DEPARTMENTS

Up Close With Dr. Michael Greenfield

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EEE Links - What are going to be the major challenges for the NEPP Program in the future from an Advanced Technologies perspective?

Greenfield - As a result of our August 2001 meeting, the Standing Independent Review Board (SIRB) outlined four areas of challenges for the NEPP program to address.

The first challenge revolves around physical environments. NASA subjects electronic parts to many harsh environments. We have issues ranging from shock, vibration, and moisture in the early stages on the pad to transit times, the aging effects, total dose, single event effects, and more. When we put a spacecraft on a surface, let's say on Mars, where it's dusty, we have to take additional factors into consideration, such as wind, dust, contamination, thermal cycling across different ranges, and other environmental conditions that we generally don’t experience in space.

The next area of challenge is in reliability. We have found and still find the majority of our parts problems in the integration and test phase. We have to do a better job in supplier assurance to be sure the manufacturing lines are producing the type of parts that can support NASA missions. We also have to do a better job in the design and screening phases to be sure that reliability is, in fact, adequate.

Thirdly, we need innovative techniques for the low cost screening and qualification of parts, particularly Commercial Off The Shelf (COTS) parts and plastic parts. In many cases we are using expensive approaches that were developed in the old days, when we used Class S and Class B parts, and when there was more money for part qualification. Now we have to go back and see how to intelligently and inexpensively screen and qualify parts.

The fourth challenge is to reduce the risk and total costs of COTS. A Class S part, in many ways, may be less expensive than putting a COTS part into operation. Although the initial costs are very low for COTS parts, the risk mitigation activity that we go through for screening the part and qualifying it results in very high costs. This doesn't mean that COTS parts are not the right ones to use, because they do have high functionality, but we do need to reduce the final costs of COTS. We can do that through a better understanding of the manufacturing lines and through better ways of doing the qualification.

EEE Links - Semiconductor chip device technologies have been rapidly advancing over more than two decades. Taking into account Moore's Law, which states that transistors on chips double every 18 months to 2 years. We now have chips with over 45 million transistors. With that in mind, what future do you envision for these chip technologies in NASA missions?

Greenfield - As I look at future missions, I see the need for much greater onboard computer power to support formation flying, constellations, and the like. We're going to have a need for lower costs and much lighter weight spacecraft – we'll have more small spacecraft launched as secondaries. We'll also see, in some of the larger spacecraft, particularly in the Earth science area, the need for on board data science analysis. We need chip technologies to support these programs in the future.

EEE Links - What are the dual roles that you see for NEPP and the Office of Safety and Mission Assurance (OSMA) as it relates to this rapidly evolving advanced chip technologies environment?

Greenfield - The NEPP program is the only activity the Agency has that is directly looking at understanding the usability of advanced and emerging EEE parts and packaging technologies. NEPP performs technical assessments, characterizations, and evaluations of newly available and emerging electronic parts and packaging. The NEPP program is divided into three areas - Electronic Radiation Characterization (ERC), Electronic Parts (EPAR), and Electronic Packaging (EPAC).

OSMA has a program, managed by Mike Sampson from the Goddard Space Flight Center, that addresses another part of the use of electronic parts. This program evaluates parts that have already undergone flight qualification and are still in use. It turns out that a high number of the problems we are having are with parts that have flight heritage. The problems can be traced back to changes by vendors, manufacturing processes, failure modes that show up in parts or packages that were never reviewed in the initial qualification, and inconsistencies in determining flight heritage. The NASA Electronic Parts Assurance Group (NEPAG) program, which OSMA funds directly ($1.5 million dollars), is an important compliment to what the NEPP program is doing. My personal quest is to foster productive integration between the two programs, because, frankly, the reliability of parts continually used in the Agency is as important as looking at advanced parts.

OSMA does not provide financial support for the flight qualification of parts for missions but this is, in fact, an area where the NEPAG expertise can assist the designers with testing and validation.

EEE Links - When you say assist the designers does that mean that they can actually do some of the qualifications or are they just providing the designers with some information?

Greenfield - I think right now because of the size of the parts assurance community, that it's mostly helping the designers make the right decision, helping them understand what qualifications are applicable to the part and whether the parts can perform well in a specific mission. You know most of our missions are very unique and it's easy to grab a part and say, "this has heritage…what a wonderful part, I'm going to fly it". But we really need someone to go back and look at the part. We have to move away from a sort of black box approach to screening our parts and hardware to be sure that in a NASA-specific mission that we understand the physics of failure in that mission's particular environment. I believe that the parts assurance people must be sure that that the technology has had sufficient qualification and understanding before it's actually put into a program.

With regard to the radiation environment, we need to improve our radiation testing analysis, particularly for parts that have very small feature sizes and very low voltages. We are starting to see new failure modes and I think a major driver in the parts world is to better understand the physics of failure in the NASA mission environment.

EEE Links - We all understand there are higher risks associated with the use of advanced and emerging (unproven) technologies in space missions. But at the same time, these technologies offer higher performance, lower power dissipation, and lower weight - the three Holy Grails for Space Missions. How can we strike a balance between these two and what is your personal philosophy on the use of COTS components and devices in achieving this balance?

Greenfield - We've been very fortunate. The COTS parts that have been used in our programs have had a high degree of reliability. The challenge is to look carefully at the qualification plan – to ensure that the testing that has been done is in conjunction with the actual mission environment. We have to be sure that we have an approach to testing and validation that is related closely to the mission that we are actually flying. Then we have to fly the mission in a way that does not create environments that we had not originally screened the part for. This is the "test as you fly, fly as you test" approach. In order to get higher performance, lower weight and power, and greater functionality we have to be sure that the people accepting these parts - these subsystems - understand the risks involved. We have to be sure that the parts community is in a position to understand the types of failures in a specific mission so that everyone can accept the risks. Where we make mistakes is making decisions driven strictly on functionality and performance and not on understanding what the trades are. So yes, COTS parts are the future. I remember many, many years ago looking at a COTS part replacement, it was an amplifier - I think, for an S part. The one single COTS part replaced 10-12 different parts. When you looked at the overall reliability, with all the interconnects involved in going the S route, the S part actually produced lower reliability than one good high functioning COTS part. That really changed my view of how we have to approach it. We just have to understand how to do the adequate qualification.

EEE Links - Do you foresee any changes in mission reliability and safety requirements with the use of these advanced technologies?

Greenfield - No, I don't see changes in mission reliability and safety requirements. I do see a need to understand and agree upon what is acceptable risk. I also see that there may be a need for additional reliability testing. Right now we have requirements that parts be qualified. The challenge is going to be to develop procedures and guidelines to qualify some of these very intricate parts. We have an activity within NEPP that we emphasized during a SIRB that dealt with ASIC parts. Since ASIC can solve a lot of our problems today, we're going to have to be sure that we develop guidelines for putting increased testability for qualification and screening into them, particularly since there are small shops that are still willing to build them. Additionally, we need to have more direct involvement and less of a reliance on an unknown manufacturer's process line. We do have an activity in place to do that -- I think the first task will be to look at some Field Programmable Gate Array.

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