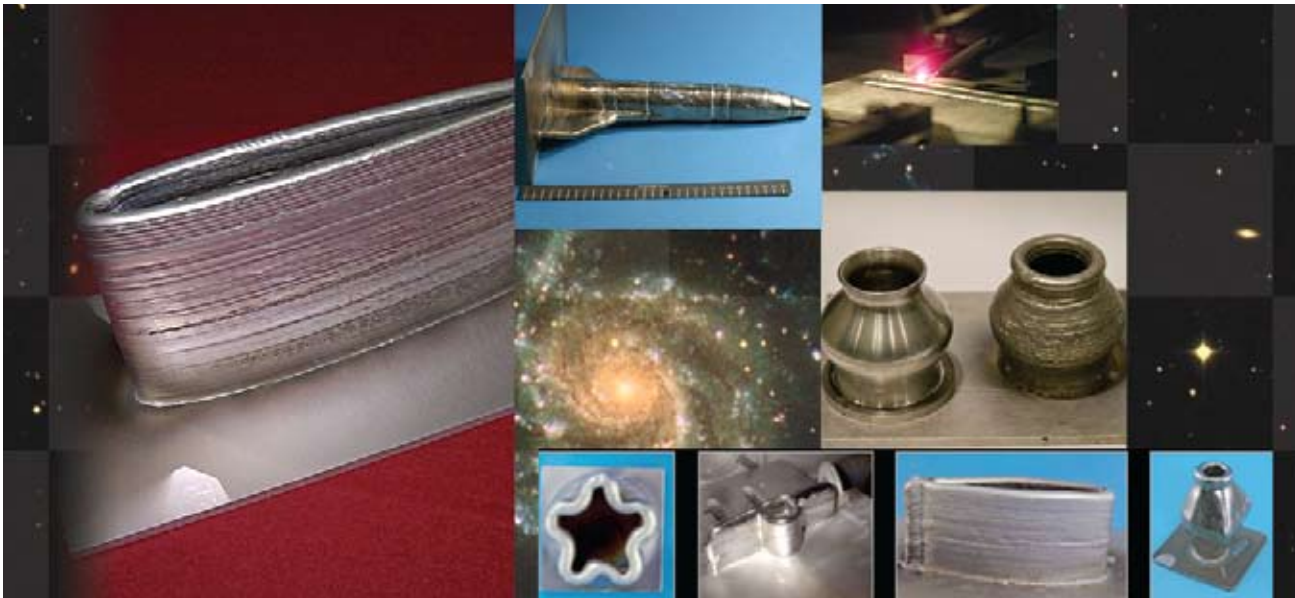


technology opportunity

# NASA's EBF3: The Future of Art-to-Part Manufacturing

*Cutting costs, reducing waste, expanding capabilities*



## NASA is making tomorrow's rapid prototyping and manufacturing technologies available today.

Companies are invited to license an innovative system for performing electron-beam freeform fabrication (EBF3) that offers significant advantages over traditional e-beam and laser-based systems. The core of NASA's EBF3 system uses a wire-feed design to deliver quality parts that are better than cast and similar to wrought materials while minimizing excess material. Multiple wires can be used to create new alloys or layered parts. The system costs significantly less to build than others, enabling companies previously hesitant to enter the market to compete and win in the expanding rapid prototyping and additive manufacturing market.

### Benefits

- **Lower material costs:** Wastes less material than traditional subtractive manufacturing (i.e., machining) processes
- **High strength parts:** Uses real engineering alloys, such as Ti-6Al-4V and Al 2219, in standard wire forms, rather than specialized metallic powders required with direct metal laser sintering processes
- **Compound material properties:** Allows deposition of multiple alloys to create parts where material chemistry can vary according to functional part requirements (e.g., changing cross-sectional strength on an airplane wing spar)
- **Lower power, higher safety:** Requires less power than machines derived from traditional e-beam welders, which lowers operational power costs and radiation, thereby increasing operator safety
- **Versatile part envelope:** Produces a wide range of part sizes, from a few inches to tens of feet
- **Mobile and rugged:** Can be relocated and has been successfully demonstrated on an aircraft in 0-g flight without requiring time-consuming alignment procedures

## Applications

### Medical

- Human bone replacement parts

### Automotive and motorsports

- Custom and replacement parts

### Aerospace structural components

- New structural components with high buy-to-fly ratios (such as bulkheads or complex housings)
- Replacement parts for aging aircraft

### Replacement parts in remote or hostile locations

- Military forward-operating locations
- Seafaring ships
- Offshore oil rigs
- Polar research stations

### Three-dimensional models for new designs

- Rapid iterative prototyping

### Metals deposition and treating

- Plating, structural mending, and spot etching and heating

## Technology Details

Companies currently providing only laser-based services (e.g., 3D stereolithography, direct metal laser sintering) can use NASA's EBF3 system to expand their offerings and take advantage of the benefits of e-beam manufacturing, while companies with e-beam fabrication will appreciate that EBF3 eliminates many of the safety and shielding requirements necessary with higher power systems that are derived from e-beam welding technologies.

### How it works

The core of the EBF3 system is an electron-beam gun, wire feeder, and positioning system enclosed in an aluminum vacuum chamber. Like other e-beam systems, the NASA system focuses the beam to melt a material, in this case metal wire, which is then accurately deposited layer by layer according to computer-aided design (CAD) data to fabricate a three-dimensional structural part without the need for a die or mold.

Unlike other e-beam systems, which operate at 60–200 kV, NASA's technology can create parts using about 20 kV accelerating voltage. The system can be used to make parts from a wide range of materials (e.g., titanium, aluminum, nickel, stainless steel) as well as alloyed and layered parts via multiple wire feeds. The size of parts will be dependent upon the size of the system's build envelope, which can be scalable from a few inches to tens of feet or even larger.

### Why it is better

The EBF3 system offers the promise of a nearly unrestricted part build envelope. The complete unit can be as small as an office desk or even smaller with an umbilical cord to the required power supply and vacuum pumps. A system that integrates EBF3's vacuum-isolation enhancement with a maneuverable, positioning arm eventually will be capable of building any size or shape complex part.

NASA's EBF3 system is less expensive than other systems. NASA installed its system for \$250K; however, a commercialized system is expected to cost significantly less. Plus, the low-power design

offers significantly reduced operating costs and minimizes the shielding required to comply with radiation safety regulations.

Other cost savings are possible because of the NASA system's reduced use of material. EBF3 uses a full 100% of the material for the part with no residual material contamination. This offers an advantage over powder-based e-beam systems, which require residual material to be recaptured and recertified before reuse. Parts made with NASA's EBF3 system can be used or shipped immediately with only minimal need for cooling.

Because two or more wires can be fed into the system, EBF3 can manufacture multi-material parts, including new alloy-based parts or layered parts with better surface properties. For industrial plating applications, EBF3 could offer a high-quality alternative to traditional plating (e.g., chrome plating) while enabling better compliance with environmental regulations. The technology works exceptionally well with such alloys as Ti-6Al-4V and Al 2219.

### Patents

NASA has patented this technology (U.S. Patent No. 7,168,935) and has other patents pending.

## Licensing and Partnering Opportunities

This technology is being made available as part of NASA's Innovative Partnerships Program (IPP), which seeks to transfer technology into and out of NASA to benefit the space program and U.S. industry. NASA invites companies to consider licensing the Wire-Feed E-Beam Freeform Fabrication technology (MSC-23518-1) for commercial applications.

### For More Information

If you would like more information or want to pursue transfer of this technology, please contact:

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For more information about other technology licensing and partnering opportunities, please visit:

**Innovations Partnership Office**  
**NASA's Johnson Space Center**  
<http://technology.jsc.nasa.gov>