Transforming inner space

Change is coming to the design, testing and procurement of components for inner space, explains **Roger Tall**

The International Space Station (ISS) is the highest-profile satellite flying in a low Earth orbit (LEO). Although China's Chang'e-4 probe has landed on the far side of the Moon and Nasa's Opportunity and Spirit rovers have explored parts of Mars, it is the activity in LEO that is showing the most dramatic growth (*Figure 1*).

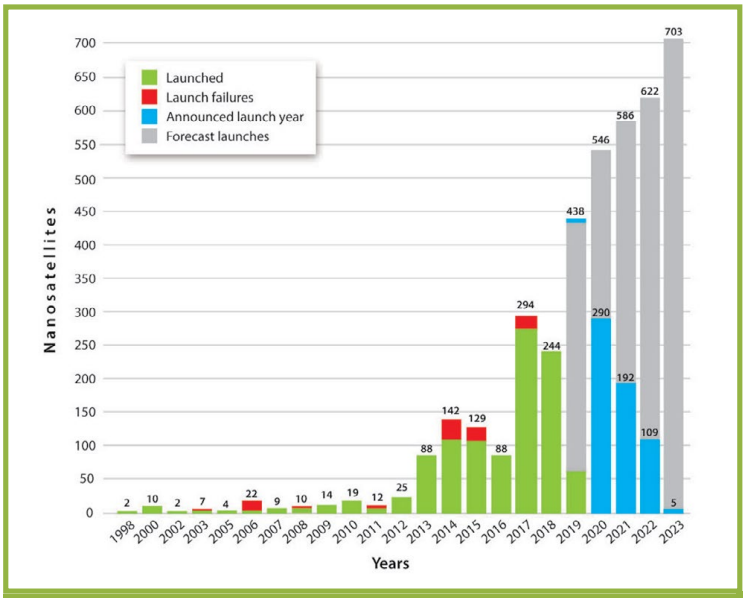

Figure 1: The number of launches predicted for 2020 has reached 546 *(Source-nanosat.eu)*

Cost-reliability trade-off

As the volume of LEO satellites rises, there is a need to maintain a lower cost which is viable for the large constellations. To meet this demand, component manufacturers are producing up-screened commercial off-the-shelf (COTS) components and automotive-grade parts, to additional reliability screening and full space-grade qualification.

An effective method for designers to reduce the time and cost of developing a LEO system is to start the design with devices at the lower end of the reliability and cost spectrum. As the design cycle progresses, the components will have higher reliability as it transitions from prototype to flight model (FM).

The challenge is that components at the commercial level of reliability often include a range of capacitance values and voltages which are not typically supported for devices with full space-level qualification (*Figure 2*).

There are over 800 versions of Kemet's industrial-grade polymer capacitors, ranging from 2.5V to 63V and up to 1500µF. For hi-reliability COTS versions there are 260 but these offer higher voltage and capacitance values of 75V and 2000µF.

For automotive-grade polymer capacitors, 77 versions provide up to 330µF and voltage up to 50V but there are only 11 fully space-grade polymer capacitors with maximum ratings of 16V and 150µF capacitance.

Designers must factor in the availability of the final grade of components for the FM system. In addition to checking the range of devices available at each level, it is also valuable to discuss future availability options with a specialist source to avoid costly re-qualification.

Manufacturers are responding to the higher volumes of LEO-based satellites by providing additional screening options and a range of choices to meet the competing needs of system reliability and tight cost constraints.

The launch of the New Space Electronics programme by TT Electronics combines two baseline screening options and full component traceability for discretes and multichip arrays. For tantalum and ceramic capacitors Kemet has developed a screening matrix up to quality products list (QPL) and mil-std parts. It details 25 screening processes to enhance the reliability of automotive-grade capacitors.

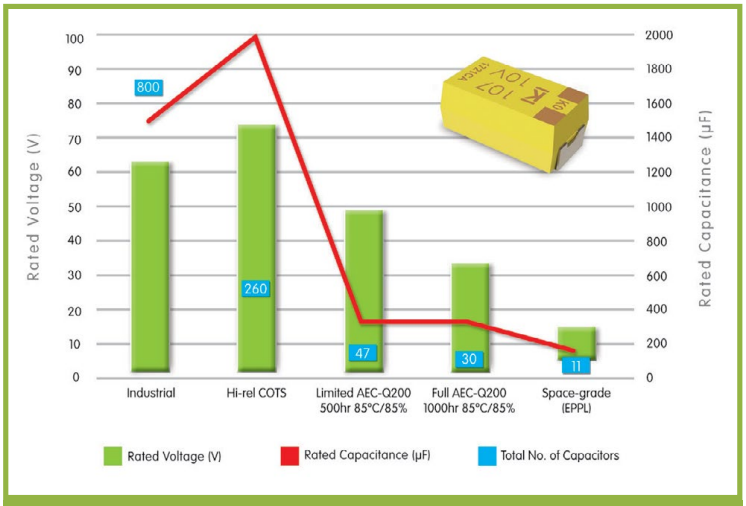

Figure 2: Voltage and capacitance ranges reduce as reliability increases

Exxelia has achieved European Space Agency (ESA) qualification for its surface-mount inductors and transformers – it has supplied capacitors for Chang'e 4 and the InSight spacecraft – and extended the availability of its space-grade capacitors and filters.

Reconfiguring satellites

New developments for geostationary earth orbit (GEO) satellites allow them to be reconfigured on-the-fly to optimise performance and improve the cost/performance ratio.

One example of this is a ferrite-based, Y-shaped switch. Manufacturing this ferrite-Y is complex, because tight control on dimensions must be achieved, but Exxelia Temex, backed by funding from the ESA, has succeeded.

The ferrites enable satellites to transition from providing a single static beam, which broadcasts across a large territory to using a narrow spot-beam which can be beam-hopped to broadcast across a range of smaller targets within the same territory. The satellite is controlled by the operator to provide a higher bandwidth to certain locations.

Adaptive beam-hopping provides greater flexibility for the payload and delivers more targeted communication which leads to increased capacity.

Supply chain challenges

Many European OEMs prefer to purchase components that have been manufactured in Europe. The location of the manufacturing facility affects the potential end-use in space applications, as restrictions can apply to

the application or to the country of use which potentially limits the customer base and could affect continuity of supply. This has led some western manufacturers to relocate production to Asia.

European OEMs bring their expertise to international programmes with Russia, China, Korea and Japan. Part of the transition has been the relaxation of components falling under the International Traffic in Arms Regulations (ITAR) restrictions which are used by the US government to safeguard the international export of defence components.

For example, ITAR export restrictions on solid-body fuses manufactured by AEM in the US were lifted in 2014. Already used in electrical systems on the ISS, these fuses can now be used in space applications by other countries, subject to the less-restrictive EAR99 classification.

There is a resurgence in the UK space industry, with new companies providing upstream technology for low-cost satellites and payloads. In downstream services, companies are commercialising the wide range of data from earth-observation satellites or providing GNSS services using GPS, GLONASS and the European Galileo systems.

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Prime contractors are increasing their footprint in the UK, via acquisition – establishing a presence at one of the UK space-clusters – or by growing an established site.

Euroquartz, for example, has upgraded its Somerset factory to include an ISO Class 7 cleanroom. This will enable it to add surface-mount oscillators to its range of through-hole devices which will be qualified for use in space and other high-reliability applications.

A UK-based manufacturer and distributor with inventory held in the UK strengthens the supply chain for OEMs that want to consolidate in the UK. Many OEMs have sourced space-level components by using a co-ordinated parts procurement agency (CPPA). Despite the low volumes in LEO and GEO satellites, this provides a direct route for sourcing which adds further testing of components, for example, pre-cap inspection of semiconductors, radiation testing, fault analysis and non-destructive testing.

OEMs would need to balance the cost of undertaking these additional tests against the overall budget for the satellite build.

Traditionally CPPAs have serviced the low volume and high reliability required by the space industry with out-sourced procurement and kitting.

The increased volume of components used in LEO constellations, however, means that designers are turning to components with a lower level of qualification, such as automotive AEC-Q200 devices. Specialist distribution backed by in-house testing from the component manufacturer helps OEMs to meet the tight balance between the cost and reliability of LEO and GEO satellites. ❑

About the author

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