Lead Free Transition Road Map

Gianni Corocher

ESCCON 2023

Toulouse

09/03/2023

Lead Free Transition Road Map

In 2018 metallic Pb was added in the REACH candidate list of SVHC.

This triggered the decision of the MPTB and CTB to launch a joint task force to assess the situation and to define a Road Map for the transition of the European Space Electronic sector to Pb free.

The Task force issued a Road MAP in April 2020 and the formation of a dedicated working group for the Pb free transition was agreed by MPTB and CTB:

- The WG is temporary and will last the time of the Lead-free transition for the European Space Sector
- It does coordinate the Roadmap development and implementation with relevant stakeholders. This includes other concerned CTB and MPTB WGs to avoid conflicts and duplications.
- It does monitor legislative evolution and report on the Roadmap implementation
- It promotes the Roadmap actions with relevant funding bodies

LFTWG Status January 2023

LFTWG members:

Alter

Airbus

Arianegroup

Beyond Gravity

CNES

DLR

EDA

ESA

ICME

Konsberg

Reach Law

Tesat

Thales Alenia Space

Sodern

SPUR

UK Space

LFTWG Observers:

IRT

RISE

HTV gmbH

Why the European Space Electronic Manufacturing needs to transition to Pb free

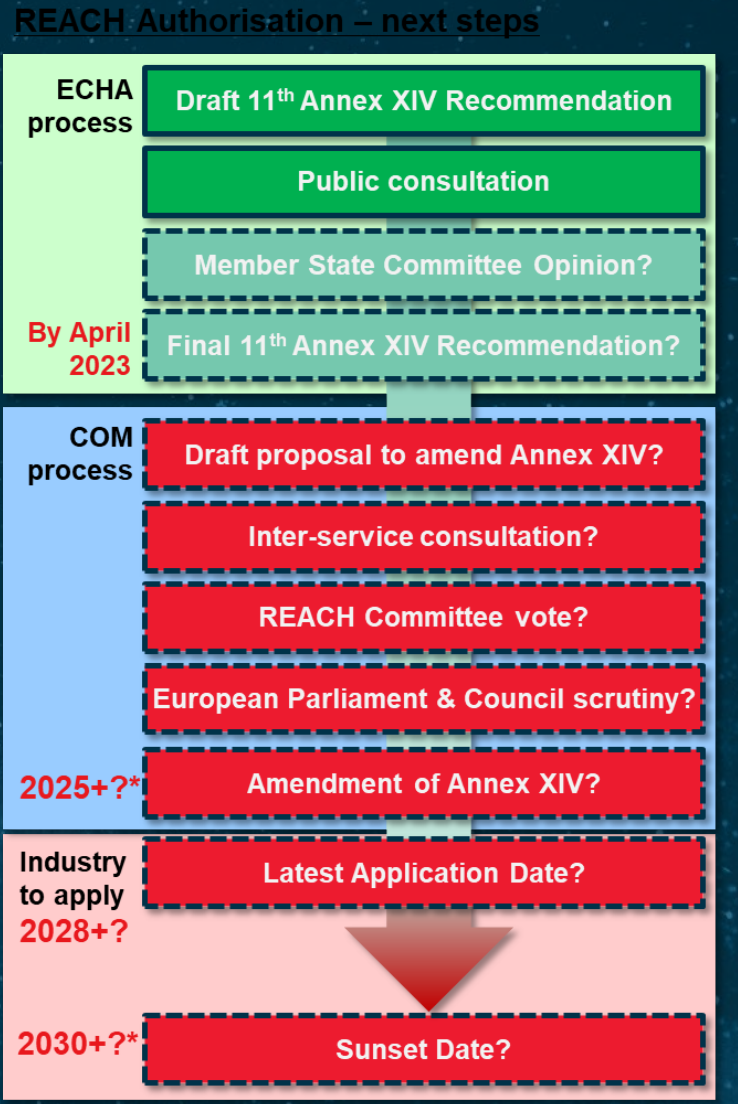
Current baseline: Reporting on presence in articles c>0.1% w/w (REACH Art. 33(1) & WFD/SCIP); OEL revision (*COM proposal of 13.2. available*) and specific REACH Restrictions

Likelihood of REACH Annex XIV inclusion?

- Numerous steps ahead (*see diagram*) – No automatism!
- Further uncertainties mainly due to on-going REACH Revision (incl. Authorisation & Restriction Reform)

***In case* of Annex XIV inclusion: Good case for authorisation of space applications without alternatives could be made, but disproportionate impact and efforts expected (up to 200+ AfAs for soldering only!)**

NOTE: No REACH authorisation requirement for lead today nor decided – but substitution pressure is increasing



Why the European Space Electronic Manufacturing needs to transition to Pb free

The road map discussed also factors defining the market pressure pushing the Space sector toward the transition to Pb Free technologies:

- Components development is driven by sectors already transitioned to Pb-Free: State of the Art components are becoming less available for SnPb based assembly processes.

- New Space : Shorter mission, Mega constellation, different approach to system level reliability.

- Traditional Space Electronics manufacturers facing competitions from companies entering the New-Space market

- Cost reduction via increased use of COTS

What are the technical issues to solve?

- Pure Sn finishing and Sn Whiskers mitigations

- Selection and characterization of most suitable Pb free solder alloys for Typical Space Applications.

- Identification of possible Pb free alloy systems suitable for extreme environments (currently no suitable Pb free alloys are available for very low temperature or high temperatures application)

- Impact of use of Pb free alloys on PCB manufacturing (increased soldering temperature inducing higher stresses on PCB)

What are the technical issues to solve?

- Impact of use of Pb free alloys on component manufacturing

- Impact of Pb free alloys on Assembly processes (use of different materials, impact on soldering systems)

- Reliability of the assembly (different metallurgy from SnPb alloys, different failure modes, different aging mechanism to SnPb)

- Standardization (workmanship standards, approach to verification of assembly processes to be redefined, modeling)

LFTWG Road map

The road map identifies 4 main topics:

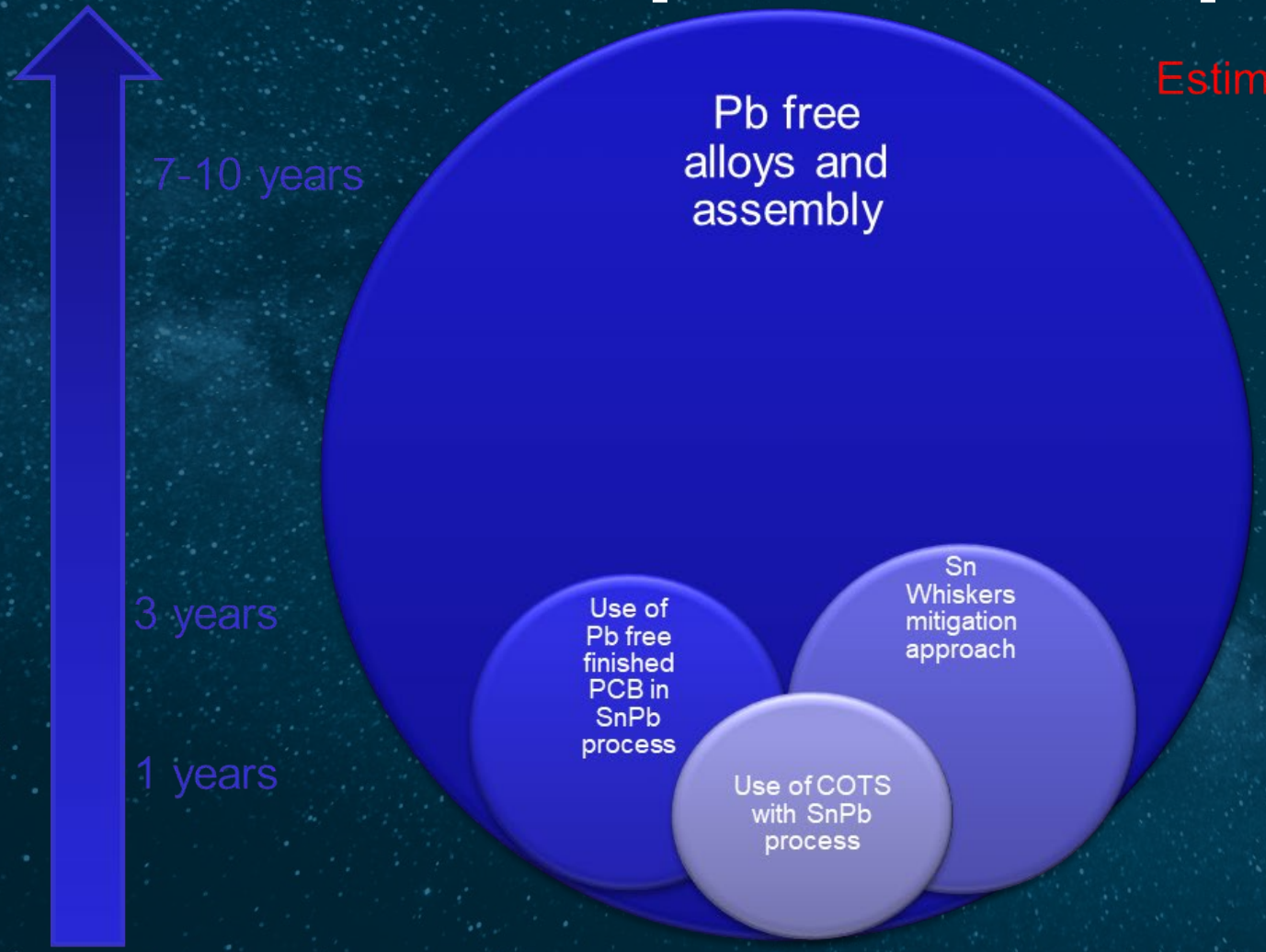
- ***Roadmap for using COTS with the standard SnPb Assembly Process on standard leaded PCBs***. **This is very urgent since it is necessary for the widespread introduction of COTS in Space Programmes**

- ***Roadmap for using lead-free PCBs with the standard SnPb Assembly Process***.

- ***Roadmap for the introduction of lead-free solder alloys***.

- ***Roadmap for assessment of Sn whiskers mitigation approach.*** **Necessary for the widespread introduction of COTS in Space Programmes**

Road Maps relationship:



Estimated cost ~11 MEuro

LFTWG Road map

Road Maps targets:

ECSS standards for Pb free assembly

Workmanship standards

Fatigue models for assembly

Impact of Pb free assembly processes on PCB

Assembly reliability characterization

Assessment of component finishes for use with SnPb processes

Assessment of Sn Whiskers mitigation methods

Assessment of Pb free finishes of PCBs

Pb free alloys selection

Pb free alloys characterization

Impact of Pb free assembly on EEE parts (ESCC)

Where are we?

LFTW Road map			Activities				
Road map refernce and goals	phase/step	Past studies/ background information studies (non in current CTB road map)	completed	in progress	Funded	proposals	Others
14.1 Using COTs with standard SnPb processes							
The Consortium will have to assess whether or not there is enough reliability data, available to everybody, in order for the PSWG to proceed with the updating of the relevant standards.		**LFTWG001**		**HP025, LFTWG005, SM067, SI078**			**LTFWG003 (in progress)**
14.2 Using Pb free PCBs with standard assembly processes							
Evaluation of different PCB finishes aimed assessing the degradation due to storage, wettability, and assess test methods for the process control.			**LFTWG10, LFTWG13**				
• Design of the standard test vehicle and definition of evaluation test approach							
• Assessment of results and identification of PCB finishes to be used in continuation of road map and candidate for qualification.				**SM003**			
• Assessment of pressfit and solderless connectors				**PA012**			
• Investigate the behavior of press-fit connectors on Pb-free finished PCB				**PA012**			

Where are we?

14.3 Road Map for the introduction of Lead free solder alloys		Past studies/ background information studies (non in current CTB road map)	completed	in progress	Funded	proposals	Others
Phase 1							
	Step 1.1 Alloys screening via reliability testing	LFTWG002	LFTWG11, LFTWG12, SM068	SM003, HP25, LFTWG007, SM044 (2 contracts)			
	Step 1.2 Preliminary characterization (metallurgical evaluation) of selected alloys						
	Step 1.2 Preliminary reliability characterization of selected alloys and assesment of influence of test parameters (dwell time , temperature)						
	Step 1.2: assesment of PCB materials for Pb free processing					SM045	
Phase 2							
	Phase 2: full characterization of alloys reliability with mechanical and thermal testing						
	Phase 2:Impact of Shock and vibration on reliability						
	Phase 2: Impact of soldering process: machine reflow, IR, HS						
	Phase 2: Impact of stand –off						
	Phase 2: Introduction of leaded component in the test						
	Phase 2: Impact of different PCB finish: solderless and pressfit connectors						
Phase 3:							
	Gathering of all data from the previous phase and to analyse if further test combination are needed to confirm or complement the data pool.						
	Testing of repair configurations.						
	Confirmation of model by performance of a life test at unit level.				SM053 LFTWG004 (activities is mainly on SnPb alloys)		
	Establishing a data base in order to collect data from assembly verifications with the aim to define rules allowing the minimum effort for verification of an assembly process.						
Phase 4							
	Task 1.1.1: Identification of components that have internal features, terminations or constructions that will be affected by the change to lead free solder alloys.		HP001				
	Task 1.1.2: Identification of components that have external features or terminations that will be affected by the change to lead free solder alloys.						
	Step 1.2: Evaluation of component with lead free internal construction to assess the degradation due to lead free solder processing during PCB assembly.						

Where are we?

14.4 Assesment of Sn Whiskers mitigation approach		Past studies/ background information studies (non in current CTB road map)	completed	in progress	Funded	proposals	Others
	Step 1.1: Definition of a test approach for the screening of susceptibility to whiskers development. Identification of types of pure Sn finishes based on their susceptibility to develop whiskers					HP032, HP033	
	Step 1.2 Scope of the activity: Identification of limitation for use of finishes or alloys and definition of mitigation actions (pre-tinning, use of coating, PCB design rules, etc..)		LFTWG 008 , LFTWG009, LFTWG014. LFTWG015	HP025, HP034:	HP030	PA37	LTFWG003 (in progress)

Where are we?

Road Map 1: several activities in progress. Once all activities are completed the results needs to be collected and analyzed to assess if recommendation can be provided toward the goal of Road Map 1

Road Map2: Few activities on going no results available yet. Need of follow up activities can be anticipated

Road Map3: Few activities running focusing on preliminary characterization of alloys. Initial results evidence the complexity of the metallurgy and characterization of Lead free alloys confirming the need of major additional activities as anticipated in the Road Map

Road Map 4: some activities which can provide input on some part of this road are ongoing . Review of Geia Standards by the LFTWG on going to assess the approach followed in US.

Other initiatives

Meeting with PERM (Pb-Free Electronic Risk Management council)

Following the contact with IPC a call was organized with PERM where the LFTWG was presented.

The PERM Chair explained that the council has a similar scope as the LFTWG and as well does not have funding for research but is active in coordinating the activity in the field of based on road similar to the LFTWG one.

PERM members are involved in various working group for standardization as the one reviewing the GEIA-STD-005 series of standards.

Participation to PERM is open to company which are IPC members.

Limitation in the membership in the LFTWG have been explained and possible way of collaboration discussed pending agreement by the LFTWG members:

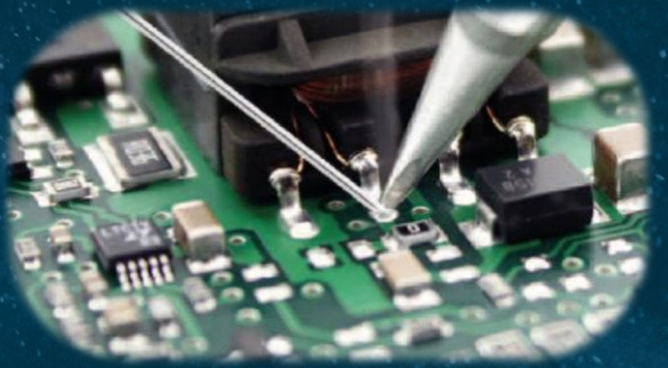
Organization of dedicated session with PERM via teleconference (pm European time) with pre-defined agenda promoting the exchange of information or discussion on topics of common interest is being discussed with PERM.

Other initiatives

- **Sovereignty EEE initiative**
- Activity Proposal: Lead-Free Assembly Technologies for High Reliability Electrical Connections

Description: to develop the knowledge, test methodologies and standards enabling the use and certification of Lead-Free solder technologies for High Reliability Electrical connections

- Phase 1: Finishes and Lead -free alloys characterization
  - Selection of candidate alloys systems
  - Mechanical and metallurgical characterization of the alloy and solder joint, (microstructure evolution during aging)
  - Reliability test of elementary configuration to assess impact of test conditions (Time/Temperature) on failure mechanism
- Phase 2: Assembly reliability characterization and modelling Reliability testing of increasingly complex configuration (assessment of different assembly technologies)
  - Development of modelling tool for assembly reliability
  - Validation of modelling tool.
  - Data set for creation of workmanship standard and processes certification methodology
- Phase 3: Dissemination and certification
- ECSS standard creation
  - Assembly process certification (of individual assembly lines)



What is happening elsewhere?

US Congress Approves Funds for R&D on Pb-Free Electronics in High-Rel Applications (/ca/editorial/menu-news/34765-us-congress-approves-funds-for-r-d-on-pb-free-electronics-in-high-rel-applications.html)

Published: 22 December 2020
by Mike Buetow

BANNOCKBURN, IL – The US Congress on Monday approved $10 million for research into the issues surrounding lead-free electronics in mission-critical applications.

The funds are part of the fiscal 2021 defense appropriations bill, which President Trump is expected to sign.

A number of trade groups including IPC had called for these funds to be included under the assertion that the high-rel sector has been slow to adopt lead-free materials, putting it at risk of falling behind best practices.

IPC said industry experts believe a five-year, $40 million investment in a public-private R&D program would yield more than $100 million in US defense savings per year and improve military readiness and overall innovation. The Congress provided $5 million for such R&D in FY 2020.

Over the past 15 years, the commercial electronics industry has largely phased out its use of lead in electronic components and circuit board assemblies, driven by government regulations and concerns about lead's harmful effects on human health and the environment. However, the aerospace, defense and high-performance (ADHP) sectors have been reluctant to migrate to lead-free electronics because there is inadequate data on the reliability of lead-free components in ADHP applications.

The gap between commercial and defense electronics is growing wider as lead-free becomes more established in commercial technologies, and as governments – particularly in Europe – have implemented more stringent rules on the use of lead. Today's defense electronics are now 15 to 20 years behind the commercial market in terms of the underlying materials used, undermining supply chain resiliency and technological superiority.

"This vote is a win for US taxpayers, defense readiness, and the electronics industry supply chain," said Chris Mitchell, IPC vice president of global government relations.

"The migration of the commercial industry to lead-free electronics has created supply-chain concerns for the ADHP sectors that can only be overcome through public-private R&D," he added. "These funds will support a collaborative research effort that will help ensure that mission-critical systems have full access to cutting-edge electronics from a robust global supply chain."

"Together with our partners in the Pb-Free Electronics Risk Management (PERM) Council, IPC will continue to advocate for a proactive, long-term approach to this issue," Mitchell added.

https://www.purdue.edu/newsroom/releases/2021/Q1/purdue-to-co-lead-u.s.-department-of-defense-funded-project-to-advance-adoption-of-lead-free-electronics.html

WEST LAFAYETTE, Ind. — A new consortium funded by an award from the U.S. Department of Defense has selected Purdue University to co-lead its first project aimed at advancing the adoption of lead-free electronics in defense systems.

The Defense Electronics Consortium (DEC), to be established and managed by the U.S. Partnership for Assured Electronics (USPAE), is designed to address the defense risks created by the contraction of the U.S. electronics manufacturing sector over the last 20 years.

Purdue, the University of Maryland and Auburn University will lead the consortium's Lead-Free Defense Electronics Project, which has received $40 million to be distributed over a period of five to seven years. Of the $3.9 million in funds for the first year of the project, approximately $1 million has been awarded to researchers at Purdue's West Lafayette and Northwest campuses.

The project's goal is to foster research and action to accelerate the transition to lead-free electronics in aerospace, defense and other high-performance electronics. Consumer and automotive electronics have been transitioning to lead-free technologies since 2006 when the **European Union banned the sale** of lead-containing electronics. Japan, India and China followed suit with similar bans.

The US Congress approved $10 million for research into the issues surrounding lead-free electronics in mission critical applications as part of the 2021 fiscal appropriations bill

Conclusions

- The transition impacts a very large supply chain (OEM, PCB and component manufacturers)

- Lead free solder alloys are fundamentally different from the SnPb alloys used so far. A full understanding of the metallurgy of these materials and their failure mode is needed.

- Several technical issues need to be solved to use Pb Free technologies in High Reliability Space Applications

- Mastering Lead free technology can be crucial for the competitiveness of European OEM on the space/aerospace markets in the future

Conclusions

- The LFTWG mapping of past and on going of R&D activities monitored under CTB and or MPTB which have relationship to the Road Map cover a limited amount of the effort expected for the transitions to Lead free

- Assessment of alloys and reliability of the assemblies is the area requiring the larger amount of development for which funding needs to be secured

- Coordination of the R&D activities and exchange of information is fundamental to prevent duplication of activities and ensure faster progress

Lead Free Transition Road Maps

Any Questions?