



Key Areas to Audit When Selecting an Aerospace/ space/Defense Contract Manufacturer

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Selecting a contract manufacturer for mission critical applications, such as those found in the aerospace, space and defense industries can be more challenging than selecting a contract manufacturer in other industries. The regulatory environment associated with these projects is more complex than most commercial products. Traceability and associated documentation requirements are more detailed. Procurement and supply chain management may require specialized knowledge and procedures. Volumes can be low and production builds may only be done a few times a year rather than continuously. Specialized production skills or equipment may be required to support processes required by harsh operating environments. Additionally, since field repairs are not an option on many of these products, quality must consider not only the workmanship requirements in production environment, but also material handling and/or compatibility issues that may impact product reliability over time. Finally, in some cases, workmanship standards or other production specifications are not well defined and the contract manufacturer must work with the customer to determine appropriate processes and associated validation and documentation. Consequently, the OEM selection team must look beyond production capabilities to determine if the contract manufacturer has the industry-specific processes and expertise to correctly address the requirements associated with each product.

Axiom Electronics, an electronics manufacturing services (EMS) provider specializing in defense, aerospace and space projects regularly supports unique requirements. This whitepaper looks at four areas that should be audited carefully in supplier selection:

- Processes to ensure conformance to regulatory requirements
- Material handling considerations
- Expertise in issues related to harsh operating environments
- Ability to handle specialized projects where not all specifications are well-defined.

Processes to Ensure Conformance to Regulatory Requirements

Military, aerospace and space projects have significantly more complex regulatory requirements. Some are subject to The International Traffic in Arms Regulations (ITAR), which means not only must the contract manufacturing facility be ITAR-registered and compliant with ITAR's security practices, procurement activities must be compliant with ITAR practices, as well.

At Axiom Electronics, each project's requirements are carefully assessed, both at the bidding stage and once the project is awarded. Axiom's new product introduction (NPI) process starts with an initial meeting where a team consisting of manufacturing engineering, program management, quality and supply chain evaluates the scope of work (SOW), notes and assembly drawings to ensure that all information is consistent across the documentation package. For example, if special instructions appear in the SOW, they also need to be noted on the relevant assembly drawings and work instructions. If work instructions are unclear or information is missing from the drawing package, the OEM's team is asked to update the documentation with the required information.

This focus on ensuring all requirements are well understood within the team supporting the project eliminates surprises that could otherwise create defect opportunities or delay the production approval process.

Material Handling Considerations

Military, aerospace and space products have very robust material handling requirements because of the mission critical nature of most of the products. Contract manufacturers should be able to demonstrate receiving, receiving inspection, traceability and material storage practices consistent with relevant industry standards and any customer or flow-down contract provisions.

At Axiom Electronics, material handling and manufacturing processes are evaluated as part of the NPI evaluation. Given the specialized requirements of many space, aerospace and defense products, special consideration is given to:

- Any enhancements needed for material handling, validation and/or traceability requirements
- Traceability requirements at the manufacturing routing and assembly level
- Changes to operator certification requirements and/or processes related to polymeric applications.

The *IPC-1782 - Standard for Manufacturing and Supply Chain Traceability of Electronic Products Based on Risk* is utilized to determine traceability requirements on IPC product classification and failure risk for both material and manufacturing routings. Most Aerospace, Defense and space products carry IPC Class 3 and/or space workmanship requirements which IPC-1782 categorizes as M4 traceability levels unless an agreement between user and supplier allows them to be categorized as M3.

The standard requires both M3 and M4 products to have the following traceability information:

- Internal Part Number
- Product Code
- Product Revision
- Unique Assembly
- Internal Work Order
- Traceability inheritance through sub-assemblies for critical components, with either general exceptions for product groups in M3 or specifically mentioned item exceptions in M4, where it is deemed there is no value traceability of the item(s).
- Actual Bill of Materials
- Use-By/Expiration Date
- Genuine/Counterfeit Screening
- Acceptance for Use
- Hazardous Substance
- Documents (paper or electronic).

The goal behind standards such as IPC-1782 is ensuring a uniform approach to identifying potential failure risks and ensuring material is correctly assessed for damage or modifications in incoming inspection, labelled with all the information needed to indicate proper storage and use requirements, and tracked in ways that minimize the potential for damage through improper storage, prep or handling on the production floor.

Axiom Electronics' incoming inspection procedure incorporates IPC-1782 requirements and has specific requirements for areas of potential risk including:

- Moisture sensitive parts

- Parts requiring re-tinning
- Parts requiring a Red Plague control plan.

Expertise in Issues related to Harsh Operating Environments

Military, aerospace and space products often operate in harsh environments where electronics are subject to factors that can accelerate corrosion and weaken solder joints. Process control, coating and encapsulation capabilities, and inspection and test processes are all critical elements in ensuring products meet quality requirements. However, an understanding of how harsh environments may impact the hardware is also critical.

For example, silver-coated copper wire is used in many aerospace and space applications. Red Plague is the corrosion of copper when the silver plating is damaged. Once the silver plating is damaged, and the copper is exposed to the environment, galvanic corrosion begins, and the copper is susceptible to Red Plague corrosion. Red Plague corrosion takes years to become visible, often long after the space hardware has left the factory. Once started, the corrosion will continue. Thus, process control is the only mechanism to prevent Red Plague. The severity of the corrosion may be minor, such as in loss of cross-sectional area of shield braiding or conductors, or major, like severing a conductor, resulting in total circuit failure, imperiling aerospace and space missions. The seeds of the failure are planted in the lack of process and environmental control during the manufacturing of silver-coated wire, the handling of silver-coated wire in the assembly facility, and manufacturing and storage of the cables or harnesses. Consequently, when building space hardware which utilizes silver-coated copper wire, it is important to have a Red Plague control plan that covers all handling and storage events from receiving inspection of wire spools through manufacturing and storage of finished hardware.

Axiom's Red Plague Control plan includes:

- Use of sealed moisture barrier bags meeting MIL-PRF-81705, Type 1, that are filled with nitrogen prior to sealing to create an inert environment.
- Wire ends capped with heat shrinkable end-caps conforming to SAE-AMSDTL-23053/4 or sealed with a material such as an insulating electrical varnish for a length of approximately 25 mm (1-inch). Note that silver-plated copper wire without insulation does not require capped ends.
- Activated desiccant conforming to MIL-D-4564 Type 2 or equivalent in each bag.
- A humidity indicator card (HIC) that is either an Irreversible Indication (50-60-70-80-90% RH) card or a combination Irreversible/Reversible Humidity Indicator (50-60-70-80-90% RH) card conforming to MIL-I-8835 or equivalent.
- Verifying that packing list and labeling on the spool include the manufacturing date, which then allows Receiving to record the expiration date, which is usually 10 years later.

Component packaging choices and insufficient spacing between components can lead to both manufacturability and fitness for environment issues. For example, SMT connectors are less robust than their through-hole counterparts. When a product with an SMT connector mates with a board stack and then is clamped in the system, the stress on the connector can pull the pads off the PCB, particularly in products subject to vibration, such as space hardware. For example, if an OEM works with Axiom Electronics in their design process, an Axiom DFX (design for excellence) recommended modification would be to use a through-hole connector. However, when this issue is identified after product qualification, the only mitigation is to apply staking material to the outside of all SMT connectors. If parts are too close together to get staking material around the connector, it increases the amount of staking required. In short, failure to consider environmental stress or maintenance considerations in component package selection and/or spacing requirements can create a cascading

series of added costs in the production process.

Ability to Handle Specialized Projects Where Not All Specifications are Well-defined

In some cases, products may have gaps in their specifications that require the contract manufacturer to work with the customer to adequately define. For example, Axiom Electronics defines space projects with these types of issues as space+.

Space+ hardware typically is a result of one of three scenarios:

- The hardware performance requirements add manufacturing processes governed by additional standards that are not adequately defined in the statement of work (SOW)
- The hardware operating environment drives a need to add additional validation requirements for safety considerations
- The hardware performance requirements drive a need to define new manufacturing processes.

Space+ requirements often drive assembly requirements that exceed industry standards, either because of product performance requirements or to provide an added layer of risk mitigation against field failures.

For example, in one project, desired circuit performance required use of paired capacitors within a certain parameter range. The OEM tested and paired the capacitors and then designed specific pairs for installation on specific assemblies. The capacitor pairs required hand soldering.

OEM-specific acceptability criteria may also exceed space addendum requirements. For example, in another project that involved plated through-hole (PTH) parts, the OEM workmanship standards did not allow blow holes (small craters created when molten solder erupts). The J-STD-001 allows blow holes and in the space addendum blow holes are acceptable provided the bottom and sides of the solder joint are visible. Rework with hot air reflow was allowed to address the issue.

Sampling plans with destructive testing of components are required in some projects as part of added safety measures.

The most challenging space+ scenarios develop when hardware requirements drive a need for development of an entirely new manufacturing process. The team at Axiom calls these “science projects” and has a specific process for analyzing the SOW and developing and validating these new processes.

Axiom’s team develops a project plan and objectives that include a timeline, scope and parameters for each science project. The next step is to develop unique soldering processes that meet the performance requirements and environmental considerations.

Best-in-class equipment and techniques are utilized for assembly and soldering. Inspection activities normally include 3D x-ray and evaluation of cross sections.

Assumptions are validated through design of experiments utilizing sample or dummy printed circuits boards and components. Multiple solder alloys and flux chemistry combinations may be evaluated.

The final output is a detailed written report which outlines the process, the results and recommendations. An assembled test board is also provided. Once the process assumptions are validated, the processes are refined for production and approved by the OEM.



One of Axiom's most recent science projects required invention of a new soldering process to attach connectors. The spacecraft has launched and worked without incident.

Working with an EMS provider with expertise in supporting a broad range of defense, aerospace, space and space+ requirements helps eliminate learning curve, reduces capital equipment cost and may result in better quality solutions than available with a less experienced internal team. This can be particularly beneficial in cases where added required workmanship standards increase operator certification requirements or there are significant in-process inspection requirements. It is also valuable in situations where new manufacturing processes may need to be developed and validated. In selecting an appropriate contract manufacturer for products in these industries, evaluate their processes for assessing the scope of work and applicable industry standards, their experience with projects of similar size and scope, and their ability to apply expertise in collaborating in situations where specifications may not be fully developed.

About Axiom Electronics

Axiom Electronics is a leading electronics manufacturing services (EMS) company founded in 1990. Based in Hillsboro, OR, Axiom provides sophisticated manufacturing services to a wide range of OEMs in high reliability sectors such as military/aerospace, instrumentation, communications, test and computer systems.

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