MEMO

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to/à	TEC-Q	copy/copie	TEC-QE, TEC-QT, TEC-QQ, TEC-QTM, TEC-QEC, TEC-QTC, TEC-QEM, J.-C. Tual (CTB Chairman)

Subject/objet **Situation regarding the use of tin-lead (Sn-Pb) finishes for solderable terminations and the continued use of Sn-Pb solder alloys for the European space industry**

The following is a summary of the points presented to the Component Technology Board (CTB) meeting on the 10th October 2002. It was updated during the CTB Lead-Free Task Force meetings held on 28th February 2006 and 3rd March 2010.

1. The European Parliament and Council directives on, a) WEEE, “waste electrical and electronic equipment”, and b) RoHS, “the restriction of the use of certain hazardous substances in electrical and electronic equipment”, do not prohibit the use of lead in solder alloys or glasses utilized in the space industry. There are no proposals which have a direct impact on the space industry.

2. Likewise, military and aerospace electronics are not affected by the prohibition of lead-containing alloys or glasses. An indirect effect has come from the restrictions on lead-containing materials that are no longer used in the manufacture and assembly of commercial electronics since 1st July 2006.

3. No policy changes have been made since this subject was discussed at the ESA-CTB meeting in 1999. Tin-lead (Sn-Pb) and indium-lead (In-Pb) alloys will continue to be the ESA required solder alloys, as prescribed in ECSS-Q-ST-70-08, for the assembly of spacecraft electronic hardware.

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4. There are no drop-in replacements for Sn-Pb or In-Pb solders for the applications utilized by the European space industry. The alternative alloys that are being researched and proposed to date will have a negative effect on both manufacturing/assembly processes and on the reliability of spacecraft electronics.

5. Alternative soldering alloys to those prescribed in ECSS-Q-ST-70-08 cause defects related to:
   - poor solderability
   - increase in solder balls (have caused short circuit in zero-g)
   - difficult inspection criteria (frosty, crystalline or orange-peel effects on solder fillets whereas Sn-Pb gives smooth bright, easily inspectable finish)
   - higher melting points which damage both parts and multilayer pcbs
   - difficult to rework
   - higher soldering and solder-rework temperatures will invalidate current component qualifications and the validation of their assembly processes
   - poor thermal fatigue resistance

6. The required finishes for electronic part terminations, terminal pins and lugs, and the termination pads on printed circuit boards are tin-lead (ECSS-Q-ST-70-10, Q-ST-70-11 and ECSS-Q-ST-70-08). These two standards define pure tin as greater than 97% purity. Pure tin is prohibited from component leads (ECSS-Q-ST-60, C Rev. 1, paragraph 4.2.2.2.d.1 and the ESCC specification for leads, No. 23500, issue 6, Rev. D, page 7). Pure tin is also prohibited in ECSS-Q-ST-70-71.
   Tin-, silver- and gold-plated terminals on part leads and printed circuit boards are prohibited (ECSS-Q-ST-70-08 A paragraph 6.5.2), but they can be removed by a solder dipping process which is prescribed in order to achieve an approved Sn-Pb finish (ECSS-Q-ST-70-08 A paragraph 7.1.2).

7. Alternative finishes to Sn-Pb on component leads, terminals and the printed circuit boards have unacceptable reliability hazards for spacecraft projects, these being:

Tin – whisker growths which are known to cause short circuits and other severe spacecraft failures (particularly when pcb line spacings are now permitted to 150 μm). Tin-whiskers are known to grow to lengths exceeding 400 μm. ALL PURE TIN ELECTROPLATINGS ARE SUSCEPTIBLE TO WHISKER GROWTHS.

Silver – under humid conditions silver-migration between pcb conductors cause dendritic growths leading to short circuits (exceedingly more susceptible than tin or lead migration).

Gold – known to form brittle intermetallic with solder alloys (unless joined using InPb alloy).

Gold flash-on-nickel – known to fail due to formation of phosphides ("black pad")

Organic lacquers – OSP coatings and solder masks, have unacceptable high outgassing-under-vacuum properties.

8. From an environmental standpoint the European space industry is committed to the elimination of "unfriendly" processes and the use of toxic materials. For instance, ozone depleting chemicals are no longer employed as cleaning media, chromate primers for passivating metallic surfaces are being phase-out and cadmium is prohibited.

Obviously lead-in-petrolium products, lead-in paints and pure lead water pipes need to be restricted as they cause a direct health hazard. However, SnPb does not constitute a health hazard as solder alloys have no way of being consumed. The lead-rich phases contained in solder are surrounded by tin-rich material and consequently (as for tin-plated steel cans) the corrosion rate of solder is extremely slow. Land-filled sites, when managed effectively do not release lead, and if this is the case it invariably originates from lead automobile batteries and lead sheet used

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for domestic roofing which account for 95% of the lead used worldwide (lead in solder is about 0.5% of world use).

9. Finally, again from an environmental standpoint, Sn-Pb solders should be promoted as:
   - alternative solders require far greater energy resources for extraction of those metals from ores and during the assembly of electronic units (E.U. study).
   - Electronic circuits are more often recycled as it is exceedingly cheaper to leach gold, copper, tin and lead from scrap (and collect by electrowinning), than to extract these elements from natural ores.
   - The alternative solders are as "toxic" as the lead in SnPb. For instance the most preferred (and far more expensive) alternative alloys are based on tin-silver-copper. Here, silver exists as minute particles within the tin-rich solder; when released, these fine silver-rich particles are extremely toxic and can kill both plant and wildlife.

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References:

ECSS-Q-ST-60 (2009)	EEE Components
ECSS-Q-ST-70 (2009)	Materials, mechanical parts and processes
ECSS-Q-ST-70-08 (2009)	The manual soldering of high-reliability electrical connections
ECSS-Q-ST-70-10 (2008)	Qualification of printed circuit board
ECSS-Q-ST-70-11 (2008)	Procurement of printed circuit board
ECSS-Q-ST-70-71 (2002)	Data for selection of space materials and processes
ESCC-23500 Issue 5, (Oct. 2009)	Requirements for lead materials and finishes for components for space application

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