A RATIONALE AND ROAD MAP FOR STANDARDIZATION OF LOGIC ELEMENT MANUFATURER DATA PRESENTATION

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The purpose of this paper is to plant a seed within the high reliability electronics parts user and supplier community that may grow into an improved means of communicating critical parts parameters, and most importantly bring honest and clear information regarding known eccentricities and failure modes ("Warts") to the forefront. All intelligent engineers who work with such parts realize, and expect that there is no such thing as perfection in the devices themselves and at the same time realize what little "miracles" these devices can perform even with some "warts" when they are well characterized and understood.

The "active electronic component" industry suffers from the same market pressures as any other manufacturing segment, and suffers from the same public relations pressures that are at work. There is however a distinct difference between the PR strategies that must be employed by an automobile manufacturer and an EE parts supplier. For example, the average car buyer is an amateur regarding the engineering issues associated with the car and therefore can't be trusted to emotionally deal with the "Warts" which all automobiles have. So, nowhere in automobile sales literature will you find even a layman's discussion about the things that are or have gone wrong with the car in the past. Some buyers will turn to Consumers Guide, and in extreme cases, the Government has stepped in and tries to get the manufacturer to fess-up to the "Warts" before someone gets killed.

In the case of the electronics parts industry, the buyer (engineer) is very sophisticated, understands the imperfections of the business, and wants the chance to understand in detail, not only the good things the part can do, but what bad things have or could happen as well. Unfortunately, almost without exception, the engineering staff at Space Dynamics Laboratory has found that the EE parts manufacturers seem to think of the average electronics engineer as only marginally more sophisticated than the average automobile buyer when it comes to publishing all relevant information. In actuality, Engineers are very good at removing the emotional element of a specific parts selection, and objectively dealing with the good, the bad, and the ugly associated with use of the part. They also think of manufacturer quality as being directly related to the clarity and honesty with which the manufacturer represents even the tricky and idiosyncratic characteristics of the part.

This is a situation that needs to be adjusted in our industry. This paper hopefully can serve as a means of starting dialogue that will result in a combination of users and manufacturers to better serve both through truth in advertising; truth being defined as inclusive of omissions as well as what is stated in the literature.

It is also pertinent to note that often, the "Warts" are in the literature. However, it is typically found only after digging down through many layers of "good news" and hyperbole. This is often a time when a manufacturers name is associated with mild to extreme profanity; not that the information was not found, but that so much time and effort was needed to get to it.

The paper will consist of three sections:

1. The failed Wide Field Infrared Explorer experience. An example where millions of dollars were lost, and many lives and careers affected because of parts information problems.
2. A recommendation about the kinds of important data that engineers need to assess risk and risk workaround.
3. A roadmap of actions by the user community will be shown which could lead to voluntary adoption of a parts information standard by the manufacturer community.

The paper does not claim to have the only correct answer in terms of the form or format for reporting data, nor does it claim to have the only correct roadmap to motivate the manufacturers. Rather, the paper is presented as a means of starting dialog in the user community and the manufacturer community that should lead to an acceptable standard format and adoption.

The WIRE, (Wide Field Infrared Explorer), experience:

This instrument was a solid hydrogen cooled infrared imaging orbiting telescope based upon the successful SPIRIT III telescope flown in 1996. WIRE was flown as part of the NASA SMEX class missions. Space Dynamics Laboratory was the prime instrument provider. GSFC provided system engineering and the spacecraft as well as mission operations. It was to have performed galactic mapping to help further understanding of star formation. It was launched in March of 1999 aboard a Pegasus launch vehicle from Vandenberg Air Force Base in California.

As a result of the failure of WIRE, shortly after orbit insertion, an internal failure review took place at SDL in parallel with reviews by NASA. The mission failure was due to premature ejection of the telescope aperture cover which resulted in heavy solar loading of the telescope, which resulted in sustained high thrust from the hydrogen vent line, sufficient to overcome the ability of the spacecraft to stabilize after separation from the booster. Pyrotechnically operated vents were opened on schedule, but the door release mechanisms prematurely fired, causing the ejection of the door. The premature release of the door was directly attributed to fire signals being sent to the pyrotechnic bolt release devices from the "Pyro Control Box" (PCB) which was designed and fabricated by Space Dynamics Laboratory.

The PCB was designed to fire initiators on the secondary vent and aperture cover as well as operated the wax actuator which opened the primary hydrogen tank vent. Three inhibits were designed in to prevent the initiators from being inadvertently fired. Analysis and testing of the design, using an engineering model, along with new knowledge of behavior of some of the parts used, indicated that there was an unexpected power up behavior in the electronics. This behavior allowed the arm and fire outputs to be driven high before the oscillator clock starts the power up reset on the chip. Aggravating this problem was the delayed power up time in the 5 volt regulator that supplies the logic power. Measurements on the engineering test unit showed that during the power up, the PLD sent signals to arm and deploy the initiators. This condition exists for approximately 14 millisecond due to arm relay closure time of 10 milliseconds. This resulted in a 2 millisecond fire pulse approximately 12 milliseconds after "A" side power was applied. Once powered up, the chip continues through reset and clears all knowledge of the event. This part anomaly was not repeatable unless the chip had an extensive time to drain the residual capacitance. An immediate retest to check for this anomaly showed no problem with the part.

Discussions were held between SDL and GSFC engineers about the PLD devices involved with the anomalous power up. GSFC parts folks were able to point to some known but obscure parts peculiarities. These devices have a built in charge pump or DC to DC converter which, as the part is powering up, disconnects all the device programming circuits from the functional logic cells. During this interval, the part is completely undefined and indeed, pins which are programmed as inputs can be outputs, output pins can and usually do, assert. In the WIRE PCB, this condition exists for approximately 14 milliseconds as the +5 volt supply is powering up. During this time, all outputs are asserted. What this causes is the arming relay to begin closing, and all output FET's to be enabled. The measured close time on the relay is 10 milliseconds. The arming relay contacts close, the FET outputs are enabled, and all initiator outputs are fired. Approximately 1.5 to 2 milliseconds later, the PLD is now operational, and the outputs clear, but the damage has been done. The frustration is that this behavior is transitory in nature. The device will not do this again unless It's allowed to sit un-powered for a period of time in excess of an hour. So, had this been seen and the box powered up to try to repeat the event, it would not have occurred until the "discharge time" of the device had been allowed to expire. This behavior was not caught during SDL testing because the box was always powered using a 35 amp power supply which takes approximately 150 milliseconds to power up. So, the device was outputting the spurious signals, but due to the reduced power supply voltage present during the first 15 milliseconds, the arming relay never closed.

In short, the anomalous condition went undetected at SDL, and during systems tests at GSFC.

The conclusion of the internal review at SDL was that the test procedures at the box and system level were not adequate and allowed the tests to be conducted in a way that did not precisely simulate the way the circuitry would be activated and used on-orbit. Therefore, the specific logic element can not be directly blamed for the failure. However, SDL reviewers also came to the conclusion after discussions with the manufacturer and deep delving into the manufacturer data that the idiosyncrasy was known to the manufacturer and could, and should have been more easily and freely communicated to the element user community.

What is important for the engineers to know?

On July 3, 2001, the SDL Electrical Engineering Committee, which is charged with communicating lessons learned within the Laboratory met to have a specific discussion regarding inputs to this paper. Some other specification needs have been added as a result of e-mails passing between GSFC and other labs interested in this issue.

The author supplies the following in basically the form in which it was submitted from minutes of the meeting.

1. The general feeling of the engineers in attendance was that an application note format was more suited to this sort of information. They felt that a "data sheet" format would not adequately address the "Warts" issue. The application note format would include data formatted like it would be in a data sheet, but a lot of the information would be textual and be in the form of a discussion rather than a table of values.
2. Detailed radiation effects was the first item discussed. What part parameters are affected by how much radiation. Input switching thresholds, power supply consumption and input leakage are all parameters that are affected. These could be graphically displayed.
3. Discussion of total dose and upset phenomenon would also be appropriate in this data sheet. If the vendor does not , as a rule, do radiation testing, they should either start, or act as a data collection point for such testing and publish data done by other institutions.
4. Noise immunity of a device and noise generated by a device (as measured from it's power supply) is another parameter inadequately specified, and very important to risk reduction techniques in the design process. This is fairly common on analog circuits, but not discussed much in digital parts specifications.
5. A more detailed power estimation recommendation from the manufacturer would be very useful. One of the big questions asked very early in any electronics system is about power draw. Some vendors provide very good resources to help estimate power once a digital design is complete, but if there were ways to specify part power draw in a "standard" circuit which would allow manufacturer to manufacturer comparisons, the better power/performance part could be selected.
6. Power up phenomenon is another area where information of parts behavior is lacking. Two manufacturers are cited here only for example, but all manufacturers have parts with hidden or obscure "Warts". Actel (the 1020 series) has a virtual memory of several hours that hides a power up phenomenon when the part rests over night. The Xilinx Virtex pins "glitch" when the part is configured and is asserting it's "done" flag. (NOTE: Both excellent parts when used properly and when all eccentricities are understood. SDL has used and will continue to use parts from these and other excellent manufacturers.
7. It would be a very good thing if the manufacturers would provide a list of systems in which there parts have been used, including the good, the bad and the ugly "Warts" that were part of lessons learned from those applications.
8. The issue of: Why should a vendor do this?, was brought up.

   SDL's response to the WIRE failure might be a good model for why a vendor needs to be forthright in covering all aspects of their product. SDL immediately undertook an internal investigation into the failure in parallel with the NASA directed study and discovered and documented the WIRE shortcomings the moment they were adequately understood. Because of that forthright approach, SDL has been very successful in acquiring further work. In some cases, that forthrightness was deemed not just to neutralize the failure, but to make the Laboratory an even more desirable partner or contractor.

   In short, vendors who are proactive in providing information on the good, the bad and even the ugly, may well become preferred vendors in the eyes of the user community.

   SPECIAL NOTE: The other side of the coin here is to make sure that the user community provides as much positive feedback as possible to the vendors on their parts . SDL for one has yet to tell a vendor how wonderfully their parts worked (and 99% of the time the vendor parts do a good job). SDL and others in the user community have been very good at pointing out parts problems to the vendors. The user community needs to let the vendor know when they do a good job for us too!

So, how do we get there from here and what's next?

A number of organizations are trying very hard within their own spheres of influence to capture the kinds of parts data that is discussed as a part of this paper. The Government has it's GIDEP alert program. Because this is an "after the fact" service, it is woefully inadequate for designs that are using new parts technologies. However, it does a good job of closing the gate once the first horse has escaped and helps designers not use parts that are clearly bad. The bigger problem is that specialized parts that have "Warts" may need to be used even if there is a current GUIEP on them. We must turn to the manufacturers for the needed data. Richard Katz at GSFC has a very useful web site featuring a quarterly compilation of parts information and technology. (http://www.klabs.org/richcontent/eeelinks/EEE_Links). This is excellent information gleaned by GSFC and other contributing engineers. However, it is unlikely that the part that is going to make your life miserable a year from now will be found in the GIDEP nor on Katz' site.

It really is time for the user community and the manufacturers to get together in a common organization or council to get to a consensus on how to best protect the interests of the consumer, be they taxpayer (Government), or commercial systems builders.

The following general theme may serve as a starting roadmap to get us to such an organization:

1. The attendees at the MAPLD conference from the user and manufacturer community are very representative of both sides, and would serve as an excellent pool from which to draw an organizing committee to produce a real roadmap towards a long enduring and effective user/manufacturer council.
2. A volunteer group could be drawn from the conference pool. Post conference, a solicitation for those who are interested in participation could be released. Mr. Katz and Mr. Ames could act as interim organizers/chairmen and develop a list of people for an interim council.
3. The Interim Council would meet at GSFC or at SDL facilities in Logan, Utah, (Central to both coasts), in after the 2002 MAPLD conference. Either GSFC or SDL would provide facilities and writer/secretarial support
4. The Interim Council charter would be to develop a more permanent roadmap for the council including:
    - A. Develop a formal charter
    - B. Develop a permanent member role and/or a rotational membership role
    - C. Develop a schedule for producing specific user/manufacturer component specification and truth in advertising materials.
    - D. Develop appropriate sub-committees to work specific areas of concern.
    - E. Develop a specific methodology of bringing top decision makers in the manufacturing community into the fold.
    - F. Establish a plan for dialogue with existing parts related institutional and Governmental agencies such as the GUIDEP organization and National Laboratories to seek advocacy and support.
    - G. Use the MAPLD conference medium on a yearly basis for one of perhaps two major Interim and/or permanent council meetings during the year. Provide useful reports to the conference.
    - H. Develop a Council web site which could be used as a holding area for as many useful links to parts related sites as well as for specific council reports and business.
    - I. Develop a funding mechanism to accommodate council needs such as the web site. (It is assumed that there would be enough self interest on the part of Interim and Permanent Council members that their time and travel would be donated to the council).
5. The major goal of this effort would be to have a permanent council in place and operating by the time of the MAPLD conference in 2003

In summary:

The high reliability parts user community is sophisticated and thrives on information both good and bad about electronic parts. Because an engineer knows a part has some downside, does not make it a bad part. Not knowing, or finding out the down side after a part is in a design makes the part a bad part. Standardization of manufacturer data sheets to give more space to parts peculiarities is very important to the user community. It is time for the user community to provide guidance to the parts vendors on how to present such information in the most user friendly way. There are resources within the user community to work on this issue. It is to the benefit of the user and the vendor to get this information unambiguously out to the user community.