; PEEK / FC containing PTFE; Polyimide + PTFE	polytetrafluoroethylene	polymer	9002-84-0
	PVDF		Polyvinylidene fluoride; Polyvinylidenedifluoride; poly(1,1-difluoroethylene)	polymer	24937-79-9
	PVDF-HFP		Polyvinylidene fluoride; Polyvinylidenedifluoride; poly(1,1-difluoroethylene) and Hexafluoropropylene	polymer	24937-79-9 and 116-15-4 polymer
			Tetrafluoroethylene-hexafluoropropene copolymer	607-524-4	25067-11-2
		Tufram	(range of surface coating products)	polymer	multiple



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Fluorinated Alkene (non polymeric)	HFP	freon R 1216; halocarbon R 1216; fluorocarbon 1216	Hexafluoropropylene; Perfluoropropene; Perfluoropropylene	204-127-4	116-15-4
	TFE		Tetrafluoroethylene	204-126-9	116-14-3
Fluorinated organic fluids (non polymeric)	2-BTP	Halotron BrX	2-bromo-3,3,3-trifluoroprop-1-ene	627-872-0	1514-82-5
		Caldene TME	reaction mass of 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane; 1,1,1,2,3,3-hexafluoro-3-methoxy-2-(trifluoromethyl)propane	425-340-0	163702-05-4
		DuPont™ Vertrel®	HFC-based products	unknown	unknown
		FK-5-1-12; Novec 1230	Dodecafluoro-2-methylpentan-3-one; 1,1,1,2,2,4,5,5-nonafluoro-4-(trifluoromethyl)-3-pentanone	436-710-6	756-13-8
	HFC	HFC	unspecified Hydrofluorocarbons	unknown	unknown
		HFC-43-10mee	(S,S)-1,1,1,2,2,3,4,5,5,5-decafluoropentane; reaction mass of: (R,R)-1,1,1,2,2,3,4,5,5,5-decafluoropentane	420-640-8	138495-42-8
	HFE	HFE	unspecified Hydrofluoroethers	unknown	unknown
	HFE-7300		Pentane, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)-	459-520-5	132182-92-4
		Methyl Nonafluorobutyl Ether	Methyl Perfluorobutyl Ether; Butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-; 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane	829-015-8	163702-07-6
		Novec 71 IPA, NOVEC 1700 (solvent); Promosolv DR1	Methyl perfluoroisobutyl ether; reaction mass of 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxybutane; 1,1,1,2,3,3-hexafluoro-3-methoxy-2-(trifluoromethyl)propane	422-270-2	163702-08-7 and 163702-07-6



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		NOVEC 7500	3-ethoxy-1,1,1,2,3,4,4,5,5,6,6,6-dodecafluoro-2-trifluoromethyl-hexane	435-790-1	297730-93-9
		Perfluoroalkyl ethers / alkanes + aromatics		unknown	unknown
			Heptafluoropropyl pentafluoroethyl ether	611-940-1	60164-51-4
		reaction mass of 2,2,3,3,5,5,6,6-octafluoro-4-(1,1,1,2,3,3,3-heptafluoropropan-2-yl)morpholine and 2,2,3,3,5,5,6,6-octafluoro-4-(heptafluoropropyl)morpholine	reaction mass of 2,2,3,3,5,5,6,6-octafluoro-4-(1,1,1,2,3,3,3-heptafluoropropan-2-yl)morpholine and 2,2,3,3,5,5,6,6-octafluoro-4-(heptafluoropropyl)morpholine	473-390-7	-
Fluorinated gases	HFC-125		Pentafluoroethane	206-557-8	354-33-6
	HFC-227ea		1,1,1,2,3,3,3-Heptafluoropropane; heptafluoropropane; HFC-227; FM-200; apaflurane	207-079-2	431-89-0
	HFC-236fa	HFC-236fa; Freon 236fa; R-236fa; FC-236fa; HCFC 236fa; MH36; R236fa	1,1,1,3,3,3-Hexafluoropropane; 2,2-dihydroperfluoropropane	425-320-1	690-39-1
	HFC-134a	Norflurane; R134a	1,1,1,2-Tetrafluoroethane	212-377-0	811-97-2
Unspecified PFAS		Carbon Fiber with Polyimide resin + PFAS	unknown	unknown	unknown
		Fluoroalkyl		unknown	unknown
		Fluorocarbon	Fluorocarbon	unknown	unknown
		not specified		unknown	unknown
		Perfluoroalkyl amine		unknown	unknown
		PFAS	unspecified PFAS	unknown	unknown



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Table 15 gives details on the derogation assessment where an ASD use may be covered by a proposed derogation. Derogations 5k, 5m, and 5s are the most assigned derogations.

Table 15. ASD application areas assessed by the dossier submitters and which may be covered by a proposed derogation

Restriction Use Category	Use Category Sub-Use	Unassessed	Assessed		Potential Derogations					Proposed Derogations									
		No	Partial	Yes	[5dd]	[5y]	[6o]	5b	5e	5i	5k	5m	5n	5o	5s	5s?	5t	6e	6a
Applications of fluorinated gas	Cargo fire extinguishing systems		x									x							
Applications of fluorinated gas	Engine and APU fire extinguishing systems		x									x							
Applications of fluorinated gas	Fire extinguishers		x									x							
Applications of fluorinated gas	Handheld fire extinguishers		x									x							
Applications of fluorinated gas	Lavatory fire extinguishing systems		x									x							
Applications of fluorinated gas	Refrigerants			x						x									
Cleaning agents	Cleaning agents			x								x							
Cleaning agents	Cleaning fluids			x								x							
Cleaning agents	Cleaning solvents			x								x							
Cleaning agents	Contact cleaners			x								x							
Cleaning agents	Degreasing solvents			x								x							
Cleaning agents	Precision cleaners			x								x							
Cleaning agents	Specialist cleaning fluids			x								x							
Energy sector	Proton exchange membrane (PEM)			x															x
Hydraulic fluids	Anti-corrosion liquids (hydraulics)		x												x				
Hydraulic fluids	Hydraulic fluids			x											x				
Laboratory equipment	Calibration of measurement instruments																	x	
Laboratory equipment	Calibration standard																	x	
Laboratory equipment	Diagnostic tests			x									x						
Lubricants	Anti-friction coatings			x												x			
Lubricants	Chemically resistant greases			x												x			
Lubricants	Dry film lubricants			x													x		
Lubricants	Greases			x													x		
Lubricants	Greases for military applications			x													x		
Lubricants	High temperature greases			x													x		
Lubricants	Lubricants			x													x		
Lubricants	Lubricating oils			x													x		
Lubricants	LVDT lubricants			x													x		
Lubricants	Perforated and non-perforated fluorocarbon release films			x															
Lubricants	PTFE and graphite filled polyamideimides			x													x		
Lubricants	PTFE sheet for cabin emergency trap sealing			x													x		
Lubricants	Self-lubricating coatings			x													x		
Lubricants	Sliding pads			x													x		
Lubricants	Solid lubricants			x													x		
Lubricants	Thread lubricants			x													x		
Miscellaneous	High performance polymeric membrane (filter)			x						x									
TULAC	Fire resistant glass cloth		x							x									

Of the ASD application areas considered to be “partially assessed”, “6o-transport” was the more assigned derogation (see Table 16). Note that this is using a very wide interpretation of “transport” – many defence uses are not readily “transport”.

Table 16. ASD application areas considered to be “partially assessed” by the dossier submitter AND possibly covered by potential derogation 6o

Restriction Use Category	Use Category Sub-Use	Unassessed	Assessed		Potential Derogations			Proposed Derogations											
		No	Partial	Yes	[5dd]	[5y]	[6o]	5b	5e	5i	5k	5m	5n	5o	5s	5s?	5t	6e	6a
Coating and finishings	Abrasion resistant coatings		x				x												
Coating and finishings	Coatings		x				x												
Coating and finishings	Fan blade wear strips		x				x												
Lubricants	Bearings		x				x												
Lubricants	Bushings		x				x												
Sealing applications	Adhesive fabrics		x				x												
Sealing applications	Adhesive sheets		x				x												
Sealing applications	Adhesive tapes		x				x												
Sealing applications	Adhesives		x				x												
Sealing applications	Aircraft window gaskets		x				x												
Sealing applications	Backup rings		x				x												
Sealing applications	Bellows		x				x												
Sealing applications	Collar trim		x				x												
Sealing applications	Drive train seals		x				x												
Sealing applications	Gaskets		x				x												
Sealing applications	Grand plates		x				x												
Sealing applications	Grommets		x				x												
Sealing applications	High temperature sealants		x				x												
Sealing applications	Hydraulic system seals		x				x												
Sealing applications	Insulation tapes		x				x												
Sealing applications	Interlay sealants		x				x												
Sealing applications	O-rings		x				x												
Sealing applications	Overcoating		x				x												
Sealing applications	Pellet and strip locking		x				x												
Sealing applications	Pressure-sensitive tapes		x				x												
Sealing applications	Primary ring adapters		x				x												
Sealing applications	Sealants		x				x												
Sealing applications	Seals		x				x												
Sealing applications	Shutters		x				x												
Sealing applications	Slipping rings		x				x												
Sealing applications	Tapes		x				x												
Sealing applications	Valve seats		x				x												
Sealing applications	Washers		x				x												
Sealing applications	Wedge		x				x												

For two ASD application areas that were assessed by the dossier submitters, release agents and release foils, it is open to interpretation if they are covered by the proposed derogation 5s “lubricant”. These two applications were mapped separately as “5s?” – see Table 17

Table 17. ASD application areas assessed by the dossier submitter and possibly covered by the proposed derogation by 5s.

Restriction Use Category	Use Category Sub-Use	Unassessed	Assessed		Potential Derogations			Proposed Derogations											
		No	Partial	Yes	[5dd]	[5y]	[6o]	5b	5e	5i	5k	5m	5n	5o	5s	5s?	5t	6e	6a
Lubricants	Release agents			x												x			
Lubricants	Release foils			x												x			

A significant number of ASD application areas were considered to be either fully or partially assessed by the dossier submitters but not covered by either a proposed/potential derogation (see Table 18).

Table 18. ASD application areas considered to be “assessed/partially assessed” by the dossier submitter NOT covered by either a proposed or potential derogation

Restriction Use Category	Use Category Sub-Use	Unassessed	Assessed			Potential Derogations			Proposed Derogations											
		No	Partial	Yes	[5dd]	[5y]	[6o]	5b	5e	5i	5k	5n	5o	5s	5s?	5t	6e	6a		
Applications of fluorinated gases	Cooling agents			x																
Applications of fluorinated gases	Heat transfer fluids		x																	
Coating and finishings	Anti-foul paints		x																	
Coating and finishings	Anti-slip paint		x																	
Coating and finishings	Chemically resistant coatings		x																	
Coating and finishings	Electrical coil varnish		x																	
Coating and finishings	Lacquers		x																	
Coating and finishings	Paints		x																	
Coating and finishings	Varnish		x																	
Coating and finishings	Varnish for electronics		x																	
Electronics and semiconductors	Batteries			x																
Electronics and semiconductors	Cable insulation			x																
Electronics and semiconductors	Cables			x																
Electronics and semiconductors	Coaxial cables			x																
Electronics and semiconductors	Conformal coatings			x																
Electronics and semiconductors	Connectors		x																	
Electronics and semiconductors	Dielectrics			x																
Electronics and semiconductors	Electronic displays and touch screens			x																
Electronics and semiconductors	Electronics			x																
Electronics and semiconductors	Harness insulation		x																	
Electronics and semiconductors	High frequency connectors		x																	
Electronics and semiconductors	Lead-free soldering			x																
Electronics and semiconductors	Optical fibre accessories		x																	
Electronics and semiconductors	Printed circuit boards			x																
Electronics and semiconductors	Soldering			x																
Electronics and semiconductors	Soldering fluxing agent			x																
Electronics and semiconductors	Tubing		x																	
Electronics and semiconductors	Vapor phase soldering			x																
Lubricants	Moulding			x																
Lubricants	Perforated and non-perforated fluorocarbon release film			x																
Lubricants	Piston bearings		x																	
Lubricants	Sliders		x																	
Metal plating and manufacture of metal product	Lamellar zinc plating		x																	
Metal plating and manufacture of metal product	Lamellar zinc surface treatments		x																	
Metal plating and manufacture of metal product	Mist suppressants		x																	
Metal plating and manufacture of metal product	Nickel PTFE coating		x																	
Miscellaneous	Composite manufacturing		x																	
Miscellaneous	Filters		x																	
Miscellaneous	Fuel hose assemblies		x																	
Miscellaneous	Fuel tank membranes		x																	
Miscellaneous	Hoses		x																	
Miscellaneous	Markings		x																	
Miscellaneous	Membranes		x																	
Miscellaneous	Pipes		x																	
TULAC	Coated yarns		x																	
TULAC	Cover vehicle seats		x																	
TULAC	Yarns		x																	

A significant number of ASD application areas were not assessed by the dossier submitters and are mostly not covered by a proposed or potential derogation (see Table 19 (red)). Potential derogations 5dd and 5y are relevant for the A&D sector.

Table 19. ASD application areas not assessed by the dossier submitters and generally not covered by a proposed or potential derogation

Restriction Use Category	Use Category Sub-Use	Unassessed	Assessed		Potential Derogations			Proposed Derogations									
		No	Partial	Yes	[5dd]	[5g]	[6o]	5b	5d	5i	5j	5m	5n	5o	5s	5t	6a
Applications of fluorinated gases	Anti-corrosion products	x															
Body-, hull- and fuselage construction	Cellular materials	x															
Body-, hull- and fuselage construction	Fire resistant bulk head	x															
Body-, hull- and fuselage construction	Housing	x															
Body-, hull- and fuselage construction	Radomes	x															
Body-, hull- and fuselage construction	Welding	x															
Electronics and semiconductors	Boots	x															
Electronics and semiconductors	Flexible sleeves	x															
Electronics and semiconductors	Loom guides	x															
Electronics and semiconductors	Looms	x															
Electronics and semiconductors	Metal-plated wires	x															
Electronics and semiconductors	Pin carriers	x															
Electronics and semiconductors	Protection sleeves	x															
Electronics and semiconductors	Shrink sleeves	x															
Electronics and semiconductors	Sleeves	x															
Electronics and semiconductors	Solder sleeves	x															
Foils	Covering foils	x															
Foils	Decorative foils	x															
Foils	Foil heaters	x															
Foils	Identification tape	x															
Foils	Label materials	x															
Foils	Wrap for engine casings	x															
Food contact materials and packaging	Critical foam packaging	x															
Food contact materials and packaging	Potable water systems	x															x
Laboratory equipment	Chemical detectors for military applications	x											x				
Miscellaneous	Anti-vibration parts	x															
Miscellaneous	Cable ties	x															
Miscellaneous	Carriers	x															
Miscellaneous	Cushion clamps	x															
Miscellaneous	Duct oil	x															
Miscellaneous	Dyes	x															
Miscellaneous	Extruded profiles	x															
Miscellaneous	Flex	x															
Miscellaneous	HAD process surface treatments	x															
Miscellaneous	Half shells for anti-rotation coils	x															
Miscellaneous	Heat transfer fluids (polymeric)	x															
Miscellaneous	Heat transfer fluids for brazing furnace	x															
Miscellaneous	Holders	x															
Miscellaneous	Hydraulic hoses	x															
Miscellaneous	Liners	x															
Miscellaneous	Low friction thermoplastics	x															
Miscellaneous	Mechanical parts	x															
Miscellaneous	Oil hose assemblies	x															
Miscellaneous	Oil level accessories	x															
Miscellaneous	Packing	x															
Miscellaneous	Pin holders	x															
Miscellaneous	Plastic for interiors	x															
Miscellaneous	Pneumatic assemblies	x															
Miscellaneous	Process equipment	x															
Miscellaneous	Pumping rings	x															
Miscellaneous	Rubber mats	x															
Miscellaneous	Rubber strips	x															
Miscellaneous	Shock absorbers	x															
Miscellaneous	Site glass	x															
Miscellaneous	Special rubbers	x															
Miscellaneous	Tank liners	x															
Miscellaneous	Thermal insulation	x															
Pyrotechnics	Igniters	x															
Pyrotechnics	Plastic bonded energetic material	x															
Pyrotechnics	Relays	x															
TULAC	Anti-g suits	x														x	
TULAC	Camouflage nets	x														x	
TULAC	Coated Fabrics for Rafts or Canopy	x														x	
TULAC	Lacing ties	x															

Annex 2. Case studies

See separate attachment.