POSITION PAPER ON RISKS TO HIGH-RELIABILITY ELECTRONICS AND ASSOCIATED HARDWARE FROM PURE TIN COATINGS

1.0 EXECUTIVE SUMMARY

A failure mode is re-emerging that has been responsible for the degradation in mission readiness and an estimated loss of at least a billion dollars worth of satellites, missiles and other equipment - electrically conductive 'tin whiskers'. Tin whiskers can develop under typical operating conditions on any product type that uses lead-free pure tin coatings. Driven by the accelerating movement to lead-free products, tin whiskers pose major safety, reliability and potential liability threats to all makers and users of high reliability electronics and associated hardware. All high reliability OEM's are subject to the effects of lead-free, due to dependence upon COTS suppliers. Existing approaches are not sufficient to control tin whiskering in high-reliability systems. The risk is here now, and unless decisive action is taken soon to fund development and implementation of a strategic action plan to devise short-term stopgap procedures and medium-term investigation of mitigation alternatives, serious consequences are inevitable.

2.0 DEPENDENCE ON COMMERCIAL PARTS RE-INTRODUCES THE TIN WHISKER PROBLEM

The transition to lead-free electronics has reached the stage where changes are occurring in the standard materials and finishes offered by component manufacturers. Most major suppliers of components are in the midst of transitioning away from tin-lead or offering finishes of lead-free processes. For this reason, the occurrence of pure tin plating as a standard finish on components used in electronics is on the increase, and will continue to increase for the foreseeable future.

Plating chemists are pursuing technologies to limit tin whiskers, and there are ongoing efforts to develop a standard test for whiskering. However, the success of these efforts is uncertain, and no workable solutions will be available for some number of years. The remaining risk may be deemed acceptable for many commercial products, which generally have substantially shorter service lives and higher acceptable failure rates than most military and other high-reliability products.

Increased dependence on COTS materials in high-reliability systems makes control of tin whisker risks more difficult than it was previously. We depend upon the advanced technology made available to us by the component vendors to meet our customers needs, but don't have enough market clout with them to dictate requirements.

The system integrator's insight into the component manufacturers plating process no longer exists because of the many levels in the component manufacturing supply chain (e.g. sub-contractor, supplier, distributor, out-sourced metal finisher...). Recent experience on a satellite program has demonstrated that an exceedingly high level of vigilance will be required to prevent the introduction of tin into any application where tin whiskering poses an unacceptable risk of failure. On the other hand, many designs will need to incorporate some amount of pure tin plating in order to meet the customer's cost and performance requirements. Assurance of the long-term reliability of these designs will require special attention to the unique risks posed by tin whiskering.

The reality of the present situation is that if we continue to operate as we have in the past, pure tin will be increasingly incorporated into our systems with the attendant reliability and safety problems.

3.0 HISTORICAL EXPERIENCE WITH TIN WHISKERS

The formation of "tin whiskers" on the surface of tin coatings has been observed for many decades. These whiskers are comprised of nearly pure tin, and are therefore electrically conductive. Pure tin-plating on a wide variety of component types have been previous sources of tin whiskers (see hot-link below). Tin whiskers have been found to form under a range of environments including: space, missile, airborne, shipboard, ground, medical implant, and office.

This has caused, and continues to cause, reliability problems for electronic systems that employ components that are plated with tin. Manufacturers of high-reliability systems and government users (Raytheon, Boeing, Honeywell, NAVY, ARMY, NASA, etc) have not been immune to these difficulties.

Field failures attributable to tin whiskers have cost individual programs many millions of dollars each, and resulted in significant customer dissatisfaction (See hot link below).

The addition of lead to tin has been shown to suppress the growth of whiskers. Therefore, the use of tin-lead alloy coatings in lieu of pure tin coatings has been a standard procedure. Unfortunately, the push to reduce and eliminate the use of lead has driven many metal finishers to switch from tin-lead to pure tin, resurrecting the specter of tin whiskering. Conformal coating has been employed as a means to mitigate against some types of tin whisker related failures. Therefore, concurrent efforts to reduce the use of conformal coating in electronics compounds the risks resulting from the increased use of tin.

4.0 AN INTEGRATED RESPONSE IS NEEDED TO MITIGATE THE RISK

Coordinated action by high reliability users is needed to mitigate the risk of using tin coated components. The need to address the issue on an urgent basis stems from the reality that the industry shift to 'pure' tin is occurring rapidly and that even if the military and others requiring high reliability are exempt from lead-free laws and regulations, there may not be enough suppliers available to meet needs. Further, both safety and mission-critical parts/components are at risk and there are presently no fully proven avenues of mitigation other than avoidance of use.

Designers, program managers, purchasing managers, reliability engineers, and materials engineers are now being confronted with a complex and dynamic risk situation. Initial efforts to devise policies for handling tin usage are being pursued by a number of organizations, in multiple locations. Therefore, significant efficiencies of scale could be realized by coordination of efforts to produce a single company-wide, or industry-wide approach to this issue. Furthermore, many programs and locations are either unaware of this problem, or lack the resources to properly address the issue. The availability of a standard process for dealing with tin would serve to enhance the reliability and cost-effectiveness of the products that would otherwise have been developed and built without a tin whisker control plan. This is consistent with improving customer satisfaction, and provides cost avoidance for both contractors and the customers.

It is therefore proposed to fund the development of a strategic action plan to address this pressing problem. The first part of the plan must quickly lead to the definition of stop-gap procedures for use in the near-term. These procedures are to be used across sites or programs to control or contain the risks associated with tin coatings. The procedures must be flexible enough so that various programs can tailor actions suitable for their particular needs. The second part of the plan should address investigation of various mitigation alternatives to be performed in the medium-term. The results from these investigations would be used to update the short-term procedures on an ongoing basis, so that the procedures could evolve over time into a properly substantiated industry best practice.

Additionally, a common source of data sharing on individual vendor practices with tin surface finishes would benefit all programs. Part or all of this effort could be leveraged through collaboration with other companies and government agencies that, like us, are members of the CALCE Consortium at the University of Maryland.

5.0 APPENDICES And Hot-Links:

The appendices provide technical details and specific examples that have motivated the participants of the CALCE Tin Whisker Alert Team to create this position paper.

Appendix A: RISKS OF CONDUCTIVE WHISKERS IN HIGH-RELIABILITY ELECTRONICS AND ASSOCIATED HARDWARE FROM PURE TIN COATINGS

Appendix B: Whisker Experiences

Examples of devices with tin whiskers: http://nepp.nasa.gov/whisker/photos/index.html

6.0 Position Paper participants:

CALCE Consortium (University of Maryland)
Raytheon (Rhode Island, Massachusetts, Texas, Arizona, and California sites)
Boeing (Seattle and El Segundo sites)
Honeywell (Tucson, Minnesota, and Florida sites)
NAVY (BMPCOE – College Park, NSWC – Dahlgren, NSWC-Corona, NAWC - China Lake)
ARMY (Huntsville)
USAF (Wright-Paterson)
Johns Hopkins University Applied Physics Lab
Sandia (Albuquerque)
Several U.S. Government agencies