Impact of REACH Legislation on European Space Programs

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Outline

- Introduction to REACH
- Technical impact on space programs
- Obsolescence risk assessment
- Status of Annex XIV
- Status of Annex XIV recommendations, example chromates
- Status of candidate list, example hydrazine
- Status of CLP, example GaAs, InP
- Outlook
- Conclusions

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REACH – Background

REACH [1] applies to all chemicals imported or manufactured in the European Economic Area (EU + NOR, ISL, LIE) [2]. It shifts the responsibility for demonstration of safe use of chemicals from authorities to industry. The manufacturing, placing on the market and use of substances in Europe is regulated by processes through:

- Registration
- Authorisation
- Restriction

SVHCs are gradually included in the Annex XIV of the REACH regulation. Once included in that annex, they cannot be placed on the market or used after a date to be set (the so-called 'sunset' date) unless an authorisation is granted. All uses not authorised have to be phased out.

The candidate list, the baseline tool to identify substances as SVHC [3], currently lists 84 entries. By 2020 it is expected to contain all relevant currently known SVHCs (300 – 500 substances).

REACH should be seen as a market opportunity for promoting green technologies.

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

[2] Note: EU member states ≠ ESA member states, e.g. CH

[3] Substance of Very High Concern based on inherent properties (criteria from REACH Article 57)

REACH impact on ESA

Legislative aspects
May lead to unforeseen liabilities

Technical aspects
May lead to unforeseen obsolescence

Standardisation
May lead to incomplete communication of PA requirements through supply chain

Communication
Various ESA programs may have a different strategy to tackle REACH

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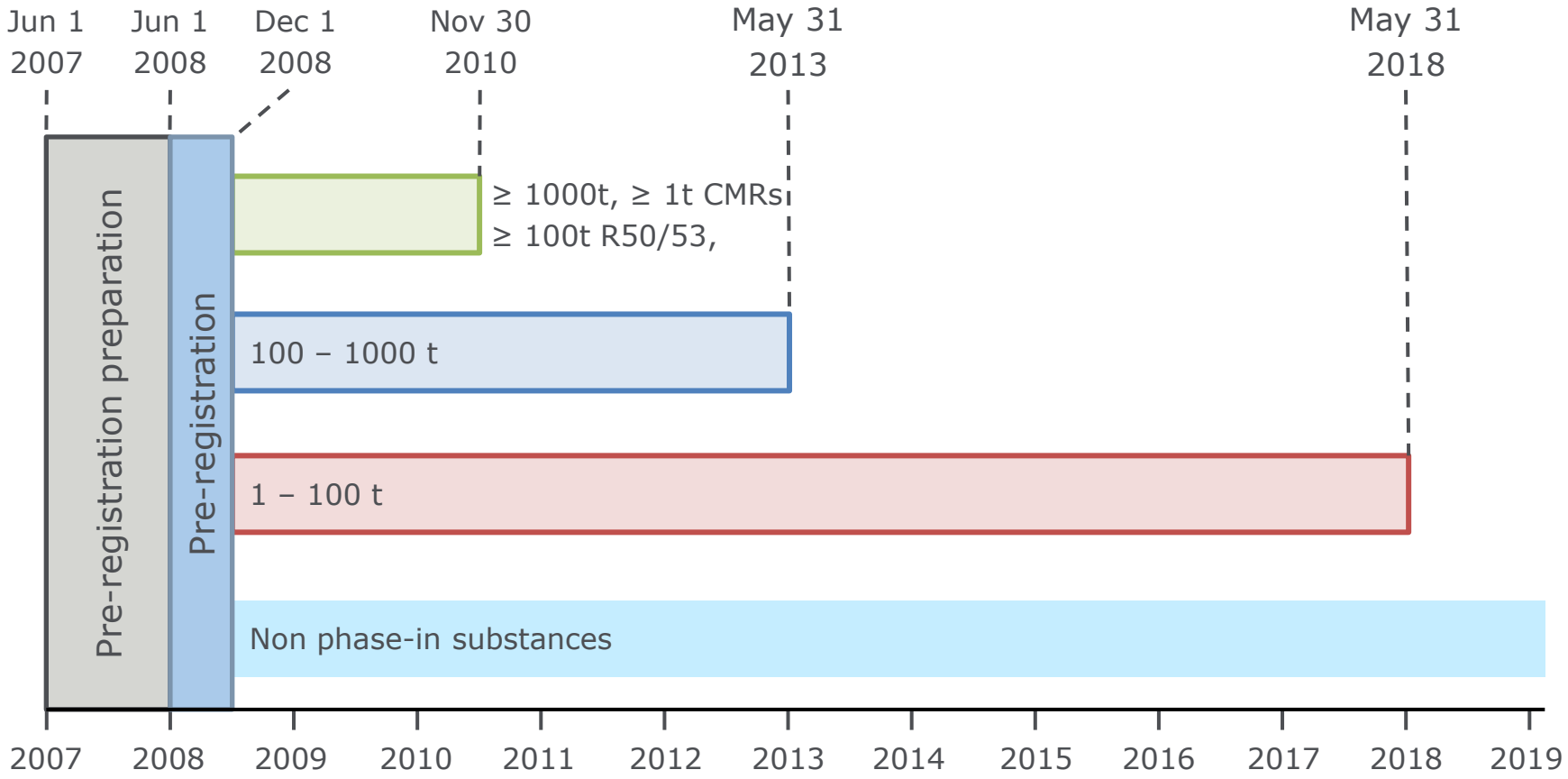
REACH – Registration Deadlines



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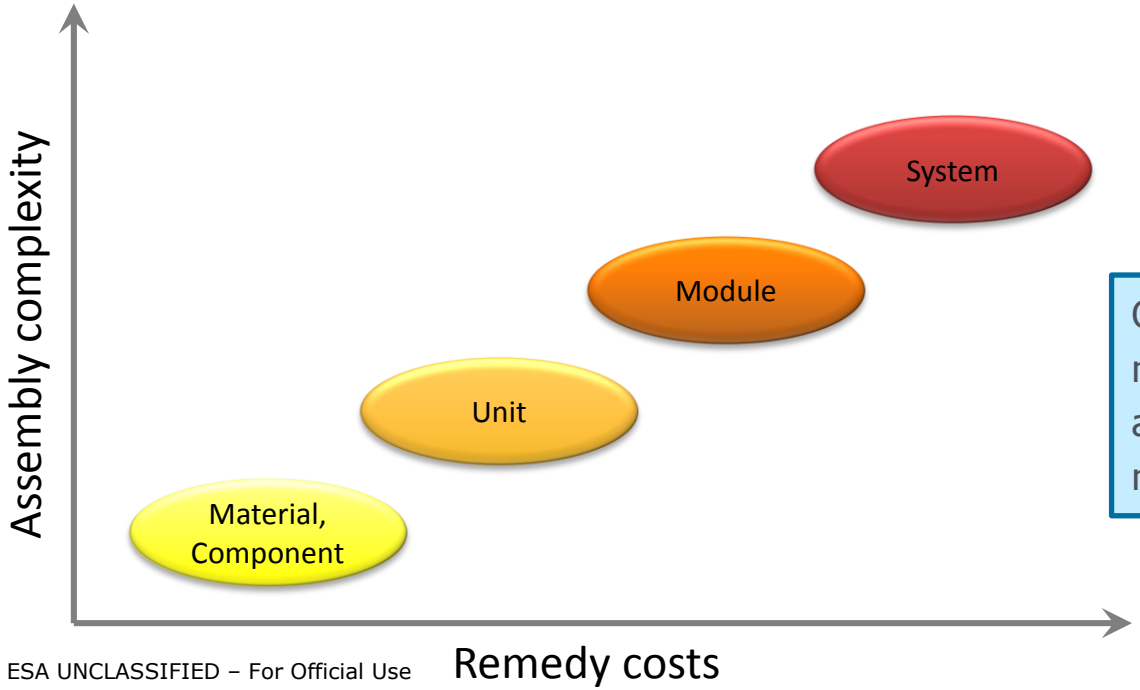
REACH Impact – Technical Aspects

Possible obsolescence of qualified materials, processes or technologies:

- Change in materials/substances compositions
- Alterations of manufacturing processes (e.g. solvents, pre-cursors)
- Removal of materials/substances from the European market
- Unanticipated risks, *e.g.* missing of deadlines for registration

Very long life-cycles (e.g. launchers 20-30 years, satellite constellations) → need to actively manage the risk (cost trade-off)



Obsolescence becomes a major issue with REACH, and requires appropriate management.

The M&P working group

Materials & Process WG is a European platform that includes industrial partners and national space agencies including Astrium, Avio, CNES, DLR, ESA, Herakles, MAP, OHB, REACHLaw, RUAG, TAS, TESAT. 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 groups cover currently

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

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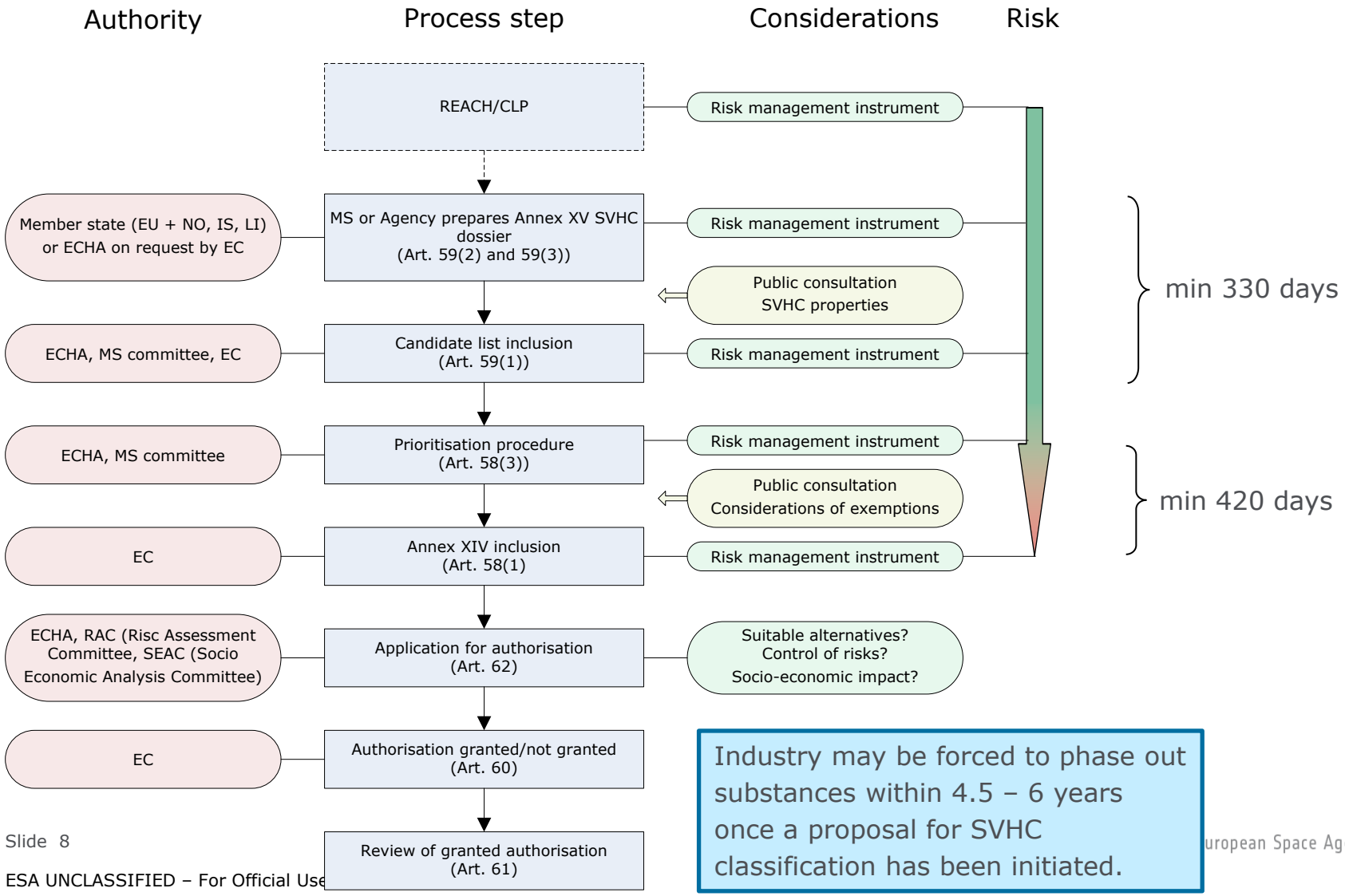
The REACH authorisation process



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

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Status of candidate list / Annex XIV

C.I. Solvent Blue 4	N,N,N',N'-tetramethyl-4,4'-methylenedianiline	1,3,5-tris[(2S and 2R)-2,3-epoxypropyl]-1,3,5-triazine-2,4,6-(1H,3H,5H)-trione	Diboron trioxide	1,2-bis(2-methoxyethoxy)ethane	4,4'-bis(dimethylamino)-4''-(methylamino)trityl alcohol	Lead(II) bis(methanesulfonate)	Formamide
C.I. Basic Violet 3	1,2-dimethoxyethane; ethylene glycol dimethyl ether	C.I. Basic Blue 26	1,3,5-Tris(oxiran-2-ylmethyl)-1,3,5-triazinane-2,4,6-trione	4,4'-bis(dimethylamino)benzo phenone	4-(1,1,3,3-tetramethylbutyl)phenol	N,N-dimethylacetamide	Phenolphthalein
Lead diazide, Lead azide	Lead dipicrate	1,2-dichloroethane	Calcium arsenate	Dichromium tris(chromate)	2-Methoxyaniline	Pentazinc chromate octahydroxide	Arsenic acid
Potassium hydroxyoctaoxodizincatedichromate	Formaldehyde, oligomeric reaction products with aniline	Lead styphnate	Trilead diarsenate	Zirconia Aluminosilicate Refractory Ceramic Fibres	Bis(2-methoxyethyl) phthalate	Aluminosilicate Refractory Ceramic Fibres	Bis(2-methoxyethyl) ether
2,2'-dichloro-4,4'-methylenedianiline	Cobalt dichloride	1,2-Benzenedicarboxylic acid, di-C6-8-branched alkyl esters, C7-rich	1,2-Benzenedicarboxylic acid, di-C7-11-branched and linear alkyl esters	Strontium chromate	1-Methyl-2-pyrrolidone	1,2,3-Trichloropropane	2-Ethoxyethyl acetate
Hydrazine	Cobalt(II) diacetate	Cobalt(II) sulphate	2-Ethoxyethanol	Chromic acid, Dichromic acid, Oligomers of chromic acid and dichromic acid.	2-Methoxyethanol	Chromium trioxide	Cobalt(II) carbonate
Cobalt(II) dinitrate	Trichloroethylene	Potassium dichromate	Tetraboron disodium heptaoxide, hydrate	Ammonium dichromate	Boric acid	Sodium chromate	Disodium tetraborate, anhydrous
Potassium chromate	Acrylamide	C.I. Pigment Yellow 34	C.I. Pigment Red 104	Anthracene oil	2,4-Dinitrotoluene	Anthracene oil, anthracene paste, anthracene fraction	Anthracene oil, anthracene-low
Tris(2-chloroethyl)phosphate	Diisobutyl phthalate	Lead chromate	Anthracene oil, anthracene paste	Pitch, coal tar, high temp.	Anthracene oil, anthracene paste,distn. lights	Lead hydrogen arsenate	Benzyl butyl phthalate
Bis (2-ethylhexyl)phthalate	5-tert-butyl-2,4,6-trinitro-m-xylene	Diarsenic trioxide	Bis(tributyltin)oxide	Triethyl arsenate	Diarsenic pentaoxide	Sodium dichromate	Dibutyl phthalate
4,4'-Diaminodiphenylmethane	Alkanes, C10-13, chloro (Short Chain Chlorinated Paraffins)	Anthracene	Alpha-, Beta-, and Gamma-hexabromocyclododecane				

Source: echa.europe.eu

(only) included on Candidate List
3rd ECHA recommendation for Annex XIV inclusion (20 Dec 2011) Inclusion in Annex XIV expected Feb 2013 – sunset date for Cr(VI) mid 2017
4th ECHA recommendation for Annex XIV inclusion (draft, 20 Jun 2012) Inclusion in Annex XIV expected Feb 2014 – sunset dates expected ~ 2017
(already) included in Annex XIV after 2nd recommendation

Materials cross-check

Compound	A	B	C	D	E	F	G	H	I	J	K	L	...	X
Composition material 1										o	o			
Composition material 2	o	o				o								
Composition material 3					o				o					o
Composition material 4														
Composition material x							o			o	o			o
e.g. Alodine 1200S (today)		n.a.	CrO_3											
e.g. Alodine 1200S (exp. Feb 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

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Risk assessment

Cross-check of materials is being performed with	Obsolescence risk	# Database hits
1. Annex XIV	imminent	7
2. Annex XIV recommendation	imminent	47
3. Candidate list	mid-term	94 (40 excl. 1,2)
4. SVHC dossiers	mid-term	39
5. HCL dossiers	long-term	> *200*
6. SIN-list [1]	long-term	195 (103 excl. 3)
7. Gap analysis – non registered substances – reason unknown	investigate	40
8. CoRAP (Community Rolling Action Plan)	investigate	164

→ Inventory of affected materials/substances, currently about 1700 joint database entries

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. List 2.0 consists of 378 chemicals that are identified as SVHC based on the criteria established by REACH.

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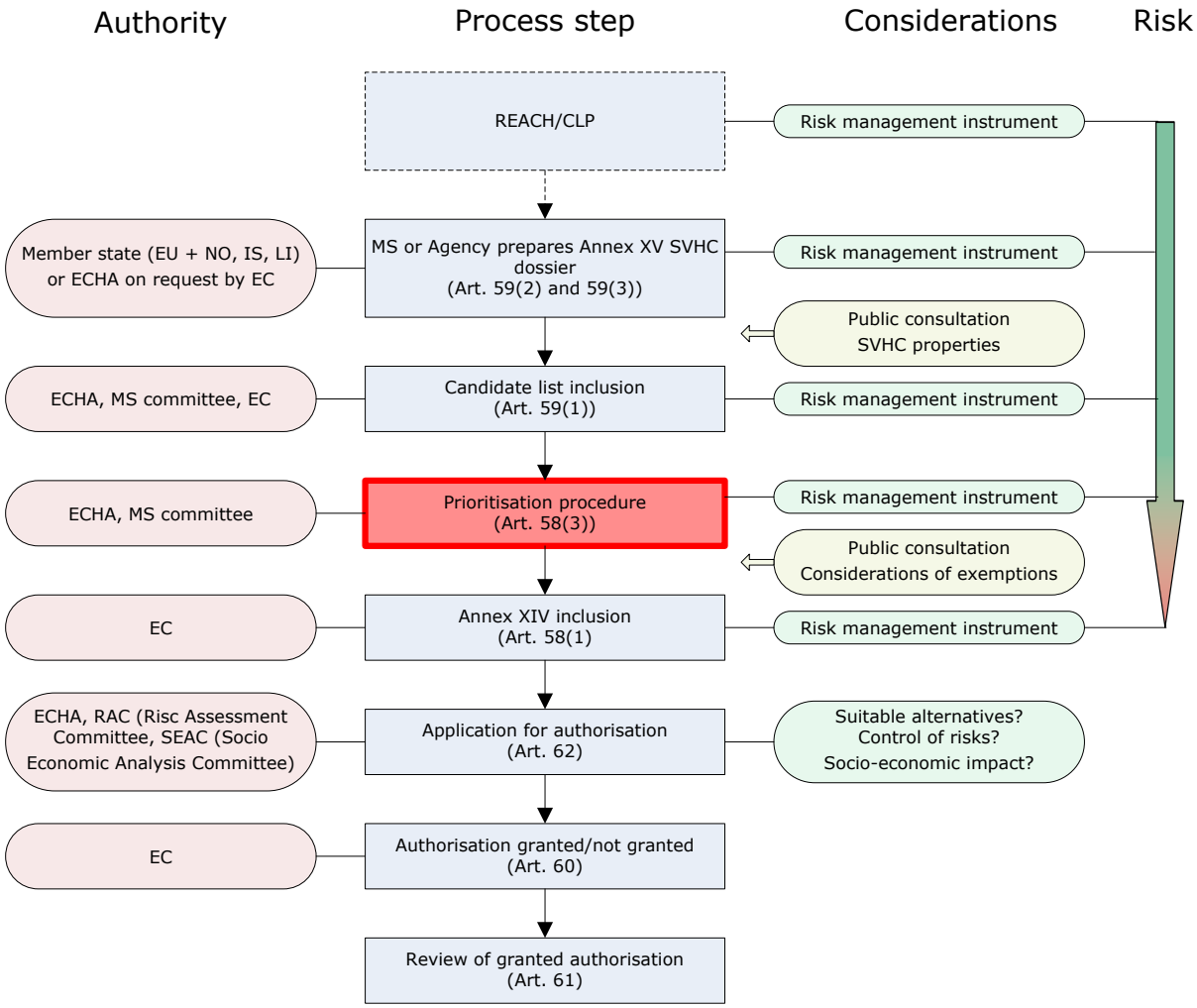
Status of Annex XIV recommendations



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Applications of Cr(VI) compounds

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 ($K_2Cr_2O_7$)
- *etc.*

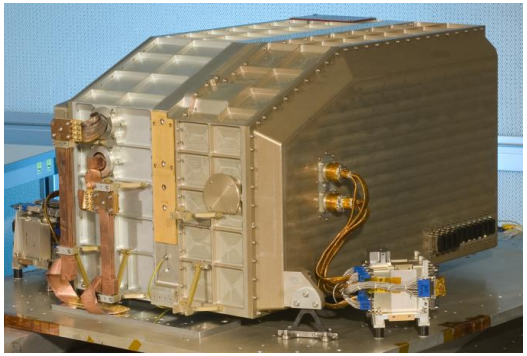

Image: ESA – Herschel/SPIRE

Need qualified replacements before reaching the sunset date 2017.

Various commercial solutions are available → Qualification programs ongoing

Problem: Latest application date for authorization for CrO_3 is 18 months before sunset date
Development of authorization dossier takes 1.5 – 2 years
→ **Need to decide about (joint) authorization very soon**

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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 1200S: Coordinated test programs by Astrium/CNES and NASA/ESA

Replacement for primer BR 127: TAS/CNES

Challenges e.g. for Alodine 1200S

- So far no commercial solution as universal as Alodine 1200S
- Experience shows that none of the Cr(VI)-free systems reach same performance

→ Cr(VI) conversion coating remains the reference system

→ Need possibly to revisit performance requirements

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

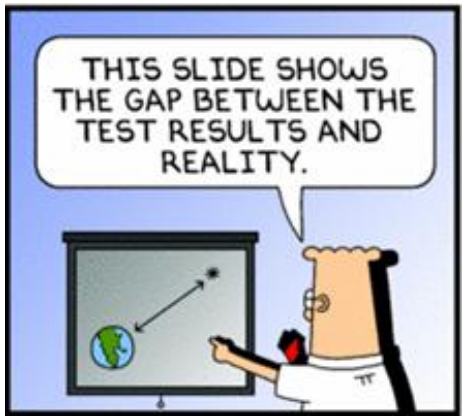

Image: From Dilbert 7 Nov 2010

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Alodine 1200S replacement – Astrium/CNES

Alodine 1200S conversion coating – contains CrO_3

1. Chromate substitution is a three-steps work
   a. Validation of a substitute at sample level (work in progress)
   b. Process industrialisation (not started)
   c. Qualification of the application (at subsystem / spacecraft level) (not started)
2. Planning for the substitution is not the same, depending on the products
   a. Target planning for Alodine 1200 replacement

Sunset date

Substitution	2012	2013	2014	2015	2016	.. 2018
Alodine						

Qualification at sample level

Qualification at system level

1. ASTRIUM/CNES co-funded R&T (see following presentation)
   a. Phase (a) in progress : work on Cr(III) chemical conversions (similar process than Alodine) and other processes (sol-gel, coatings)
   b. Focus on specific products : Surtec 650, Surtec 650V, MAPSIL Silico, Iridite NCP, Lanthane 613,3 (with and without post-treatment), Alodine 5923+
   c. Objective is to freeze a process and qualify it at sample scale.

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Alodine 1200S replacement – ESA/NASA

Test matrix definition

Substrates (3” x 10”)

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

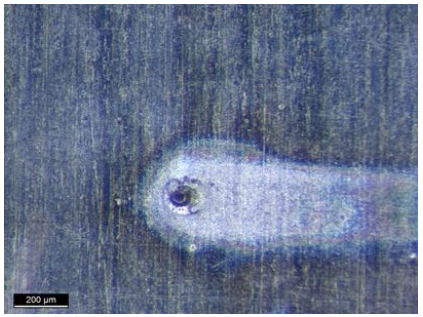
Configurations

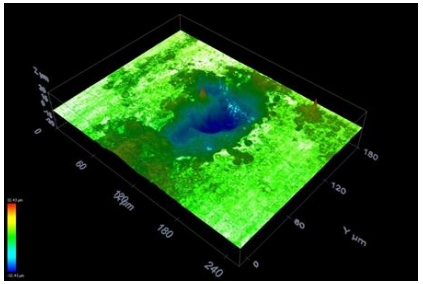
- Pre-treatment only
- Best pre-treatment + primer (considering ESA/NASA systems)
- Best Pre-treatment/primer + topcoat (considering ESA/NASA systems)

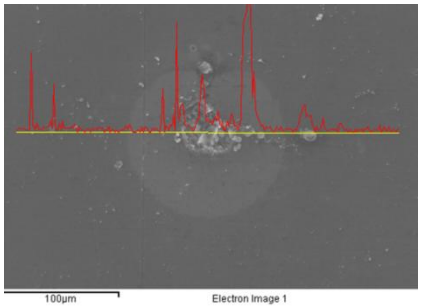
Pre-treatments	Primers	Topcoats
Alodine 1600	Super Koropon	Deft APC Topcoat
Iridite 14-2	ANAC / Mg Rich	MAP Aero Static B
Alodine 5900	Hentzen (Type II - 7176KEP / 16709 CEH)	MAP AQ Static
Iridite NCP	VpCI-373	MAP Mastic AS
Metalast TCP-HF	Deft 084 (High Solid)	
Metalast TCP-HF EPA	Hentzen (Type I - 16708TEP / 16709 CEH)	
SurTec 650 – chromitAL TCP	Deft 098 (Waterborne)	
SurTec 650C	MAP Aero WP	
Xbond 4000	MAPSIL SILICo	
Alodine 5923 plus	PM 820	
Alodine 160/161		
Interlox 5705		
MAPSIL SILICo		
Alodine EC2		
Corrlink 30A		
Deft RECC		
MS&T CECC		
EonCoat		

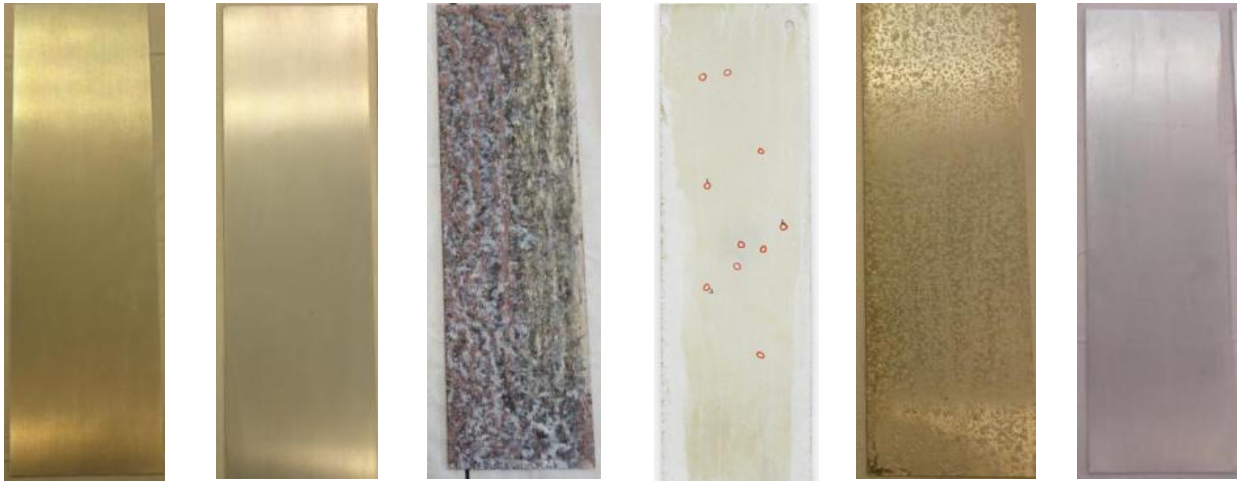
Alodine 1200S replacement – ESA/NASA schedule

Nov 2012	Conclusion of pre-screening
Dec 2012	Down-selection of pre-treatments and primers
	Procurement of pre-treatments and primers
Dec 2012	Start of panel preparation and characterization
Q1/Q2 2013	Full test campaign
Q4 2013	Intermediate test report (without atmospheric exposure)
Q1 2014	Finalization of atmospheric exposure
Q2 2014	Final report









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BR 127 replacement – TAS/CNES

BR 127 corrosion inhibiting primer – contains $SrCrO_4$

- Corrosion inhibiting
- Increases time between surface treatment and bonding

Image: TAS – BR 127 on Invar

Selection phase

- Inventory of requirements: AST, CNES, ESA, TAS
- Ranking of requirements under functional, operational and industrial needs
- Supplier contact: 3M, Cytec, MAP, Henkel, JD Lincoln, Socomore, *etc.*
- Selection of 3 Non-Chromate primers for test campaign
  EW 5000 AS (3M), AQPS (MAP), BR6747-1 NC (Cytec)

Evaluation phase

- Risk analysis and risk mitigation → Development plan
- Evaluation test campaign (ongoing)
- Selection of candidate(s) for qualification phase

Qualification phase

- Qualification plan and testing
- Qualification of new primer for space applications

Achieved

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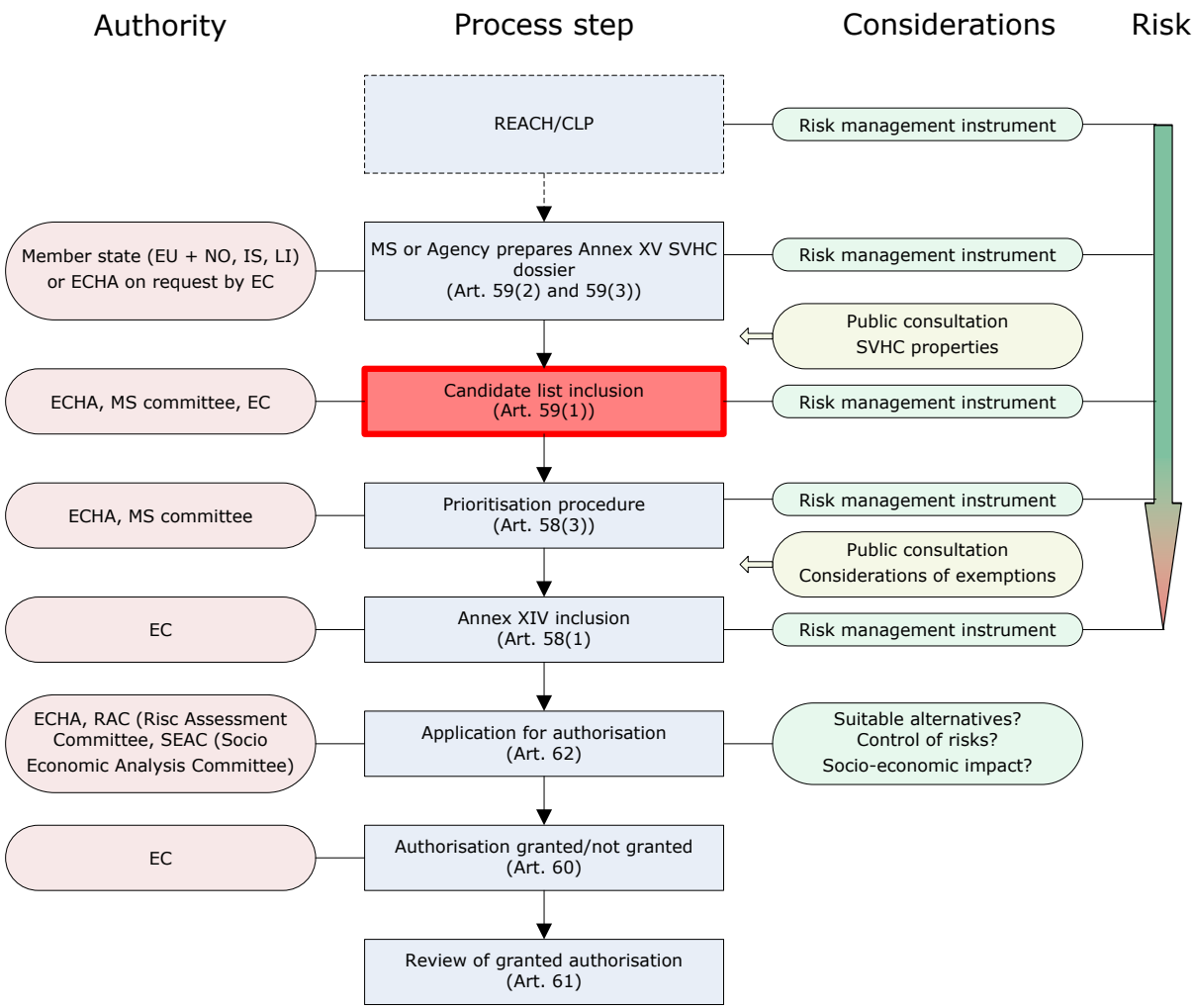
Status of candidate list



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Example: Hydrazine

- Classified carc 1B, on candidate list since 20.6.2011
- Expect Annex XIV inclusion (earliest) Q1 2015, sunset date possibly Q2 2018
- 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 steps/uses
  - Import/manufacture low/high grade hydrazine. Currently most hydrazine imported from US and China
  - Purification
  - Distribution/transport
  - Ground testing
  - Loading, off-loading, quality/compatibility testing, waste disposal
  - In-orbit firing
- Very well controlled procedures to exclude human/environmental exposure
- No viable alternative is available yet
- Green alternative *e.g.* ADN, technology demonstration on PRISMA satellite

Image: ESA – Fuelling MetOp-B

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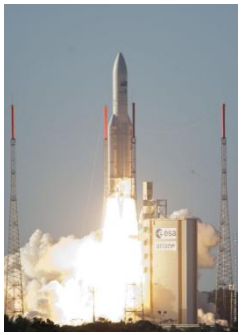
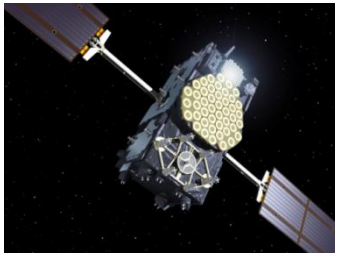
Hydrazine – Strategic Technology

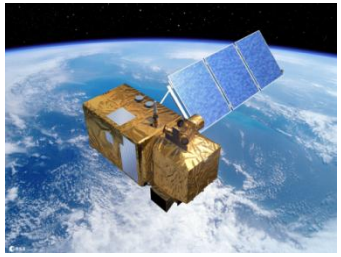


Hydrazine is strategic for satellite and launcher programs (access to space, earth observation, science, exploration, navigation (Galileo), telecommunication, *etc.*).

Promising alternatives exist, but the development and qualification would require both, significant time and funding. Even in mid/long-term only three options are feasible:

- Exemption: Requires the existence of an appropriate legal exemption clause
- Authorization: Demonstration of adequate control (safe use) and/or socio-economic benefit of continued use higher than the risk. Authorisation is always time-limited, current experience indicates 5 – 15 years, but is considered use specific.
- Development of green alternatives: Replacement of hydrazine with green alternatives is the ultimate goal, such technologies may also bring a competitive advantage for European space industry. Even with appropriate resourcing, the replacement of hydrazine for all spacecraft and launcher applications is a long-term effort, significantly longer then expected REACH milestones.
  This option is not seen as a stand-alone solution, but needs to be pursued in parallel to exemption/authorization efforts.





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

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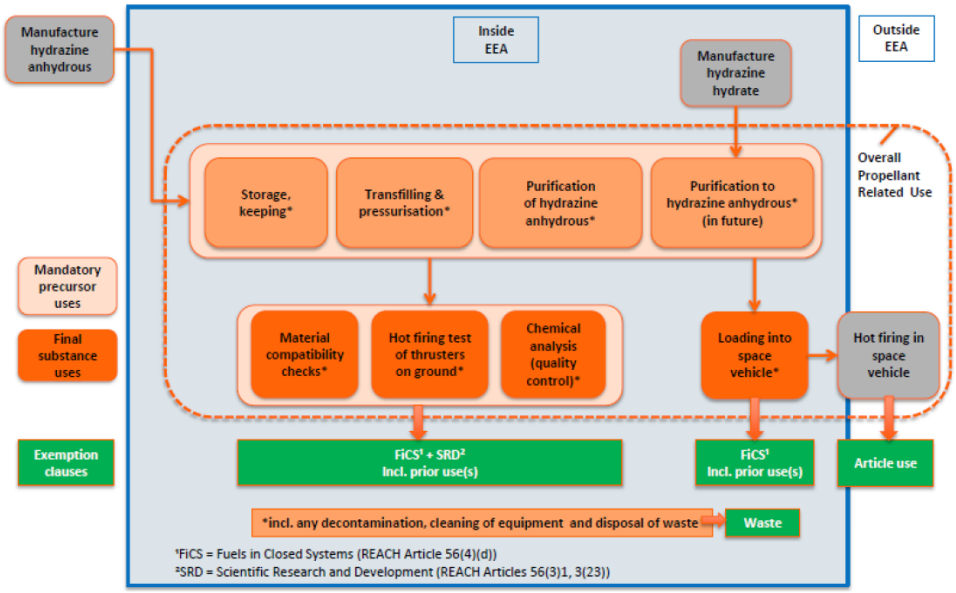
Hydrazine – Workplan

1. Exemption

Exemption study with REACHLaw 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).

Communication with the EC/ECHA under the lead of Eurospace is ongoing awaiting feedback.

NB: Exemption is an enforcement issue and is not granted in analogy to authorisation.



2. Authorisation

Backup solution but always time limited

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

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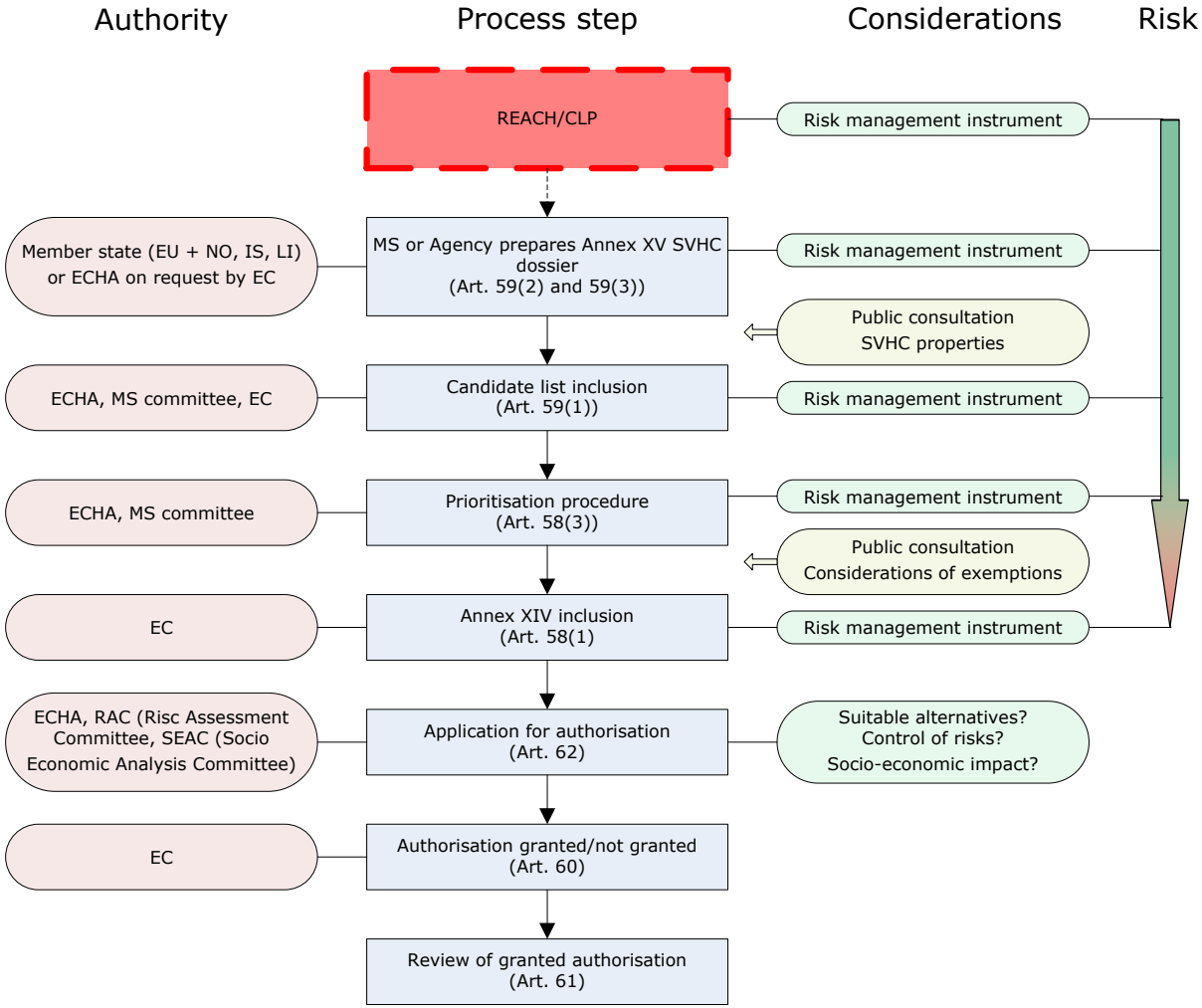
Status of REACH/CLP



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Status of 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 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
- Gallium arsenide (carc. 1B, draft repr. 1B), not yet included in Annex VI. Decision expected with the 5th ATP in 2013.

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

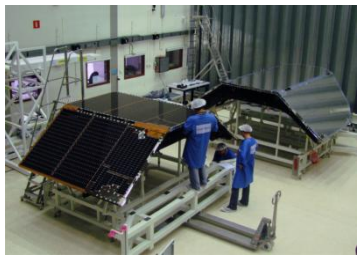

Image: ESA – Herschel SA

Image: ESA – Gaia antenna

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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 (M&P WG 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
  - 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.

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