FEATURE

Applications Engineering for Military & Aerospace

by Ashley Luxton
GRAPHIC PLC

***Summary:** Current functionality demands mean that designers and engineers no longer have the luxury of keeping designs simple and sticking with known technology; in fact, increasingly more designers are now among the first to try new technology, and become innovators rather than followers. Applications engineering services help bridge the safest, most cost-effective designs possible with performance requirements.*

Military/Aerospace Requirements

When designing PCBs for the mil/aero segment, some specific, and often unique, requirements need to be considered.

Operating environments can be harsh, with conditions and temperatures ranging from desert to arctic. Humidity levels may also vary, as well as levels of vibration—either from the platform in which the PCB is installed, or from handling. And rather than being able to design the PCB to handle a particular environment, it must be designed to cope with the full range of these conditions throughout its life.

Additionally, it's quite possible that the assembled unit could sit on a shelf for months, or even years, in any one of these environments, and then be expected to perform perfectly—at a moment's notice, and continue performing for years.

The key aspect of mil/aero is, of course, reliability. Many systems will be life critical—either in terms of keeping an aircraft in the air, or ensuring that a missile hits its intended target (and doesn't detonate before or during launch). This, in contrast to consumer electronics, which will generally operate in a benign environment and have a comparatively short life expectancy, with the consequence of failure being little more than inconvenience.

The environment for industrial electronics may be a little more demanding, with vibration and temperature perhaps coming into play, and a board failure could result in significant financial loss, but even this doesn't compare with the long-term reliability requirements of the military and aerospace industry.

The Importance of Applications Engineering

In the past, where high reliability was required, the circuit board would have been designed with minimum complexity. High-reliability industries would have been reluctant to embrace new technologies until they had been well proven in the field.

Today, demands for functionality mean that designers and engineers no longer have the luxury of keeping their designs simple and sticking with technology that has been tried and tested over many years. In fact, the pace of change means that increasingly more designers

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are now among the first to try new technology, and become innovators rather than followers.

With the increase in board technology and complexity comes an increased need to ensure that it is designed with manufacture in mind. Applications engineering services must specifically help designers produce the safest, most cost-effective designs possible, while achieving their performance requirements. This benefits both the customer and designer by ensuring that risks in manufacture, and in service and cost, are optimised. The two go very much together, since ensuring the lowest risk often requires additional processes, and hence, costs. However, these costs are well worth it when weighed against the potential cost of the board failing in the field due to the increased risk involved with a compromised process. The fabricator benefits too, by receiving designs that are optimised, allowing greater efficiency through both the front end and manufacturing processes, and resulting in optimised yields.

The customer again benefits via on-time delivery and cost control.

How it Works

This process is based on two-way dialogue between the designer and applications engineer at an early stage in the design process. This is important, as it is all too easy for a design to be started and a board structure set, which then turns out to be compromised, and unnecessary risks introduced simply because it would be too much work at a late stage in the design to go back and change it.

By engaging in this dialogue early in the process, the designer can be made fully aware of the fabricator's manufacturing capability, and design the board accordingly. This applies not just to the relatively simple things like track/gap/annular ring, etc. (this is usually available on a fabricator's website), but it's how these things work in combination with the overall proposed design, considering board type, material, via structure, power requirements, etc.

By incorporating best practice right from the beginning, there is no need to spend the time correcting a design later, which can lead to significant changes, excess paperwork, cost, and delays if the design has already been issued.

The Role of Applications Engineering

One of the most critical aspects of applications engineering is advising on drawing and documentation specification. This is partly with the aim of ensuring that information is clear and concise with no ambiguity so as to minimise the opportunities for error and misunderstanding, but also to advise on the relevant quality standards that should be called up.

There has been something of a move away from the traditional MIL specifications towards IPC. This has in no way made the quality requirements any more straightforward, as most of the requirements are on a par with MIL. In fact, in some ways it has made it more confusing because many people don't have a full understanding of IPC specifications. It is easy to specify IPC on a drawing, but for this to be really meaningful the design has to have been based around IPC from the start.

With quality systems like AS/EN9100 and NADCAP, there is even greater need for the drawings to be correctly specified, and all requirements fully understood.

In conjunction with advising on the quality standards and requirements, applications engineers also advise on the design rules required to ensure that those quality requirements are met. This can also be a difficult job since those that are fully aware of IPC are often happy to work to exactly what it says, without taking into account that IPC doesn't really allow for many of the more complex board technologies commonly in use in the military and aerospace industries these days. For example, IPC gives land size requirements based on three different producibility levels, but doesn't differentiate between a simple through-hole multilayer and a multiple sub-assembly SBU HDI design. These more complex constructions have a significant impact on registration and producibility, and hence this has to be allowed for in the land sizes at the outset.

IPC correctly states that the more difficult producibility levels should only be used where necessary, but this is often overlooked with the tightest possible feature sizes being used throughout the board. To ensure optimum yields, saving cost and improving delivery performance (which is in everyone's interest) feature sizes should be optimised and increased where there is room to do so. Minimum feature sizes are just that—minimums—and should not be the standard.

Applications engineering also includes advising on the materials to be used. This is partly driven by the customer's requirements, but the fabricator's experience should also be considered, where possible, using materials that are available to the fabricator and which they have good knowledge of. In theory they would be quite capable of using a material that the designer may have selected by researching on the web, but they may need to run process trials first—increasing lead-time, experiencing poor yields due to inexperience with the material, and possibly having to pay more for that material than an equivalent that they do have knowledge of simply because it is from an unfamiliar supplier.

With the fairly recent trend towards higher-speed materials, this experience is perhaps even more important. There is now a wide range of high-speed materials on the market, and the data sheet can only tell so much. A material that has very good electrical properties may not perform well from a reliability point of view when subjected to thermal stresses, particularly in more complex structures. Data sheets can give an indication of which materials may be better than others, but experience with the material is the only way to really know how it performs.

The most widely used aspect of applications engineering, and one of the most important, is providing constructions. The reason is because different fabricators may have different preferences for construction based on their experience and capability. There can also be differences in the way impedance is calculated, and generally speaking, the fabricator will calculate the impedance to give the most accurate results for their particular process. This may not tally with other calculators or other fabricator's calculations.

The construction is also important as it is very easy at this point to either build in unnecessary cost, or unnecessary risk by making the construction too complicated, or simply not suited to a fabricators preferred manufacturing method.

As well as being fundamental to a fabricator's ability to manufacture a given board, the construction will also have a significant impact on the fabricator's ability to meet the various quality requirements; things like minimum dielectric separation are fairly obvious, whereas the impact on wrap plating and registration is not so obvious.

For these reasons input from the fabricator is vital at this point.

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As mentioned earlier, it is important to have the controlled impedance calculated, or at least checked, by the fabricator. Their calculations will be tailored to their processes to give the most accurate results. Achieving the given impedance a requirement basically comes down to the stack-up and the line widths. It is important to achieve the impedance with minimal compromise to either as it is otherwise quite possible to engineer a situation where the impedance tolerances can't realistically be achieved, or yields can be reduced by compromised registration, dielectric separation or track/gap definition.

Panelisation is, of course, essential to cost, but can also have an impact on manufacturability in the case of more complex constructions and it will also have an impact on the assembly of the boards. If the assembly is to be done by a CEM, there should be discussion with the board fabricator and the CEM to ensure that all requirements are met without compromising either the manufacturability, or the ease of assembly.

Historically, cost was less of an issue for the mil/aero industry, but in the current climate it is becoming more and more important. As discussed previously, it is very easy to build unnecessary cost into a board, and applications engineering can help to optimise this. Sometimes an increase in cost is needed to reduce risks, and this needs to be weighed against the cost of failure, or possibly the knock-on cost of a more complex assembly process.

Having involvement in the design from an early stage is absolutely the best way to ensure success, but it is always possible for something to be overlooked, or design rules compromised due to a misunderstanding. If the data has been formally issued it can be a time-consuming process to make changes if errors are picked up during the fabricator's front-end tooling process, as well as of course introducing delays in the lead-time. To try and reduce this risk another service that applications engineering offers is a review of the completed data set prior to formal data release and order placement. Often this review will not be as thorough as the full DRC analysis that takes place during front-end tooling, but it can help to pick up any key issues and allow these to be corrected more easily.

If issues with the way the data has been supplied occurs, in terms of the way the features are created in the data, this can also be fed back. The presentation of data, particularly in the case of plane data, can have a huge impact on the processing time at the fabricator. This is yet another aspect of applications engineering that can give benefits all around by improving efficiency and lead-times.

With applications engineering, Graphic PLC has been able to successfully bring these technologies to key military projects such as the European Fighter -Typhoon, Joint Strike Fighter–F35 and also key aviation programmes such as A380 and A350. **PCB**

Ashley Luxton is an applications engineer at Graphic Plc Group and 18-year veteran in the PCB manufacturing industry. He may be reached at aluxton@graphic.plc.uk.
