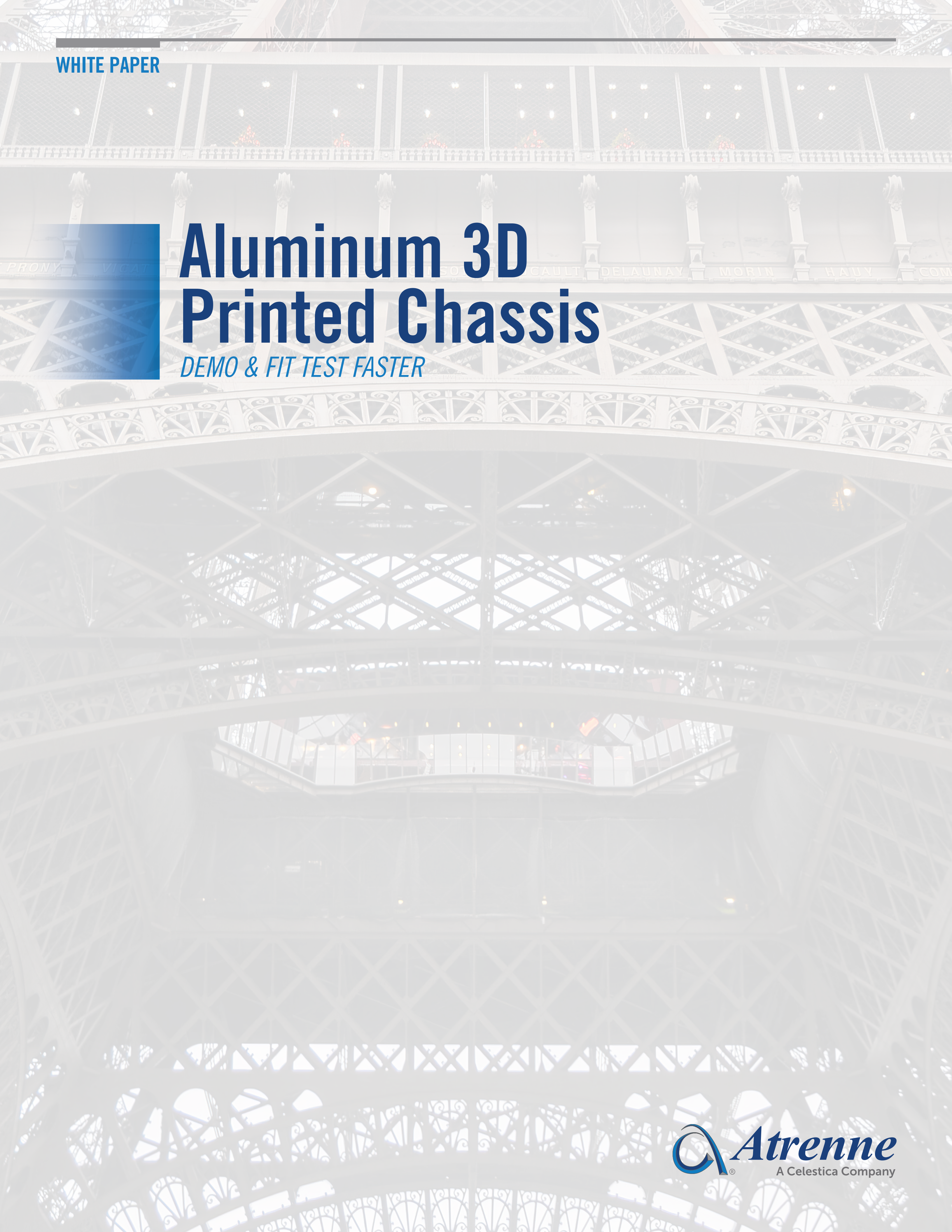
WHITE PAPER

Aluminum 3D Printed Chassis

DEMO & FIT TEST FASTER



Atrenne
A Celestica Company

Aluminum 3D Printed Chassis

Demo & Fit Test Faster

Show Customers Your Mechanical Designs in Weeks, Not Months

Keeping a new deployable system on schedule is a constant challenge. Closely related is demonstrating progress to your customer. These hurdles become even higher when significant customization is required.

At Atrenne, our focus on optimized defense electronics customization lead us to develop a unique and innovative capability, aluminum alloy 3D printed chassis. This cutting-edge process creates real, deployable enclosures, not mock-ups. It means you can show your customer a new design in weeks, not months. Your team can implement fit checks, quickly make any needed adjustments, and keep your project on schedule.

There are other advantages to 3D printed chassis, including some we are still evolving. But the huge advantage of a compressed development schedule is clear and demonstrable.

Aluminum Alloy 3D Printing

Also referred to as Metal Additive Manufacturing (MAM), metal 3D printing gives mechanical engineers the freedom to create complex parts without the design constraints of traditional manufacturing methods. Initially seen as only a prototyping technology, 3D printing has matured rapidly and is currently being used, with great success, for production components in the automotive, aerospace, and biomedical industries. Examples range from hip cup replacements to engine manifolds in high performance cars. The underlying economics make 3D printing technology well suited for prototypes, one-off custom parts, and low volume production runs.

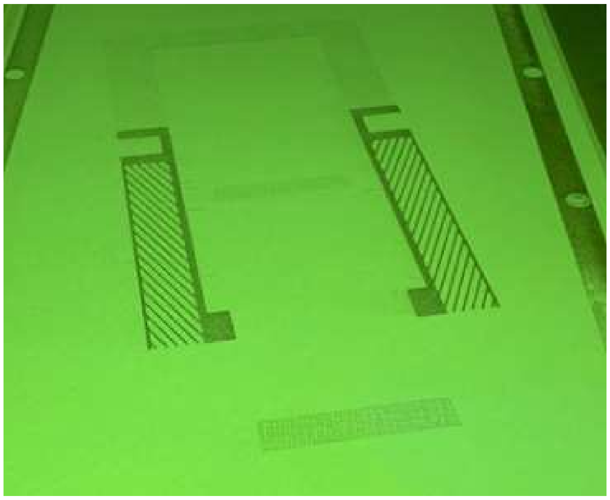
Most of the electronic systems chassis deployed on today's defense platforms are made from aluminum alloys, with metal sections joined by dip-brazing. These materials deliver an outstanding combination of structural strength, light weight, and thermal conductivity. Metal 3D printing can also use aluminum alloys, delivering the same set of advantages for system chassis.

Metal 3D printing works by addressing very thin layers of metal powder with a laser beam that fuses the particles together. Each layer of metal powder is approximately 2 thousandths of an inch thick, or half the thickness of a human hair. The laser fuses just the particles that define the design's cross section for that layer, then another layer of powder is put down and another defined cross section fused.

3D printing not only means that any required physical changes are identified early, but also that a modified chassis version incorporating those changes can be created without delay. Issues arise in many programs; success is achieved by being able to identify and address those issues quickly.

This automated process, moving layer by layer, is used to complete a chassis and results in a single metal piece that matches the CAD model input with extreme precision. Shapes and contours in the design are not limited by the capabilities of a CNC machining tool and there are literally no joints between sections because there are no separate sections.

ATR chassis fiber laser printing



ATR chassis cooling fins during print process

3D Printed Chassis: Business & Technical Advantages

Aluminum alloy 3D printed chassis deliver multiple advantages to both prime contractors and their customers. The most obvious advantage is a significantly reduced system development schedule. After completion of the CAD design, a new, custom-designed chassis can be created using 3D printing in about six weeks. This compares with roughly 26 weeks from completed design to delivery for a chassis created from milled sections joined via dip brazing.

While the six week chassis development schedule does not include the time needed to fabricate a backplane and assemble the electronic components, it is not extended for situations that involve unique chassis shapes. 3D printing can create a chassis to fit any defined space within a platform.

The fast development time means that a prime contractor can get something tangible in front of a customer during a project's initial stages. This, of course, builds confidence, but it also allows a physical fit check to insure that the chassis design is actually compatible with the platform in terms of dimensions, cabling connections, etc. Constructed from aluminum alloy, the same chassis used for the fit check can also be used for system testing, after integration of the backplane, electronics, and power supplies.

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Because a 3D printed chassis is a single, monolithic unit, there are no anomalies associated with seams between sections. In contrast, brazements seams sometimes have tiny holes that make a chassis less than watertight.

One of the most exciting characteristics of 3D printing is that chassis designers can implement innovative material shapes. Lattice structures are the prime example, delivering strength with greatly reduced weight, as well as outstanding heat dissipation based on huge increases in exposed surface area. *(See the sidebar page 5,* **Lattice Structures Offer New Options for Chassis** *to learn more details on lattice structures.)*

Bringing 3D Printed Chassis to the Defense Community

Atrenne's expertise is centered on providing innovatively designed and customized solutions for defense electronics. With that focus, it is not surprising that we are first to market with an aluminum alloy 3D printed chassis, as recognized by the Military and Aerospace Electronics 2021 Technology and Innovators Awards.

Off the shelf, cookie cutter products have limited utility in defense programs. While standards-based components are an essential starting point, virtually every deployed system requires some level of customization. Our 3D printing capability means we can work with prime contractors to develop and deliver customized, innovative, and cost-effective chassis on time and on budget.

Atrenne 3D Printed Aluminum ATR - Patent Pending

Here you can see the chassis after machining

A 3D Printed ATR Chassis

The first aluminum alloy 3D printed chassis is a ½ ATR unit with a custom length, as defined by the ARINC 404A standard. The chassis design was based on an existing Atrenne ATR product which uses conduction cooled cards and employs air flow directed over the heatsink. The metal 3D printing process used for this example can be used for any ATR chassis size, from ¼ to full

This chassis successfully completed the following series of shock and vibration tests:

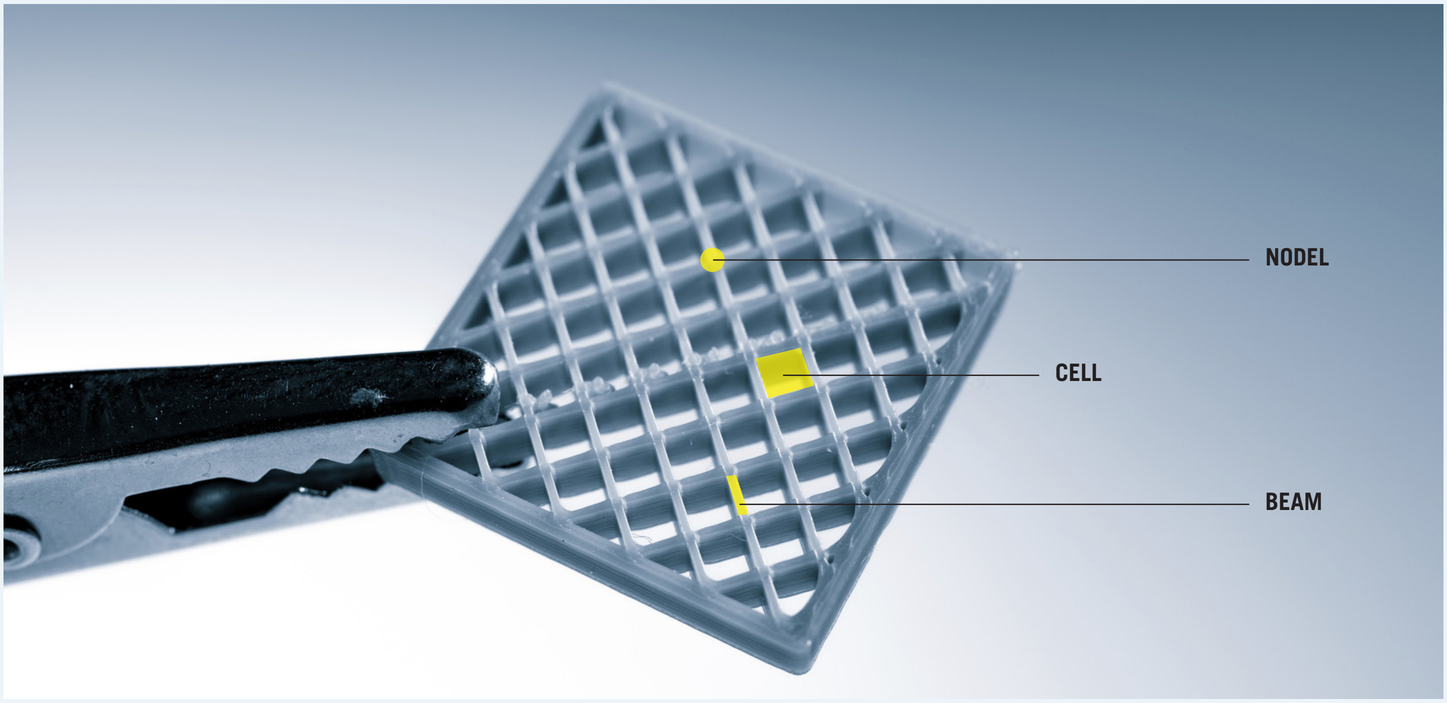
- RTCA DO-160G Section 8 - Random Vibration (one hour per each of the three axes)
- RTCA DO-160G Section 7.2.1 – Shock (6g, 11ms for each +/- axis for a total of 6 shocks)
- RTCA DO-160G Section 7.3.1 – Crash Safety Shock (20g, 20ms for each +/- axis for a total of 6 shocks)
- MIL-STD-810F Section 514.5 – Transportation Vibration (one hour per each of the three axes)
- RTCA DO-160G Section 7.3.3 – Acceleration (9g in each +/- axis for a total of six tests)

This is the chassis after nickel plating, painting, and addition of the front I/O panel.

Engage with Atrenne to Discuss 3D Printed Chassis for Your Program

With more than 50 years of experience, Atrenne harnesses the power of engineering innovation and integration to develop application-specific solutions that provide exceptional value to our customers. We've learned that all our innovations are complemented and enhanced by collaborating with our customers to solve problems.

Aluminum alloy 3D printing is clearly the way future enclosures will be built. Engage with our team to explore how a 3D printed chassis can bring value to your program today by compressing development schedules and enabling unique design features. We would value the opportunity to discuss your program, its schedule, and unique requirements.



Lattice Structures Offer New Options for Chassis

Lattices structures are architectures comprised of a network of nodes and beams (sometimes referred to as rods) that are organized into repeating units called cells. The Eiffel Tower is a photogenic example, reaching up to the sky with not just great beauty but also a terrific strength-to-weight ratio for the 19th century materials used to build it.

Great strength-to-weight characteristics are a defining feature of lattice structures. Open areas obviously reduce weight, while beam-node components can be designed so that all the material is bearing a roughly equivalent portion of the load. This is not the case with solid structures, where the load stresses are distributed unevenly across a material cross-section.

Designers can adjust the geometry of cells and the thickness of beams to create unique interactions with external forces. In addition to increasing fixed load limits, this flexibility also gives expanded control over responses to shock and vibration.

Beyond these wide ranging mechanical advantages, lattice structures also offer outstanding capabilities for heat dissipation. Expanded surface area means more efficient thermal transfer to surrounding air (or liquid). In a similar fashion to load bearing optimization, lattice structures can be customized to increase heat transfer characteristics for specific environmental conditions.

Despite all the advantages, lattice structures have not been used in deployable chassis because they are impossible to construct using milling machines or any other type of subtractive manufacturing technology. However, metal 3D printing has matured and is now very capable of creating lattice structures as integral parts of a chassis.

This is an exciting capability, with almost limitless options for innovative mechanical designs. Our engineering team is currently exploring some of these options and would value the opportunity to collaborate with your team on new ideas and customized implementations.

The Eiffel Tower is a classic example of lattice structure design.