REACH Obsolescence Risk Management for Space Programs

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ESA, ESTEC
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European Space Agency

Introduction

Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) [1]

REACH addresses

- the production and use of chemical substances
- their potential impacts human health
- their potential impact on the environment

It is the strictest law to date regulating chemical substances and has worldwide impact.

As a consequence many chemical substances will be ‘forced’ to be phased out (cost/benefit of continuous use, availability of alternatives) directly affecting the qualification status of materials, processes, and technologies.

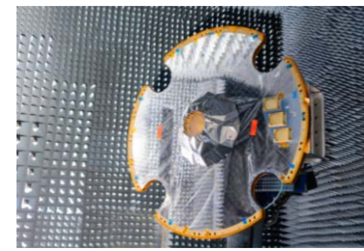
The regulation is very desirable and ambitious to contribute to a safer and healthier environment, but it poses wide-reaching engineering challenges for the space sector which is by nature driven by performance and heritage design.

[1] EU Regulation 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the registration, evaluation, authorization and restriction of chemicals (REACH)

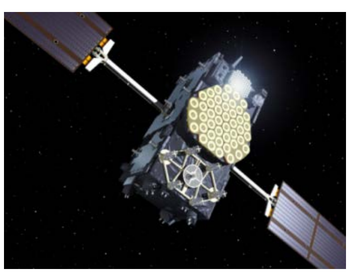
REACH obsolescence risks


Chromium trioxide

- Wider range of applications, covering chromic conversion coatings for corrosion protection of Al and Mg alloys and chromic acid anodization.
- Conversion coating Alodine 1200 used on essentially all Al-alloys
- Classified carcinogenic 1A, mutagenic 1B
- REACH candidate list inclusion 15.12.2010
- Annex XIV inclusion 21.4.2013
- Latest application date 21.3.2016
- Sunset date 21.9.2017

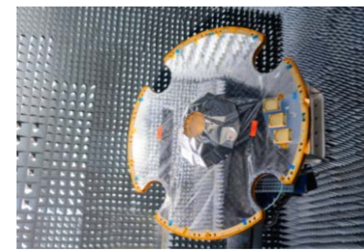


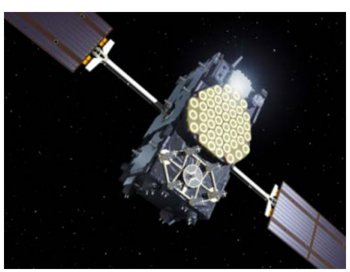



REACH obsolescence risks

Strontium chromate

- Corrosion inhibiting, typically used in primers such as BR 127.
- Classified carcinogenic 1B
- REACH candidate list inclusion 20.6.2011
- Annex XIV inclusion 22.8.2014
- Latest application date 22.7.2017
- Sunset date 22.1.2019

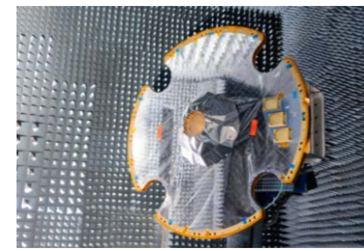


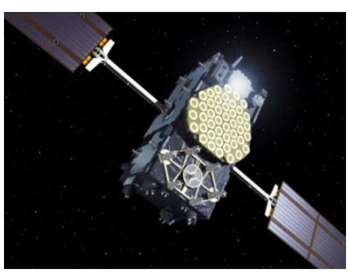


REACH obsolescence risks

Ammonium dichromate

- Used in powder mixture for pyrotechnic devices.
- Classified carcinogenic 1B, mutagenic 1B, toxic for reproduction 1B
- REACH candidate list inclusion 20.6.2011
- Annex XIV inclusion 21.4.2013
- Latest application date 21.3.2016
- Sunset date 21.9.2017

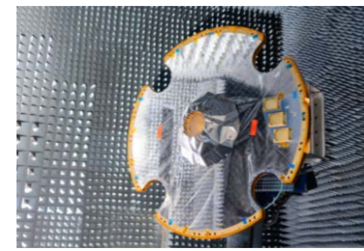


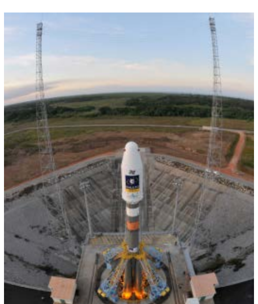
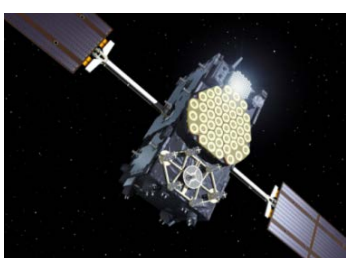


REACH obsolescence risks


Boric acid

- Used e.g. for electrolytic deposition of metals such as Ni and SnPb
- Classified toxic for reproduction 1B
- REACH candidate list inclusion 18.6.2010
- Annex XIV inclusion: On 6th draft recommendation
- Annex XIV inclusion ≥ Q1 2016
- Latest application date ≥ Q3 2018
- Sunset date ≥ Q1 2019

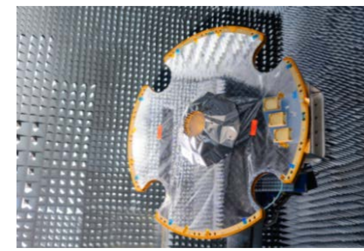



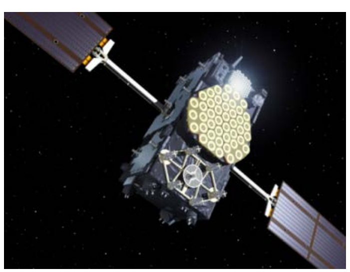




REACH obsolescence risks

Hydrazine

- Propellant for attitude control of launch vehicles and spacecrafts
- Strategic for satellite and launcher programs, no viable alternative is available yet
- Classified carcinogenic 1B
- REACH candidate list inclusion 20.6.2011
- Annex XIV inclusion ≥ Q1 2017
- Latest application date ≥ Q3 2019
- Sunset date ≥ Q1 2020

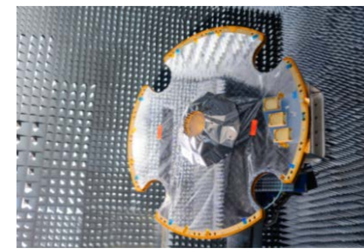


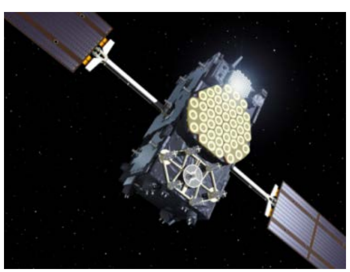


REACH obsolescence risks

Lead(II) bis(methanesulfonate)

- Used for electrolytic deposition of SnPb
- No replacement yet available for SnPb soldering for space applications
- Classified toxic for reproduction 1A
- REACH candidate list inclusion 18.6.2012
- Annex XIV inclusion ≥ Q1 2017
- Latest application date ≥ Q3 2019
- Sunset date ≥ Q1 2020

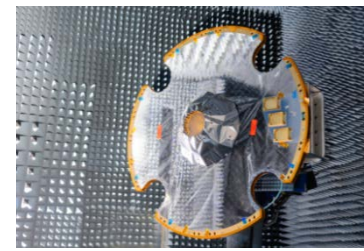


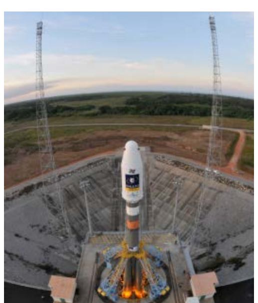


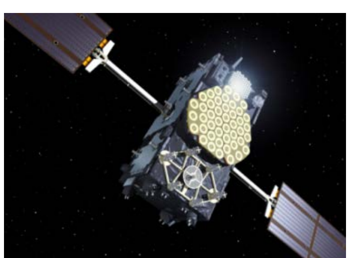
REACH obsolescence risks

Gallium Arsenide

- Used for EEE components and solar cells
- Classified carcinogenic 1B, toxic for reproduction 1B TBC
- Has not yet entered the REACH authorisation process.
- REACH candidate list inclusion ?
- Annex XIV inclusion ?
- Sunset date ?







REACH corollary

Directly affects materials, processes and technologies

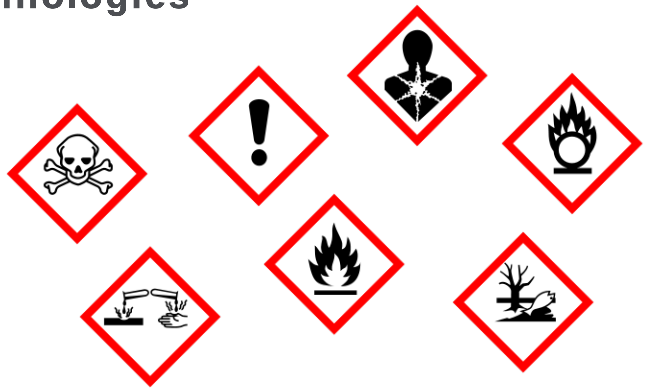
Adhesive, coating and primer formulations

Solvents, surface treatments

Fuels, energetic materials

EEE components, sensors, PCB assembly

Power generation



Exposure to projects depends on project life

- Affects entire industrial sector
- Affects ground phase from moment of design
- REACH exposure does not end after manufacturing (e.g. fuelling, pyrotechnics, repair, recurrent h/w)
- Uncertainty increases with increasing time (scientific payload vs. launcher or satellite platform)
- Legal compliance ≠ risk management
- Space is a niche market

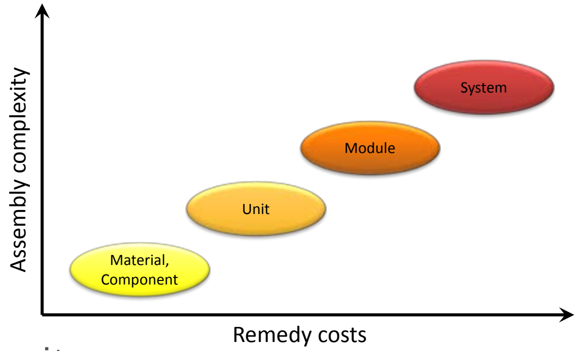
Scope of workshop

Why

REACH affects the entire supply chain of space industry through obsolescence of materials, processes, and technologies.

- Unprecedented scale
- Increasing remedy costs with increasing assembly complexity

→ Require appropriate management within space community



Target audience

System integrators, manufacturers, suppliers, space agencies, ESA programs

Objectives

- Enable a dialogue between industry, national space agencies, and ESA programs on long-term obsolescence risks of REACH
- Outline current efforts for risk management
- Identify major challenges for space industry
- Engage in a dialogue on future requirements and needs

Agenda

Time	Presenter	Title
09:00 – 09:10	W. Veith (ESA)	Opening
09:10 – 09:20	T. Rohr (ESA)	Introduction
09:20 – 10:00	T. Becker (REACHLaw)	REACH: How it works from a space sector perspective
10:00 – 10:20	T. Rohr (ESA)	REACH obsolescence management through the Materials and Processes Technology Board
10:20 – 10:30	I. McNair (Airbus DS)	Innovative substances in the spotlight of chemicals legislation REACH
10:30 – 10:50	Coffee break	
10:50 – 11:10	I. Mcnair (Airbus DS)	ASD REACH Implementation Working Group
11:10 – 11:30	J.M. Besson (Herakles), A. Eriteau (Airbus DS)	Concerns about obsolescences management : the Airbus-Safran-Launchers overview
11:30 – 11:50	M.C. Contino (ESA)	REACH impact on European Launchers programmes and associated activities: An overview of ESA strategy
11:50 – 12:10	F. Valencia Bel (ESA)	Green Propulsion. State-of-art, prospectives and roadmap
12:10 – 12:30	G. Sierra (MAP coatings)	REACH management for MAP space products
12:30 – 14:00	Lunch break	
14:00 – 14:10	S. Heltzel (ESA)	REACH obsolescence for PCB assemblies
14:10 – 14:30	M.E. Boeschoten (BTMO)	Obsolete components & aging effects of electronics in processautomation equipment used for a 650 MW powerplant
14:30 – 14:50	C. Durin (CNES)	The REACH Regulation and the materials obsolescence for the Space Activities
14:50 – 15:10	L. Innocenti (ESA)	ESA Cleanspace Program
15:10 – 15:30	X. Barbier (ESA)	ESA TRP and GSTP technology program
15:30 – 15:40	K. Benamar (ESA)	ESA SME Industrial policy; a new way forward
15:40 – 16:00	Coffee break	
16:00 – 17:00	A. Coello-Vera (REACHLaw)	Round table discussion on industry needs

Materials & Processes Technology Board

Materials & Process Technology Board is a European platform that includes industrial partners and national space agencies including with members from Airbus DS (satellites and space transportation), ASI, Avio, CNES, DLR, ESA, Herakles, MAP, OHB, REACHLaw, RUAG, TESAT, and Thales Alenia Space. Tasks include:

- Legislation: Intelligence of legislative processes (e.g. REACH, RoHS) and coordination of preventive and corrective actions.
- Obsolescence: Proposition of action plans to mitigate risk of obsolescence in the field of Materials & Processes.
- Data exchange: Coordination to share materials characterisation data and avoidance of test duplication.
- R&D activities: Strategy definition for M&P, harmonisation of R&D activities, monitoring of alerts, analysis of in-orbit anomalies, establishment of lessons learned, *etc.*
- Communication & information exchange: Support and coordination of information via symposia, WGs, training. Development of synergies with M&P activities with other industrial areas.

Dedicated splinter activities cover currently

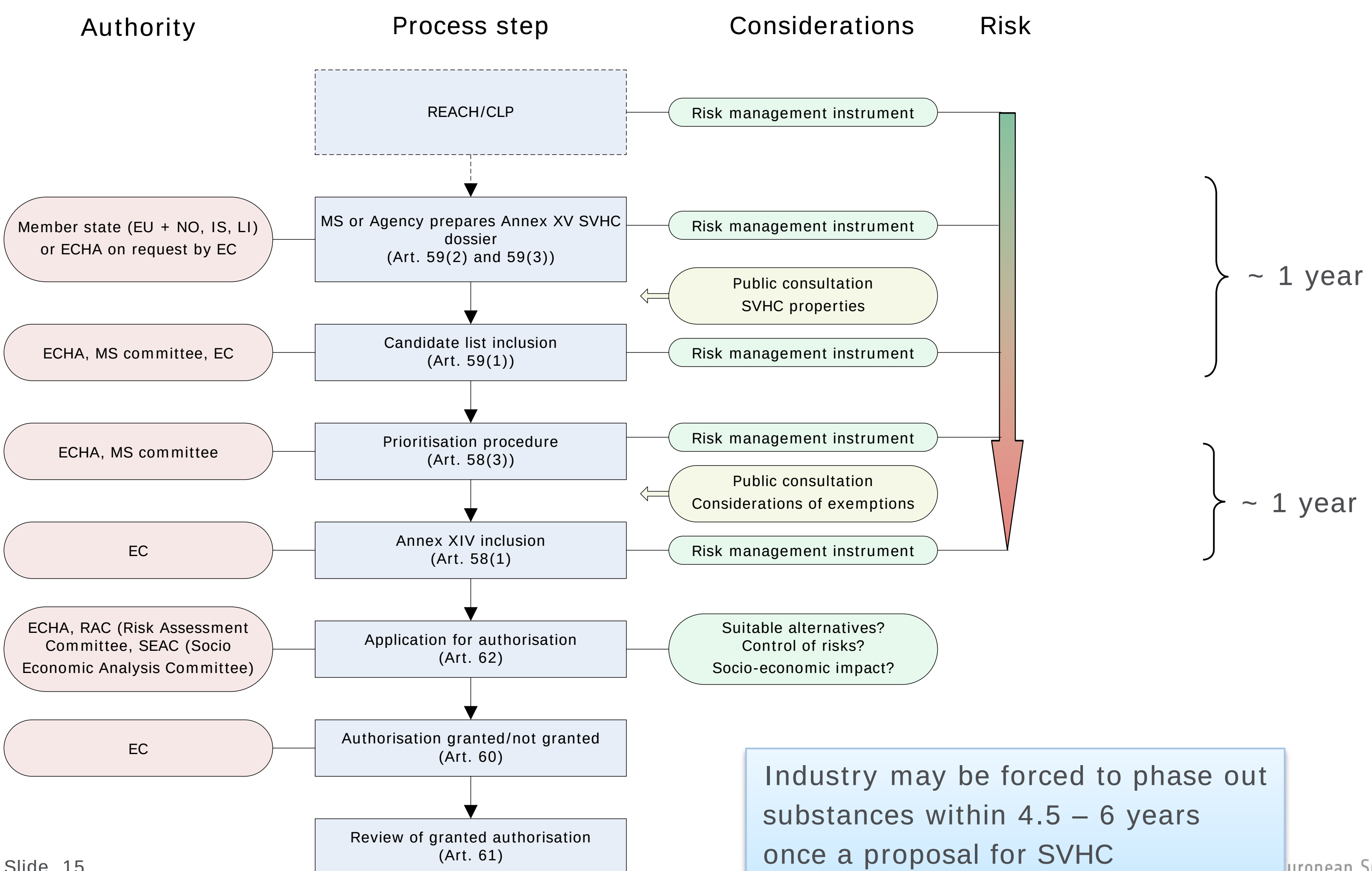
- Chromate space task force
- Pb-free control plan
- Hydrazine task force

Obsolescence Risk Mitigation

One major objective of the MPTB is the early obsolescence risk mitigation with the objectives to:

- Identify in advance potential critical materials and processes for satellite platforms and launchers.
- Reduce programmatic risks and costs by early replacement, including use of alternatives, re-qualification or possibly new developments.
- Perform a risk assessment of identified materials and processes taking into account the status in the REACH process, diversity of uses, availability of alternatives, *etc.*
- Propose corrective actions that may include
  - Use of already qualified or qualification of alternatives
  - Alternatives in the context of R&D
  - Authorisation for space-related applications
  - Exemption from REACH regulation for space industry (if legally applicable)

The REACH authorisation process



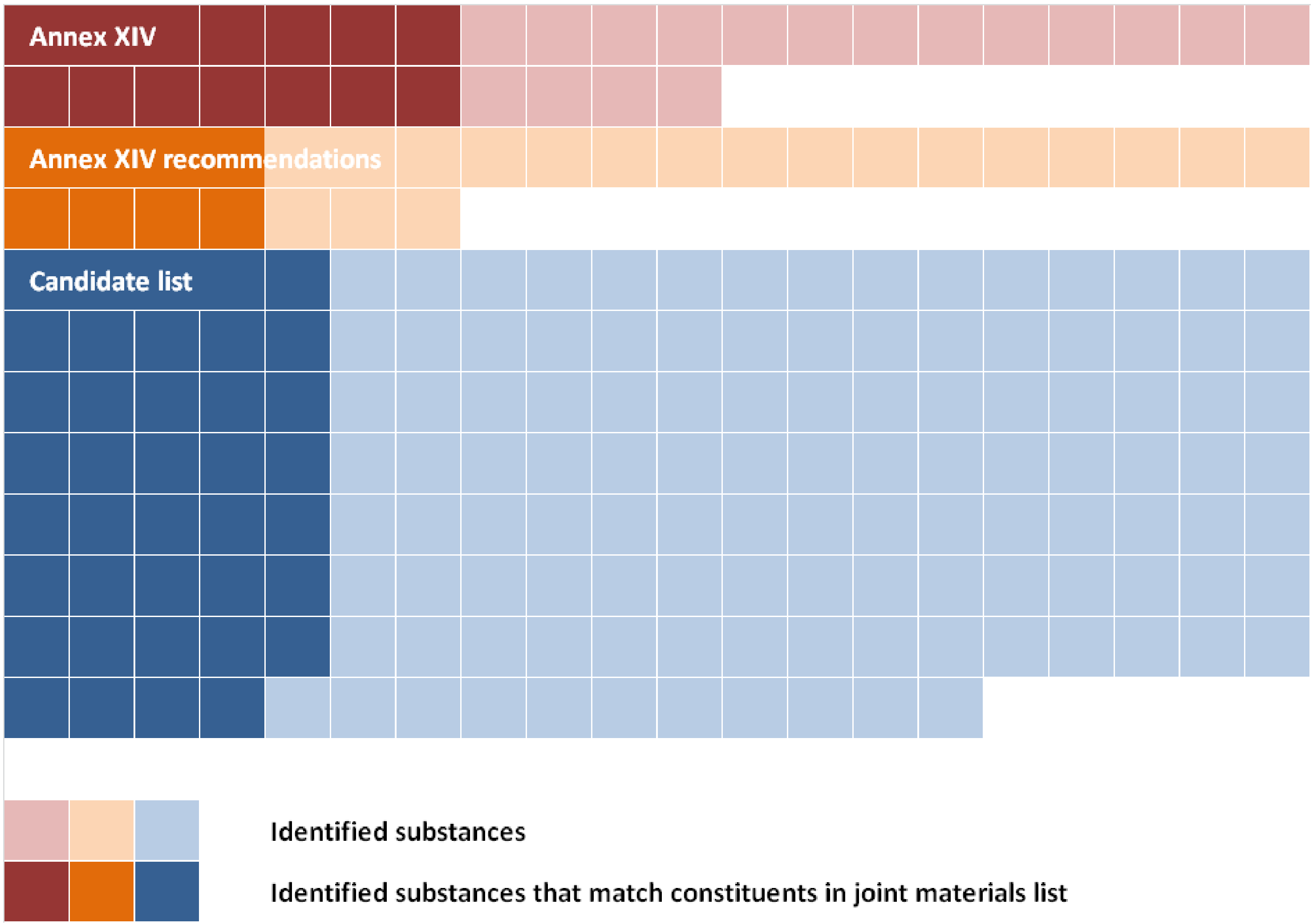
Industry may be forced to phase out substances within 4.5 – 6 years once a proposal for SVHC classification has been initiated.

Materials cross-check

Compound	A	B	C	D	E	F	G	H	I	J	K	L	...	X
Composition material 1										⊙	⊙			
Composition material 2	⊙	⊙				⊙								
Composition material 3					⊙				⊙					⊙
Composition material 4														
Composition material x							⊙			⊙	⊙			⊙
e.g. Alodine 1200S (20.10.2011)	n.a.		CrO_3											
e.g. Alodine 1200S (17.4.2013)	CrO_3		n.a.											
	Annex XIV	Annex XIV	Annex XIV recom.	Annex XIV recom.	Candidate list	Candidate list	Registry of Int.	Registry of Int.	SIN list	SIN list	REACH/CLP	REACH/CLP		National regulat.

Obsolescence risk	Imminent	Probably mid-term	Possibly long-term

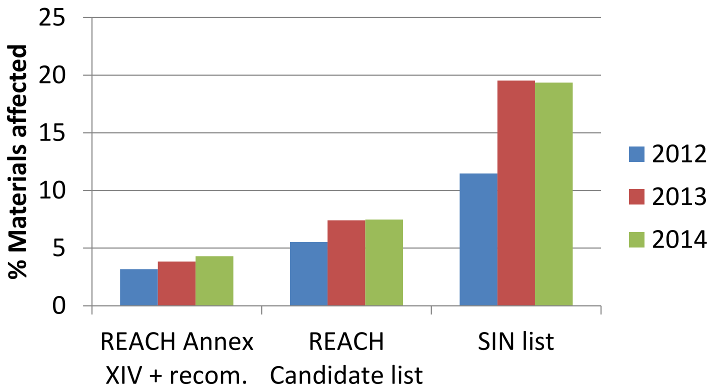
Status of candidate list / Annex XIV



Risk assessment

From joint materials inventory a regular cross-check is performed with:

		Obsolescence risk
1.	Annex XIV	imminent
2.	Annex XIV recommendation	imminent
3.	Candidate list	mid-term
4.	SVHC dossiers	mid-term
5.	SVHC roadmap 2020	long-term
6.	SIN-list [1]	long-term
7.	HCL dossiers	long-term
8.	Gap analysis – non reg. subst. – reason unknown	investigate
9.	CoRAP (Community Rolling Action Plan)	investigate



The risk is weighed according to several parameters:

- Diversity of different applications and users (*e.g.* standard process, common technology)
- Procurement implications (*e.g.* single source, high value/consumption, scarce)
- Design implications (*e.g.* heritage, design/technology driver)
- Availability of alternatives (*e.g.* none identified, resource intensive requalification)
- Strategic value for space applications

→ Mitigate risk accordingly (alternatives, authorisation, exemption)

[1] The SIN list (www.sinlist.org) is an NGO driven project to speed up the transition to a toxic free world. The latest update from Oct 2014 consists of 830 entries. Substances are identified as SVHC based on the criteria established by REACH.

Example of Annex XIV – Cr(VI)

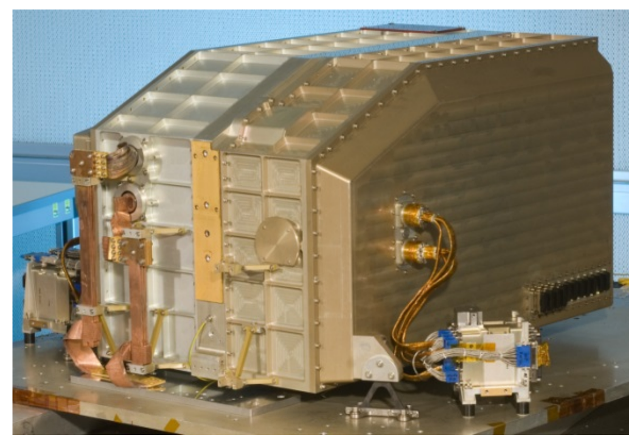
A larger number of chromates are on Annex XIV with sunset dates

21st Sep 2017: Including CrO_3, $Na_2Cr_2O_7$, $K_2Cr_2O_7$, Na_2CrO_4, K_2CrO_4 , $(NH_4)_2Cr_2O_7$

22nd Jan 2019: Including $SrCrO_4$

Examples of Cr(VI) applications cover

- Chromic conversion coating
  Corrosion protection for Al and Mg alloys, *e.g.* Alodine 1200S (CrO_3)
- Primers
  Corrosion inhibition, adhesion promotion, *e.g.* structural primer BR 127 ($SrCrO_4$)
- Greases
  Corrosion inhibition (Na_2CrO_4)
- Chromic acid anodisation
  Corrosion protection, thermal control (CrO_3)
- Sealing after chromic acid anodisation
  Improvement of corrosion protection ($K_2Cr_2O_7$)
- Pyrotechnic devices ($(NH_4)_2Cr_2O_7$)
- *etc.*



Current test/qualification programs for Cr(VI) replacement

Intention to bring qualification programs on European/international platform to

- Perform evaluations and 'pre-qualifications' early to reduce program impacts
- Avoid duplication, safe resources
- Give industry access to test data

Replacement for Alodine 1200: Coordinated test programs by Airbus DS/CNES, ESA/NASA

Replacement for primer BR 127: TAS/CNES\

Challenges for Alodine 1200

21 Sep 2017: Sunset date, availability for qualified alternatives

21 Mar 2016: Latest application date, *i.e.* latest submission for REACH authorisation

Replacement is technically very demanding due to wide variety of configurations and performance penalties with possible alternatives

1. Replace what can be replaced by Sep 2017 → Test and qualification campaigns
2. Ensure authorisation for the remaining for sufficiently long time → prepare authorisation dossier
3. Are our performance requirements justified? → Revisit corrosion requirements

Alodine 1200S replacement – ESA / NASA

Test matrix definition

Substrates (3” x 10”)

- 2024-T3, 2024-T8
- 6061-T6
- 7075-T6, 7075-T73

Configurations

- Pre-treatment only
- Best pre-treatment + primer (both ESA/NASA systems)
- Best Pre-treatment/primer + topcoat (both ESA/NASA systems)

Pre-treatments	Primers	Topcoats
About 20 systems for during pre-screening phase, 4 best performing systems for comprehensive testing: • Metalast TCP • SurTec 650V • Boderite M-NT 65000 (formerly Alodine 5926 plus) • Mapsil SILICo (thin)	Combination of 4 primers with 4 best performing pre-treatments • Hentzen 16708 • Deft 02GN084 • Mapsil SILICo (thick) • Mapsil SILICo AS	Combination of 4 topcoats with 4 best performing pre-treatment/primer system TBD
Salt spray (168h)	Salt spray (2000h)	Salt spray (2000h)
Humidity exposure (50°C, 80°C/95%rh)	Launch-site exposure	Launch-site exposure
Thermal cycling (± 100°C)	Thermal cycling (± 100°C)	Thermal cycling (± 100°C)
Cleanroom exposure	Adhesion	Adhesion
Surface resistivity		

Pretreatments – other ongoing tests

Humidity exposure

50°C/80°C at 95%rh, weekly inspection → representative test conditions under evaluation

Cleanroom exposure

Selection of most challenging substrates (2024) for long-duration exposure at different industrial sites (TBC, e.g. ESTEC, Zurich, Turin, Cannes, Toulouse), test panels are ready and exposure scenario agreed with MPTB members.

Thermal cycling

ECSS-Q-ST-70-04C, 100 cycles at ± 100°C (vacuum/ambient/vacuum)

Surface resistivity

ASTM D 257 (TBC), challenging to get reproducible solid data due to effect of humidity

Besides ESA/NASA test campaign a complementary contract was kicked-off with ISQ to evaluate optimisation and reproducibility of process also in view of later industrialisation.

Image: From Dilbert 7 Nov 2010

Current test / qualification programs for Cr(VI) replacement

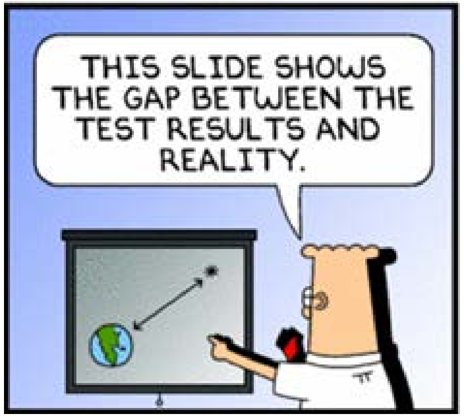


Image: From Dilbert 7 Nov 2010

Challenges e.g. for Alodine 1200

- So far no commercial solution as universal as Alodine 1200, systems are less forgiving and very sensitive to preceding process steps
- Experience shows that none of the Cr(VI)-free systems reach same performance, especially challenging are 2xxx alloys
- Corrosion resistance is not the only requirement, need also to take into account the thermal endurance and surface resistivity
- Systems are generally more difficult to inspect (optical appearance)

→ Cr(VI) conversion coating remains the reference system

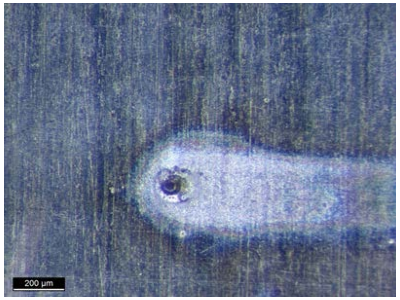
→ Need to revisit performance requirements, ESCC –Q-ST-70-14C 'Corrosion'

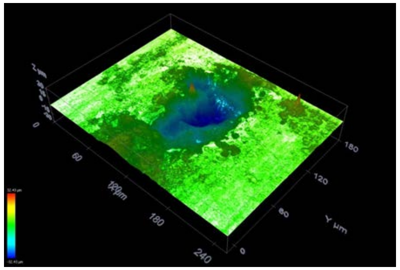
→ Include standard 'rough' test environment (salt spray) and 'mild' test environment (moist heat)

→ Cannot conclude on performance today

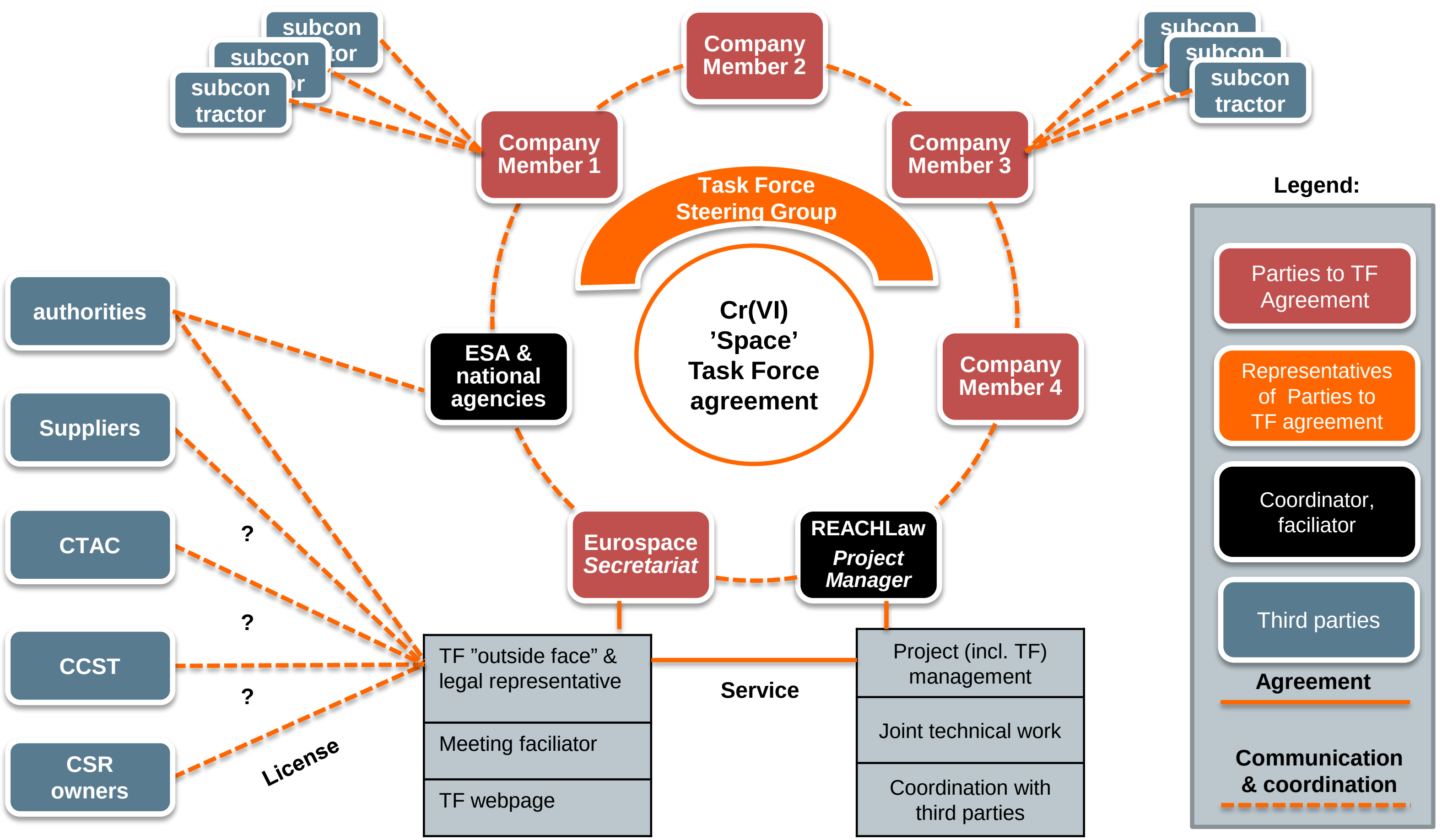
ESA / NASA test campaign schedule

Aug 2015	Finalisation for testing pretreatments and primers
Oct 2015	Finalisation for testing topcoats
Q4 2015	Intermediate test report (without launch site exposure)
Q2 2017	Final report





REACH authorisation - Space Task Force



REACH authorisation – Workplan of STF

Phase 1: Scoping

ESA funded, no financial obligations for participants except their own manpower and travel resources. Objectives

- Task force kick-off
- Definition of substances and uses to be covered for authorisation
- Initiation of 3rd party communication (other chromate task forces, authorities, suppliers, etc.)
- Agreement on final workplan and budgeting for phase 2

Work concluded March 2014

Phase 2: Joint technical work

Cost sharing mechanism by industry members through Eurospace. Objectives:

- Development of relevant dossier elements as agreed in phase 1 such as AoA (Analysis of alternatives), SEA (Socio-Economic Analysis), substitution plan
- Development of authorisation strategy (who does apply?), coordination with non-space actors.

Kick-off Q3 2014, target is the latest application window Mar 2016.

Phase 3: Application for authorisation

Not part of current project plan

ECSS-Q-ST-70-14C Corrosion

Work started Q2 2014, publication is scheduled end 2015

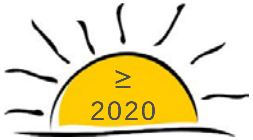
- Summarises corrosion protection requirements applicable to the materials, surface treatments, finishing and manufacturing processes used for space flight hardware.
- Provides the minimum requirements necessary to guarantee and verify the suitability of materials, coatings systems and processes for corrosion control of space rated products.
- Classifies the corrosion environments and requires the issuing of a Corrosion Prevention and Control Plan based on the identified environmental classes. Testing and acceptance criteria are specified for each environmental class.

The standard should

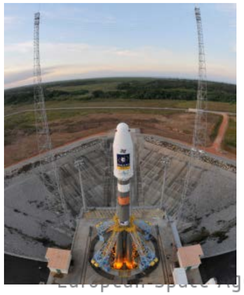
- Classify corrosive environments relevant to the space industry.
  Different test methods and requirements are applicable for different environments such as seacoast, inland/outdoor, indoor uncontrolled, indoor controlled
- Define corrosion requirements for Spacecraft and GSE
  Materials, coatings, processes *etc.*, what is ‘good enough’?

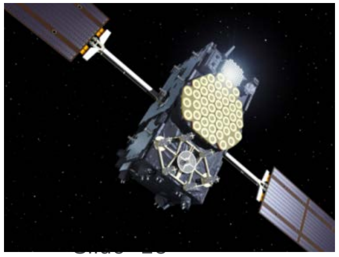
The need for using Alodine 1200 will probably decrease.

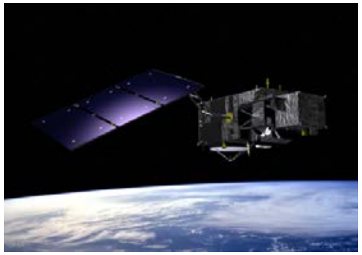
Example for Candidate List – Hydrazine



- Classified carc 1B, on candidate list since 20.6.2011
- Annex XIV inclusion ≥ Q1 2017, sunset date ≥ Q1 2020
- Monopropellant for attitude control of launchers and satellites
- Produce thrust by catalytic decomposition ($N_2H_4 \rightarrow N_2$, NH_3, H_2)
- High purity grade (~ 99%)
- Several uses such as:
  - Import/manufacture low/high grade hydrazine
  - Purification
  - Distribution/transport
  - Ground testing
  - Loading, off-loading, quality/compatibility testing
  - In-orbit firing
- Controlled procedures to exclude human/environmental exposure
- Strategic for satellite and launcher programs, no viable alternative is available yet







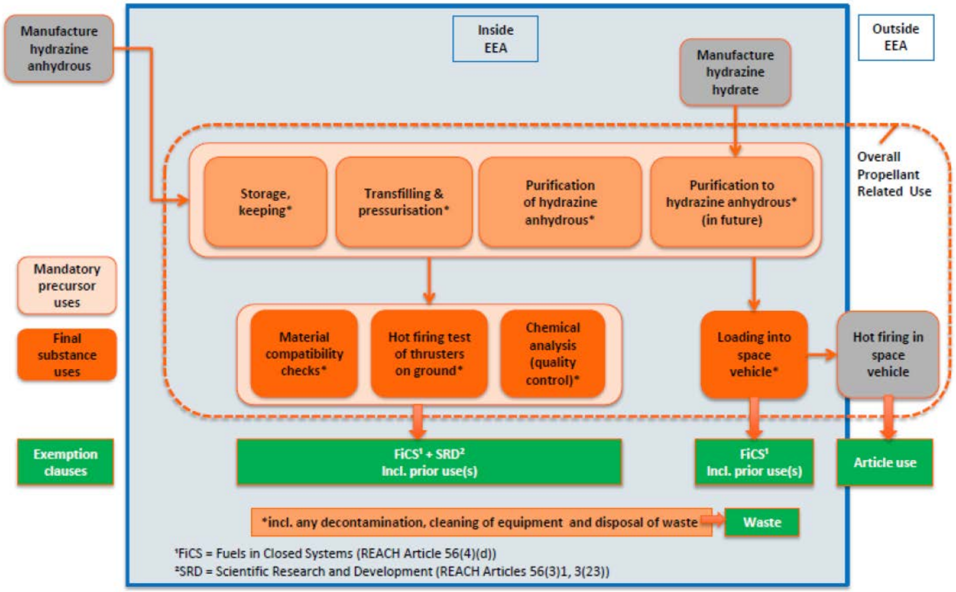
Images: ESA –Fuelling MetOp-B, Galileo, Sentinel-2, Sentinel-3, MetOp, Ariane 5, VEGA, Soyuz-ST

Hydrazine – Workplan

1. Exemption

Exemption study indicated this option to be viable. Task force including all stakeholders (industry, agencies, Eurospace, REACHLaw) developed a position paper (http://www.eurospace.org/position-papers.aspx).

Eurospace presented the position paper to the EC end 2012 with the request for legal clarification.



2. Authorisation

Backup solution in case exemption is legally not applicable.

3. Development of green alternatives

Independent of the final route, a roadmap towards alternative technology needs to be pursued to

- substantiate the arguments for authorisation/exemption,
- position European space industry on the forefront of green technologies, and provide it with a commercial advantage after successful qualification.

REACH is not only a compliance issue but **needs to be addressed in the context of R&D**.

Alternative green technologies are addressed in the ESA ‘Clean Space’ proposal

Example for REACH / CLP – GaAs / InP

CLP or CLP Regulation is the new European Regulation on **C**lassification, **L**abelling and **P**ackaging of chemical substances and mixtures. It identifies:

- Potential Substance of Very High Concern (SVHC) → Authorization (Annex XIV)
- Potential substance posing ‘unacceptable risk’ → Restriction (Annex XVII)

After the 3rd/5th Adaptation to Technical Progress (ATP), among others, the following substances space relevant substances (RF components, solar cells) are under considerations:

- Indium phosphide (carc. 1B, repr. 2) is included in Annex VI after 3rd ATP
- Gallium arsenide (carc. 1B) is included in Annex VI after 5th ATP, repr. 1B TBC

Identification as SVHC requires CMR 1A/1B, PBT, vPvB
→ **GaAs and InP qualify in principle for definition as SVHC**

Harmonized CMR classification may lead directly or indirectly to future authorization/restriction process of the substance → industry should be active already at this stage

Image: ESA – Herschel SA

Image: ESA – Gaia antenna

Solvents

Various solvents appear throughout the authorisation process such as use for paint applications, cleaning, quality control, manufacturing. The following table is non exhaustive:

Substance	Status	Comments, example uses
Trichloroethylene	Annex XIV	Sunset date Apr 2016 Primers, degreasing
1,2-Dichloroethane	Annex XIV	Sunset date exp. Q2 2017
N,N-Dimethylacetamide	Annex XIV 4th recom.	Put on hold to await RAC/ SEAC opinions on NMP restriction Residue in polyimides
N,N-Dimethylformamide	Annex XIV 5th recom.	Sunset date exp. Q2 2018 Residue in resins
1-Methyl-2-pyrrolidone	Candidate list	Possibly restriction process Residue in adhesives
2-Ethoxyethanol	Candidate list	Primers
2-Methoxyethanol	Candidate list	Primers
2-Methoxypropyl acetate	SIN list	Primers, paints
Naphtha (petroleum), hydrotreated light	SIN list	Paints, glues, anti-seize
Solvent naphtha (petroleum), light arom.	SIN list	Primers, paints

Examples of other critical substances

Substance	Status	Comments, example uses
Ammonium dichromate	Annex XIV	Sunset date Sep 2017 Used in MIRA powder for pyrotechnic initiators
Cadmium	Candidate list	Restriction … shall not apply to … articles used in the aeronautical, aerospace … sectors whose applications require high safety standards … Authorisation still possible for unrestricted uses
Lead(II) bis(methanesulfonate)	Candidate list	Electrolytic deposition of SnPb
Boric acid	Annex XIV 6th recom.	Electrolytic deposition processes
…		

Conclusions

- REACH addresses the manufacture, placing on the market and us of chemical substances and reduces the negative impact of chemicals to human health and environment through the control of SVHCs. Through this, a progressive reduction of availability of materials and processes is expected.
- Impairment of quality and reliability or even loss of critical technologies through obsolescence of qualified materials and processes must be avoided.
- Active obsolescence risk management is required (MPTB as European observatory)
  - Long-term view, risk matrix, risk mitigation
  - Active involvement in public consultations
  - Joint qualification of alternatives (European, international stakeholders), cooperation on European and international level is envisaged to exploit synergies
  - Propose R&D activities, e.g. CleanSpace
  - Collaboration to comply with authorisation and establishment of basis for exemption.
- Communication to the authorities is crucial

  Supply chains can be extremely complex, and the authorities cannot be expected to have the depth of knowledge to recognise all possible consequences of regulatory decisions. It is crucial to the space community to make use of all elements of the regulatory procedure (e.g. public consultations), and to enter into a constructive dialog with the authorities and policy makers to actively communicate its concerns.
- Early replacement of materials/processes containing SVHCs may position European space industry on the forefront of green technologies, and provide it with a commercial advantage after successful qualification.

Questions?