Excerpts from Round Table 1. 25/01-2007 at 13:40

Panel members: Renaud Mangeret, Nicolas Renaud & Michel Melotte

Notes by: Ali Mohammadzadeh

Renaud initiated the round table by referring to his previous presentation indicating that in many cases, one may perform SEE rate calculations employing only LET values up to 15 and still get reasonable (within margin) results. Renaud, admitted that this method was not very scientific however, provides a very good indication of the importance of the lower LET values in the SEE rate calculations.

- **Question: Are we testing devices to too high LET levels?**

Comment from design engineer: Agrees with Renaud. Projects want to have security, and concerned about uncertainties and effects previously not considered. However, projects do not happily provide extra funding to clarify unknown issues but still require more information.

Projects are mainly concerned with risks and probably do not care about LETs.

Ray argues that the high LET points give us information that may not influence the results quantitatively but may do so qualitatively. In a few cases high LET points are useful. The high LET points may shed light on issues such as:

- Does the cross section saturate? If not, high LET values provide useful information when calculating the Weibul.
- Whether a device is susceptible to a particular phenomenon. If one does not test at high temperatures one would not know if there is a problem at low LETs.
- Issue with lot to lot variability. If you know that there is a susceptibility (at say 110), how do we know that the part flown is not susceptible at lower LETs (say in operating conditions at 60). We are not helping the project by trying to eliminate the cost of the testing.

Renaud: Industry feels a strong pressure to reduce the cost of testing. Practically, a programme manager is happy if a couple of 100 Euros is saved. Parameters such as temperature may be placed in the requirements.

Andrew: Suggests that the specifications are given up to a certain heavy ion species instead of LET values. Current specifications in terms of LET sometime result in large development costs. For modern components one may set a LET value as low as approximately 30. Fore some devices we do not have infinitely wide sensitive volumes and it is impractical to specify LET of 100. However, for old fashioned parts with longer SVs high LET values may still be practical.

Ray: Raised an issue with respect to the representativeness of parts and how one ensures that tested parts are representative to flight parts.

Andrew: Reiterated specifying requirements with respect to heavy ion species rather than LET value. Additionally, for most devices one may make an assumption of what the lateral dimension is for the SV and employ this information in the rate calculations.

Reno: ESA project specify accurate TID requirements for different orbits. However, SEE requirements are always the same regardless of orbit. **Suggestion**: To split components in groups specifying which components have problems and which do not.

No clear SV may be specified for LU, one may instead consider the cross section at saturation to define the SV for LU.

Andrew: One should encourage people to define the sensitive volume. For modern devices one could assess this by knowing what type of device (technology) is employed.

Reno: It is agreed to employ Andrew's suggestions, however, one does not always have the required component information.

Ray: If one specifies a particular species, looking at results for SRAMs, this should be the highest Z material in the package.

Reno: Can we identify such groups of devices without expensive testing?

Andrew: The particle species specified should be the particle species in space and not the particle species we have available in the lab.

Ray: In some cases the secondary will dominate the rate:

Robert: Agree with Reno, we should introduce a component classification. We may come to better prediction through classification. We have strict specification and then we do prediction employing course methods.

Renaud: The first input is to separate the missions (for the specification)

Reno: Specifications shall also be given at component level. JAXA has a very good approach. Robert did not find any high LET data in the literature. There are many LU events detected. However, all events had LETs < 10 (This is said without having detailed info).

Ray: Coming back to worst case application such as SSR flying 1000s SDRAMs. How to qualify: If one does not have consistency in the representativeness with respect to devices flown it is important to test devices at high LET values (increasing ones confidence level). Traditionally, high LET test were performed because it made sense and no good statistical methodologies were available. **Suggestion**: If we want to reduce the specified LET value we should also revisit the SEE rate prediction procedures such as the methodologies, number of samples etc.

Renaud: When calculating the event rates we are probably wrong all the time considering the number of assumptions made. I am not convinced that the LET issue raised here represents the most important issue. The LET issue is a practical issue and may require large effort and money to resolve. **Suggestion**: To focus efforts on areas where it is known that calculations give the largest errors.

Ray: Renaud, why are the rates calculations so far off?

Renaud: Assumptions are made all the time, for environment, prediction and testing, etc. I believe predictions are far from reality.

Ray. In 1997 we found that in most cases where there was a great difference between prediction and in-flight results it was due to the inaccuracy in the shielding or some other deficiency of the data. Most calculations were accurate within a factor of two.

Renaud: Does this also apply to SEFI etc.

Fredrik: The assumptions are enormous and we may have a factor of 2 to 3 difference especially since we do not have any information regarding the SV.

Andrew: The reason is that the LET spectrum is so steep for ions. Quite a lot of parts are rejected because of the infinite SV length.

Robert: **Question**: Do we have examples of SET results with an ion threshold below a LET of 15 sensitive to protons and were these parts sensitive to protons?

Renaud: There is data but very few, LM139 are one example.

Renaud: What shall we employ as the proper parameter?

Robert: **Suggestion:** To use the sensitive charge as the key parameter

Robert: Currently 2µm is employed as the SV thickness. This should be defined better.

Industry: Several commercially available parts were tested, several effects below 15 were observed including LU. In many cases it is interesting to start with proton testing. For design, in some cases it is interesting to characterise only few critical parameters but accurately (this is necessary when selecting parts). Performing key tests ensures that one may circumvent problems that one has observed previously. It is easier to compare numbers if one employs the same test conditions and environment. For LET the SV depth etc should possibly be specified.

Renaud: We need simple parameters to perform initial assessments. Up to now this parameter is the LET. In most cases this is between 70 and 100. Is this redundant, may be this is not the appropriate parameter to focus on. May be one should use the critical charge, but we need to determine a number value for this parameter. We have to demonstrate that the customer is happy with his spacecraft. The customer wants to be assured and industry has to provide the numbers. As mentioned earlier, money and effort must be put on the most critical issues. Do not include any requirements that do not contribute to confidence and reliability.

Ray: Not all numbers have the same qualitative meaning, 0 and 9 have special meanings. Getting 0 for failure is a very difficult issue. It is better to define a finite rate that we can show is not a problem for the mission. For SOC one may not be able to guarantee that the parts are from the same foundry. For SEU there is no problem to test to LET of 30 however, when we measure rates closer and closer to zero that is when we should start worrying.

Renaud: What does an immune device mean? Is it zero SEEs?? What numbers are we using? There is also an issue with part to part variability: Do you think if we go to higher LET it makes a difference specially if you go to COTS?

Ray: I have seen parts where there is a factor of 10 for LU and SEFI rate part to part difference.

Reno: Let us look at a complex device: We need to produce numbers. For LU let us go to extreme but separate from other SEE tests. Testing to higher LETs than 30, will never provide us with a complete and proper test. Can we do the tests in a safe way? Can we live with lower LET data? What are our margins? Literature does not show in-flight problems with LETs above 30, why should we test to 70? What type of margin do we need to employ to be sure?

Ralf: We have the following dilemma: why discuss LET? Because we needed a simple reference for comparison. At the time it was probably a good reference. We clearly know that we are uncomfortable with it. It is case to case dependent. It has become more ambiguous. We need to communicate alternatives to work with. If you want to make sense out of it start from system design. System guys have to make their design based on the components available and I can not easily change PU or other components when the design is available. They want to know what is a good and what is a bad component. The LET value and cross section will not give us this answer. It is not trivial to specify the RHA process. This may lead to large costs. We need to have a right technical answer (approach). Part of the radiation analysis is the determination; can we use or not. Subsequently we may define what the parameters are that we have to focus on. It is important to discuss the approach that will give us compliance or non-compliance with respect to customer requirements. I am assured again that I do not have to worry that the high end of the cross section skews the results. What do we replace the LET with?

Renaud: I agree that we need to provide a technical explanation. But while waiting for this capability, are there parameters that we can modify/change/improve in order to be more comfortable with our approach without increasing the risks? We may start thinking of the technical content of the specification. Could we stop and decide on this approach? Could we make small changes to a few parameters that can make every body happy including our customers? People think that this is only one point in the global scheme. Before this process and reflection is matured, could we simplify a parameter but still be compatible with the customers risk requirements.

Ray: Is the main issue the lack of facilities?

Renaud: It may not be the main issue but it is a very practical issue to consider. In some cases we now need to tilt the devices to reach the high LET requirements.

Ralf: Simply looking at abundances in space of particles with LET up to 36 seems to be fine for most cases the rest are exotic. Now suppose that this would be enough, we could lower the LET level and discard higher LETs. What does that mean? Since we have no evidence that the higher LET particles do not exist. How confident are we that for any arbitrary component that we get good confidence by employing the new LET test levels? Are we not sacrificing other issue that provide undesirable side effects. Let us discuss what it takes to prove that lowering the LET is adequate and then go ahead and change the requirements.

Robert: I agree with Ralf.

Ray: Cell size is important.

Andrew: The problem with specifying a LET of 36 is a translation problem. It should be up to the contractor to decide on the LET specification.

Ralf: This will not be possible as the customer will not accept that the contractor defines the specification.

Renaud: I am not convinced that it is useful.

Ralf: We all think we need something else. The change should hinge around a set of numbers not just a single number.

Reno: There is nothing wrong with what we have today. **The question is**, can we reduce the LET requirement slightly since in space we do not “see” the higher LETs?