Satellite Reliability

Introduction

Over the past few years, the number of satellite in-orbit anomalies and failures has increased significantly. These anomalies have had serious effects on both the service performance and financial position of satellite operators. One of the reasons for the decline of satellite reliability is that satellite operators have been demanding greater capacity on even the largest satellites in order to maximize the channel capacity per kilogram launched. Another is that commercial pressures have increased as the industry transitions from what was primarily driven by the government to a more 'buyer's market' type of business, with satellite manufacturers being asked to design and manufacture more complicated satellites in less time, at an extremely competitive rate.

With this trend, satellite reliability has become a great concern to underwriters, manufacturers and satellite operators alike, with significant financial impact on the industry. As an example of its impact, 1998, 2000 and 2001 were the worst years for the insurance communities with claims over US$4 billion, and a loss of US1.3 billion, mostly due to anomalies attributed to one manufacturer.

As a result of the reduction in the design and build quality of satellites, satellite manufacturers have been the target of criticism over the quality of their products. In addition, insurance premiums have also gone up significantly; the bigger operators may take some of the risk themselves or even may not insure their satellites.

Potential Ways Forward

Faced with reducing satellite reliability it is important for all participants to focus on the fundamentals - approaches and processes that reduce uncertainty and increase reliability:

Adequate Quality Control Processes: The quality control and product assurance processes implemented during the construction of the spacecraft are a primary contributor to the overall reliability of the spacecraft. These processes are undertaken both by the spacecraft vendor and the satellite operator.

The spacecraft vendor specifies a detailed product assurance plan, which will be reviewed by the satellite operator. The satellite operator must ensure that the plan meets the stringent requirements and addresses heritage and technology issues. The satellite operator must also be satisfied that qualified and highly experienced key personnel are assigned to the spacecraft construction; and that only qualified key sub-contractors are employed in the program.

The satellite operator also plays a part by instituting its own quality control process. In most cases, in addition to its own engineers, the satellite operator employs third party consultants to gain confidence that the programs are properly managed and monitored. This further ensures that the manufacturer complies with the spacecraft specifications. The satellite operator will also ensure that various test data as well as other information are properly scrutinized and reviewed to ensure compliance.

Since 1999 US ITAR (International Traffic in Arms Regulations) restrictions have had an increasingly serious effect on the visibility granted to non-US satellite operators during the design, assembly, and test phases of their spacecraft. Most satellite manufacturers regard customer involvement as an important part of their own process, both for ensuring that all requirements are accurately interpreted and implemented, and because the

second set of minds reviewing the documentation minimizes the chance of costly error. The limiting of customer visibility is having serious impact on the quality control process. As a short-term measure to mitigating the lack of customer visibility, some satellite operators have resorted to employing third party US consultants to perform a detailed technical review.

It is important for all in the industry, especially those involved in manufacturing, to ensure that strict quality control is adopted in their manufacturing process flow. This is to ensure that their products are good and reliable in nature. Satellite manufacturers should take measures such as improving the quality of satellite design, supplier quality and manufacturing process.

Systematic and Proper Test Procedures: In addition to adequate quality assurance processes, systematic and proper test program can reduce risk and improve the probability of the success of a mission. Testing involves a simulation process in a laboratory under certain predetermined operating conditions. This is to demonstrate that a particular component/ system/ subsystem subjected to the testing will function as it is expected to, without fault, throughout its design mission life. Prior to testing, a test requirement is written. It

operations. The test is used on components or systems of new design where no in-orbit heritage has been demonstrated but has undergone the development testing

- *Protoflight Testing:* A protoflight test is similar to a qualification test but with reduced test requirement levels. The test is subjected to the flight heritage component or system that requires minor modifications to suit the satellite's mission.
- *Acceptance Testing:* Acceptance testing is conducted to demonstrate the workmanship of each deliverable product. It is subjected to a flight component or system of new design whereby its qualification has been completed on a flight representative article.

The heritage of a particular component or system plays an important role in determining the level of testing it is subjected to. For example, if a new component is being developed for a particular satellite mission, the component will be subjected to all testing levels mentioned above, beginning with the development testing. However, if similar components that have already possessed some years of in-orbit heritage were to be used, an acceptance test will be sufficient. This is known as "qualification-by-similarity" It is critical that the

technologies have failed in providing their merits and benefits, or in some cases have proven to be catastrophic. This is not to say that a new technology is not essential or always fails. New technologies such as Xenon Ion Propulsion System (XIPS), Lithium Ion battery or solar cells with higher efficiency (or modification to array systems and technology) are used to maximize the performance, capacity and power of a satellite while it remains within reasonable parameters for the size and the weight of the spacecraft.

It becomes a challenge for manufacturers when there is not enough flight proven basis or heritage for these new technologies. In fact, this has forced some manufacturers to come up with more complex versions of their original platforms. Taking a close look at the performance of both payloads and buses of current satellites and analyzing the weaknesses and strengths of the main satellite manufacturers, it can be observed that the same manufacturers keep on repeating the same anomalies and failures. These repeated problems originated in either the design or the manufacturing process of the satellite and can be related to a specific component, unit or subsystem. Although most of the known problems for most of satellite platforms have been detected and corrected, we have yet to see how future satellites actually perform in orbit.

Launch vehicle agencies are also aggressively moving to a new generation of launch vehicles, i.e. a launch vehicle that can handle a bigger satellite or multiple satellites. While the most reliable of commercial launch vehicles are no longer in use, the new generation vehicles are now causing a reverse impact on the insurance market. Further, there are not enough launch vehicles with good heritage to launch a medium class of satellites. The reliability of existing launch vehicles is a major concern from the insurance community's point of view. This brings about a situation where for instance, even 10 continuous successful launches of a particular launch vehicle may contribute to 1 to 2 percent reduction in the premium while a single failure of the same launch vehicle may contribute up to 10% increase in the premium.

Taking more responsibility for their products: Satellite manufacturers should stand behind their products and take more responsibility when their products fail in orbit or suffer performance degradation. Satellite operators should withhold an amount of the satellite purchase price in the form of in-orbit incentive payments, to be paid gradually over the life of satellite once the satellite is operational. Incentive payments in the range of 10% to 20% of the satellite price, should also be increased. It is also not unusual to keep a higher percentage of the payment after a successful In-Orbit Test (IOT). Perhaps the handover period of the satellite from the manufacturer to the operator (i.e. after IOT) should also be increased. This will allow the manufacturers time to monitor the health of their satellite more carefully prior to transferring ownership to the operator.

Conclusion

The space insurance industry is going through a very difficult time at this moment. Claims resulting from anomalies on satellites in orbit, rather than claims coming from launch vehicles failure, have become the biggest cause of claims. Capacity has minimized, resulting in more restrictions and limitation on insurance coverage. The current maximum capacity for a dedicated launch is around USD 250 million to USD 300 million, which is much lower than the previous years. Underwriters are asking for a minimum 7.5% margin in power end of life, with a single string failure in the cells. In addition, they ask for extra fuel margin and full redundancy and try to exclude any single point failure from the coverage.

Where both the insurance world and the entire satellite business are uncertain about the future space insurance market, it is advisable that satellite manufacturers and operators focus on the fundamentals to ensure spacecraft reliability. While these are not "rocket science", they will help the industry move into an environment of increased satellite reliability, with positive effects for underwriters, manufacturers and satellite operators alike.

Dr Ali R. Ebadi
Vice President, Space Systems,
MEASAT