Outsourcing assembly and manufacturing is a strong trend in the industry. This is especially true with startup companies that do not have or want the floor space, equipment, and personnel required to assemble electronic equipment. Outsourcing allows a company to focus its resources on core competencies instead of assembly and testing. This trend is driving manufacturers that traditionally supply mechanical components to do design, certification, assembly, wiring, board installation, and software installation. The complete assembly process is called system integration. This article outlines six steps to system integration, as well as what to look for when selecting a manufacturer to do system integration.

Six levels
The six levels of system integration can be defined as follows:

- Level 0 consists of supplying the customer with a kit of mechanical components for a subassembly, which the customer then assembles.

- Level 1 is the actual mechanical assembly of the components into a subassembly.

- Level 2 brings electrical as well as mechanical components into the subassembly. The electrical components must be tested for functionality, performance, safety, and proper configuration.

- Level 3 provides a complete electronic enclosure assembly. This can take the form of a chassis, subrack, or cabinet.

- Level 4 adds active boards, disks, and other devices and software that are loaded into the chassis. The system must be tested for functionality, performance, safety, and proper configuration.

- Level 5 provides logistical support to manage inventory, custom configure a chassis, and drop ship the chassis to the final integration site or end customer.

Each integration level has specific design, certification, testing, and manufacturing requirements. Integration levels 0 through 2 are usually not difficult to design, but can be challenging to manufacture economically. Dedicated fabrication and assembly tooling is used because of the high manufacturing volume and cost-sensitive nature of electronic packaging products. Design for Manufacturing (DFM) plays a large part in efficient manufacturing of these products.

Level 3 integration takes components from levels 0 through 2 and assembles them into a complete electronic chassis or cabinet.
The backplanes and other electronic subassemblies are electrically tested with specialized equipment before they are incorporated into the assembly. Since this assembly contains a power supply, the manufacturer is responsible for safety testing. Electrical safety test equipment ensures that the ground wiring can handle 25A of current and that the power wiring insulation can withstand 1,500VDC without breakdown. Shock and vibration tests may be performed for telecom applications with the equipment running.

Level 4 integration adds active boards, disks, and software to the complete chassis. In many cases the customer supplies the active boards and software as consigned inventory. The active boards, software, and configuration of the systems are subject to revision and must be tracked, while the serial numbers of each component should be recorded for traceability.

Level 5 integration adds logistical support to the complete chassis. In this stage the customer specifies the quantity, configuration, and destination of the chassis. Accurate delivery dates are very important, since a missed shipping date means that expensive installers will be idle and time will be lost.

Customer relationship
System integration is a partnership with the customer. Therefore, it often means the manufacturer becomes the customer’s design, manufacturing, planning, purchasing, and logistics departments.

Ideally, the relationship begins before the design of the integrated system is complete. During the early stages of design, the customer is advised to use an industry standard board size and standard mechanical packaging. For example, Pentair Electronic Packaging can use its Schroff® brand standard products and manufacturing processes to reduce cost and delivery time.

The customer is constantly adapting the prototype to changing requirements and working with a compressed schedule in the initial phases of the project. Sometimes this leads to incomplete or even nonexistent documentation from the customer, which slows the development of the new product. To these ends, a manufacturer should have the design and manufacturing expertise to help fill in the documentation gaps without slipping behind on the shipment schedule. In addition, the revision system must track the customer’s manufacturability changes as well as the manufacturer’s own changes throughout the process.

Getting the pilot product shipped is often a challenging process, but it is not unusual to see shipping schedules that are shorter than standard component lead times. An effective system integration process will include the manufacturer searching for and locating parts in order to expedite deliveries. The manufacturing department can then accommodate a small production run with a fast turnaround time.

Since a customer’s initial delivery schedule can change dramatically based on product demand and industry-show dates, constant communication with the customer is required to insure that their schedule changes are accommodated. The best way to communicate might be by an Electronic Data Interchange (EDI) between the customer’s MRP system and the order management system, because it eliminates the possibility of transcription errors.

Flexible manufacturing
A flexible manufacturing facility is a must to accommodate the customer’s aggressive shipping times. This facility includes fabrication of components, assembly, testing, and material management. LASER sheet metal fabricators that fulfill special tooling requirements, similar to those used by Pentair, will not limit the parts that can be manufactured. When the manufacturing volume of a particular product gets high, a manufacturer should be able to make dedicated fabrication and assembly tooling.

Furthermore, the boards and active components that go into a level 4 integration assembly must be protected from Electro-Static Discharge (ESD). The following are some typical ways to help eliminate ESD and protect equipment.

- Cover the floor in the assembly area with conductive paint or conductive floor tiles.
- Assemblers should wear wrist straps that are grounded to a conductive workbench.
- The containers, carts, and shelving for components must be conductive and grounded.

- Each time the assembler enters the ESD protected room the integrity of the personnel grounding should be verified.
- Visitors to this area must remain in marked lanes to avoid damaging sensitive components.

Logistics and material management
Many integration projects have several shipping destinations, including international sites. Therefore, a manufacturer that offers system integration should offer a number of assembly locations in order to accommodate the site’s capacity, capabilities, and distance to the final destination. This way the production can originate in a particular country and move to other countries to match demand and minimize shipping. For example, components of the chassis can be manufactured in several different facilities and shipped to the integration location.

A global network, quality control, capacity planning, and material management contribute to the selection of an appropriate manufacturing and integration location. Each integration location should provide a product that has power supplies, power cords, and other components tailored to the equipment’s final destination.

System integration through a manufacturer enables the customer to take advantage of volume purchasing discounts for components and raw materials, since manufacturers can often place a single blanket purchase order with a vendor and have the products delivered to many locations. Also, a global network allows the purchase of components and materials in countries where the currency exchange rates are favorable.

CAD/CAM
Often the customer has developed CAD models of the cabinet, chassis, or subrack, accessible via the Internet and protected by a firewall. An FTP server is a bi-directional CAD file repository that allows the manufacturer to exchange CAD data with the customer. Before the first project is started, a user ID, password, and private file storage area on the FTP server can be configured. The security on an FTP server allows the easy exchange of sensitive design data and it is possible to e-mail small CAD files or exchange magnetic disks of CAD data.
Sometimes customers’ CAD models are more of a concept than a finished manufacturable design. Because of this, a manufacturer that offers system integration should have a design engineering department that can import the customer’s model into its CAD system and complete the design. This can include DFM and cost reductions that come from using standard components and manufacturing methods.

As the enclosure goes from concept to pilot production, the design must be validated. This includes using Computational Fluid Dynamics (CFD) to simulate air flow and cooling, Finite Element Analysis (FEA) to measure resistance to shock and vibration, and tolerance analysis to determine manufacturability. These tools require the design to be done on 3D solids modeling CAD systems.

Meanwhile, mechanical design and PCB design are usually done on separate CAD systems, but to ensure that the chassis can be assembled, the backplane and other PCB designs can be imported into the mechanical CAD system. When this is finished, the mechanical CAD data should then be sent to the manufacturing engineer.

Overall, there are several advantages here. Specialized CAM tools can create programs for fabrication machines directly from the CAD data, minimizing the possibility of a fabrication error. Electrical CAD data can be processed through custom tools that create electrical test programs allowing the original design data to be tested instead of the usual “Golden Board.” This eliminates another possibility for a testing error.

Certification
The electronic packaging might require certifications for a particular market including Bellcore NEBS for North American telecom and seismic requirements, ETSI for European telecom requirements, CE for European safety and EMC, UL/CSA for North American safety, and FCC for North American EMC. Each country has slightly different certification requirements. Fortunately, with the formation of the European Union many of the individual European country’s requirements have been incorporated into a single set of EN requirements. When using a manufacturer that offers system integration, a customer should make sure the manufacturer is familiar with all of the current standards.

Furthering the certification confusion is the fact that many certifications only apply to a complete product. For level 2 and level 3 integration, a label stating that the subassembly or chassis is a UL recognized component might be applied. When the remainder of the boards are added, the customer might have to apply a label stating that the chassis is a UL listed product. The same situation applies to European certifications – the chassis can be tested with a particular set of boards and given a CE mark. If the customer uses a different set of boards the chassis must be retested to indicate that it still complies with applicable EN requirements.

Conclusion
When a company looks to outsource assembly and manufacturing many factors should be considered, that includes not only the degree of integration that a manufacturer provides, but also the flexibility and management the manufacturer can offer. System integration is comprised of design, certification, assembly, wiring, board installation, and software installation and outsourcing this function will enable a company to free up resources and focus on core competencies.

Michael Thompson
is the Principal Engineer at Pentair Electronic Packaging. He acts as technical liaison between a customer and Pentair’s engineering and manufacturing groups. He has worked on computer architecture and mechanical standards for nearly 20 years and represents Pentair at VITA, PICMG, and IEEE standards organizations. Michael holds a BS in engineering from Northeastern University.

For more information, contact Michael at:

Michael Thompson
Principal Engineer
Pentair Electronic Packaging Company
170 Commerce Drive
Warwick, RI 02886
Tel: 800-451-8755 • Fax: 401-738-7988
E-mail: mthompson@pentair-ep.com
Web site: www.pentair-ep.com