Long Term Development
Needs for Airframe Structure

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Means of Reducing Carrier Operating Costs

- **Reduced Drag – Smoother Structure**
  - Design and manufacture of “wet” components
- **Specific Fuel Consumption**
  - Improved performance, primarily weight reduction
- **Reduced Airframe Maintenance Costs**
  - Titanium strong contributor, very few problems with Ti components
- **Reduced Engine Maintenance Costs**

The attributes of Ti can contribute to reducing carrier operating costs; lower cost titanium would enable increased utilization, further reducing operating costs for the airlines.
Cost Reduction Approaches for Ti Hardware

Reduced Buy:Fly

- **Welding**
  - Solid State
    - Linear friction
    - Friction Stir
    - Inertia
  - Fusion Welding
    - Laser beam
    - Electron beam

- **Superplastic Forming/Superplastic Forming/ Diffusion Bonding**
- **Hot Stretch Forming**
- **Rolled Shapes**
- **Extrusions**

Low Cost Titanium

- **MER, ITA, etc.**

**Processing Improvements**

- **Powder Metallurgy**
- **Improved Machining/ More Machinable Alloys**

Improved Performance

- **Higher temperature materials – primarily oxidation resistance**
Solid-State Welding

- **Advantages**
  - Base-Metal properties
  - Reduced buy:fly
  - Minimal surface prep

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Linear Friction Welding

Friction Stir Welding
Fusion Welding

- Laser beam welding for thinner gages
- Electron beam welding for heavier gages

Hot Stretch Forming
Low Cost Titanium

- Single melt
- Lower cost alloy additions
- New reduction processes
  - ITP
  - MER
  - Powder Metallurgy
    - Pre-alloyed
    - Blended Elemental

In startup phase for pilot plant
Improved Machinability

Could be via more machinable alloys or advances in machining technology
Superplastic Forming, SPF/DB

- Enables the fabrication of complex monolithic structures (has replaced castings in complex structures)

   Eliminated from built up design
   - 37 tools
   - 15 detail parts
   - 111 fasteners
   - >4 lbs of weight
   - 21 hours of assembly time

   - Heat shield side panels
     - Beaded surface is fine grain
     - Standard grain for outer surface (no mark off)

Advantages of fine grain
- Lower SPF and SPF/DB temperatures
- Increased die life
- Higher forming rate
- Less thinning
- Less surface contamination
- Improved operator comfort/safety
Higher Temperature Capability

(Higher temperature oxidation resistance)

With present aircraft, hot day engine starts and taxi can result in temperatures high enough to cause surface oxidation.
Titanium can be utilized in several ways to decrease airlines operating costs.

Maximum titanium utilization toward this goal will require reducing the cost of titanium hardware.

Titanium cost reduction/performance improvement approaches:

- Reduce buy:fly
  - Welding
  - Powder metallurgy
  - Hot stretch forming
  - Extrusions
  - SPF – SPF/DB
  - Improved machining technology – machinability

- Improved performance
  - Strength
  - Temperature capability

- Lower temperature SPF alloys