Satellite Lifetime Issues

Satellites have design lifetimes, but actual lifetimes vary considerably. “Infant mortality” happens, but successful satellites often live >1.5*Design-Life. Actual life may be governed by replacement more than by failure.

Three Approaches to Scheduling

- Quasi-deterministic (flyout charts)
  - Assume a fixed lifetime and build to redundancy requirement
  - Fixed cadence with availability metrics
  - New flight when design life curve hits a threshold
  - Windowed launch-on-need
  - Fly when redundancy condition is lost, using no-earlier-than and no-later-than bounds

Flyout Chart Scheduling: Generic and Real

Available launch constraints are impacted by a range of factors, including the space environment, geodetic conditions, and payload operational needs. These constraints can be modeled to determine the most feasible launch opportunities.

Comparative Results

Typical design lifetime curve (NL-10) versus empirical curves for satellites like geostationary weather satellites. A GEO is empirical with heuristics, Brown is unrestricted empirical.

Table 2: Results of Two Scenarios and Three Launch Policies

<table>
<thead>
<tr>
<th>Launch Policy</th>
<th>Min Avail</th>
<th>Prob HS</th>
<th>Prob SG</th>
<th>Worst HG</th>
<th># Launch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed 32</td>
<td>93%</td>
<td>4.9%</td>
<td>47%</td>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>Fixed 72</td>
<td>57%</td>
<td>31%</td>
<td>97%</td>
<td>68</td>
<td>10</td>
</tr>
<tr>
<td>Link 12/72</td>
<td>95%</td>
<td>88%</td>
<td>95%</td>
<td>12</td>
<td>17-24</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>95.5%</td>
<td>0.05%</td>
<td>2.6%</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Link 12/72</td>
<td>99.9%</td>
<td>0.45%</td>
<td>7%</td>
<td>36</td>
<td>10</td>
</tr>
</tbody>
</table>

Summary

- Quasi-deterministic with redundancy (“two failures from a gap”) may yield unexpectedly poor gap statistics.
- Fixed cadence availability schedules provide very regular launches and controlled availability, but no adaptation when lifetime performance is better (or worse) than anticipated.
- Launch on need policies put difficult demands on production, but provide performance robust to actual lifetime characteristics.
- Minimum time between launches is key.

References


Disclaimer

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