Boeing Ultra Lightweight Seat

Statement of Work

- “Conceptualize, define and validate new and novel light weight passenger support and retention system(s) (seats) applicable to commercial jet transport aircraft.”
- Target 16 lbs per passenger place. Current seat in class production is 24 lbs.
- Meet FAA regulations and Boeing Requirements
- Provide validation to support belief in concepts via demonstration models, CAD, simulations, etc.
- Focus on weight reduction. Aesthetics, ergonomics, and comfort should not be diminished.

Design Space

- All structures must withstand operation, dynamic, and user abuse loads
- Spaces must accommodate large range of passenger dimensions
- Functionality of existing seat must be maintained – e.g., armrest and tray table functions

Overall Weight Breakdown

<table>
<thead>
<tr>
<th>Category</th>
<th>Traditional Seat</th>
<th>Weight Seat New Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>12.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Padding</td>
<td>4.8</td>
<td>4.7</td>
</tr>
<tr>
<td>Dress Cover</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Peripherals</td>
<td>2.1</td>
<td>2.6</td>
</tr>
<tr>
<td>Structure</td>
<td>1.1</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Padding

- The padding and dress cover on the traditional seat weighed over 8 lbs, while the new seat design calls for less than 2 lbs of padding and dress cover.
- The foam padding is a composite of three materials: a low density polyurethane foam with expandable graphite (traditionally used in aircraft seating), a soft high density open-cell polyurethane, and a hard high density open-cell polyurethane foam. The dress cover is made of lightweight seven FRL, a synthetic fiber which has no melting point and does not ignite.

Peripherals

- Ut pocket & life seat holder - made of non-flammable mesh that is lighter than the traditional fabric and plastic (shown)
- Seatbelt — integrated lighter automotive buckle

Material Swaps

- Replace aluminum crossbeam for composite crossbeam
- 30 ksi carbon fibers and epoxy
- Weight savings
- Good mechanical properties:
  - Tensile strength: 15,000 psi
  - Peal/tear: 15,800 psi
  - Shear strength: 12,000 psi
  - Density: 0.005 lb/ft³

Seat Back

- Seat back of thin extruded tubing with a strong fabric stretched over it
- Modified after efficient traditional seatback
- Tapered profile and straightened structure to reduce weight, accommodate armrests
- Redesigned recline mechanism allows for less weight in seat attachment
- Validated for 200% off load along top edge via ANSYS

Seat Back Pivot Point

- Hinge mechanism is actuated by button on the headrest. Wire pulls the bottom of the lock forward, allowing pin on seat back to slide forward.
- Torso spring is in hinge and lock mechanism on both sides of seat to distribute load path
- Validated via shear and bearing stress calculations

Legs

- Optimized shape – Simplified load path of traditional seat
- Position – Leg position moved so all legs support the same load
- Finite Element Analysis – Complies with FAA tests

Transverse Beam and Spreaders

- Designed to maximize stiffness / weight
- Typical seat design smooths loads
- Model restricted to linear-elastic regime
- System does not behave permanently as modeled
- Dynamic testing was performed due to modeling problems

Preliminary market study for Boeing’s seat business

- The value of lightness is simply “fuel saving”.
- Each aircraft type (market segment) has different fuel efficiency and market scale (number of seat and prospective aircraft).
- Completed financial simulation of investable amount on each aircraft type and summarized the quantitative characteristics of each market segment.
- Implications about marketing planning were also provided.