Designing for ESPA: The Challenges of Designing a Spacecraft for a Launch Accommodation Still in Development

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ESPÁA Ring Features

- Bolts onto launch vehicle below primary payload adapter fairing.
- Encapsulated within the same fairing as the primary payload.
- Spacecraft are cantilever-mounted.
ESPA Ring Advantages

**Advantages:**
- Secondary payloads can eject before the primary payload.
- Secondary payloads can be accessed after encapsulation via standard fairing access doors.
- Generous mass-to-volume ratio

**Disadvantages:**
- Cantilevered launch position.
- Separation system bolt circle diameter is only 15 inches.
<table>
<thead>
<tr>
<th>Critical Dimension</th>
<th>Requirement</th>
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<tbody>
<tr>
<td>Width</td>
<td>24 in (60cm)</td>
</tr>
<tr>
<td>Height</td>
<td>24 in (60cm)</td>
</tr>
<tr>
<td>Length (from flange mount)</td>
<td>38 in (96 cm)</td>
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<tr>
<td>CG (from flange mount)</td>
<td>19 in (48 cm)</td>
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<tr>
<td>Sep. System Bolt Diameter</td>
<td>15 in (38 cm)</td>
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<tr>
<td>Mass</td>
<td>397 lb (180 kg)</td>
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<tr>
<td>1st Fundamental Frequency</td>
<td>35 Hz</td>
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<tr>
<td>Delta-IV Quasi-Static Load</td>
<td>18.75 g’s (10.6g’s in two axes simultaneously + 1.25 SF)</td>
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The Problem in a Nutshell

- Launch loads are not completely characterized
  - Inflated launch loads must be imposed to provide a level of comfort to the primary payload and the LV.
- Cantilevered orientation is requires non-traditional spacecraft structure design
- Traditional spacecraft construction methods and materials would not survive the anticipated loads.
STPSat-1 Separation Interface Plate

- Traditional honeycomb baseplate would delaminate under the loads.
- Material: 6061 Aluminum Plate
- Baseplate Features:
  - Solid 1” wide ring to be drilled and tapped for the separation ring.
  - 5mm wide internal ribs.
  - 3mm thick face sheets
- Hogged out of two solid plates and vacuum-brazed together
- Final Dimensions: 23”x 23”x 1”
- Mass: over 6 kg
STPSat-1 Avionics Assembly

- Three walls machined from 1” thick aluminum plate.
  - Extend 9” from the baseplate
  - Assembled I-beam cross section
- Heavy avionics components mounted directly to the baseplate
- Major components clamped in place with wedgelock retainers.
  - Easy access.
  - Simplify troubleshooting.
STPSat-1 Payload Assembly

- Built using SpaceFrame tube-and-fitting spacecraft architecture on a solid machined base.
- Provides additional stiffness to the avionics structure.
- Each tube/fitting joint bolted and bonded to support the 18.75 g load.
Finished STPSat-1 EDU Structure
Lessons Learned

- Back-to-basics approach to spacecraft structure design.
  - No exotic composites as structural components
  - No revolutionary bonding or machining techniques
  - Use of well-documented and well-understood engineering methods.
- Remember that a cantilevered orientation is typical for other types of high-performance vehicles, such as aircraft.
- High launch loads (18.75 g’s) must be designed to in order to provide a level of comfort to the primary payload and the launch vehicle.
- The ESPA ring represents the most significant addition to the secondary launch capacity: It is worth designing to.
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