Historical Perspectives of NASA Missions

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Earth Science
  - Land surface, atmosphere, oceans & climate

Space Science
  - Heliophysics, astrophysics & lunar excluding the Small Explorer Program (SMEX)
Ground Rules & Assumptions

- Database excludes Hubble Space Telescope (HST)
- Database excludes planetary missions (lunar missions are included)
  - Slides 26 & 27 include all NASA SMD missions
- Costs are for Phase C/D except where designated as life cycle cost
  - Excludes: formulation, Phase C/D for ground systems/mission operations, prime contractor fee, Phase E and launch vehicle
- Costs normalized to out-of-house rate and are in constant year millions
- Satellite refers to the instrument payload (WBS 5), spacecraft bus (WBS 6) and systems I&T (WBS 10)
- Bus costs include the cost of the spacecraft bus and systems I&T
- Meteorological and operational missions in a series are included in cost and mass, but schedule represents only the first build
3 Satellite Characteristics
Average Number of Instruments per Satellite

<table>
<thead>
<tr>
<th>Launch Decade</th>
<th>Earth</th>
<th>Space</th>
<th>SMEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980s</td>
<td>2.1</td>
<td>5</td>
<td>4.3</td>
</tr>
<tr>
<td>1990s</td>
<td>2.2</td>
<td>4.9</td>
<td>3.5</td>
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<td>2000s</td>
<td>1.8</td>
<td>3.6</td>
<td>4.1</td>
</tr>
<tr>
<td>After 2010</td>
<td>1</td>
<td>4</td>
<td>4</td>
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</table>
Average Percentage Distribution of Satellite Cost

<table>
<thead>
<tr>
<th>Type</th>
<th>Launch Decade</th>
<th>Instruments</th>
<th>Bus</th>
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</thead>
<tbody>
<tr>
<td>Earth</td>
<td>1980's</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td></td>
<td>1990's</td>
<td>65%</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>2000's</td>
<td>56%</td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td>After 2010</td>
<td>43%</td>
<td>57%</td>
</tr>
<tr>
<td>Space</td>
<td>1980's</td>
<td>59%</td>
<td>41%</td>
</tr>
<tr>
<td></td>
<td>1990's</td>
<td>62%</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>2000's</td>
<td>62%</td>
<td>38%</td>
</tr>
<tr>
<td></td>
<td>After 2010</td>
<td>61%</td>
<td>39%</td>
</tr>
<tr>
<td>SMEX</td>
<td>1980's</td>
<td>77%</td>
<td>23%</td>
</tr>
<tr>
<td></td>
<td>1990's</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td></td>
<td>2000's</td>
<td>61%</td>
<td>39%</td>
</tr>
<tr>
<td></td>
<td>After 2010</td>
<td>53%</td>
<td>47%</td>
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</table>
Instrument Payload Cost per Kilogram Time Series

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Satellite Cost per Kilogram & Satellite Mass

**Satellite Cost per Kilogram**

- **Earth**: $0.32
- **Space**: $0.32
- **SMEX**: $0.39

**Satellite Mass**

- **Earth**: 1429 kg
- **Space**: 264 kg
- **SMEX**: 1910 kg

*Mission Class*
- Earth
- Space
- SMEX
Cost per Kilogram & Mass Comparison

Cost per Kilogram

- **Satellite**
  - Earth: $0.32
  - Space: $0.32
  - SMEX: $0.39

- **Bus**
  - Earth: $0.23
  - Space: $0.32
  - SMEX: $0.4

- **Instrument Payload**
  - Earth: $0.37
  - Space: $0.4
  - SMEX: $0.4

Average Mass

- **Satellite**
  - Earth: 1429 kg
  - Space: 1910 kg
  - SMEX: 264 kg

- **Bus**
  - Earth: 1074 kg
  - Space: 1063 kg
  - SMEX: 167 kg

- **Instrument Payload**
  - Earth: 354 kg
  - Space: 847 kg
  - SMEX: 97 kg
Average Mission Schedule by Decade
Start of Phase A to Launch
Life Cycle Average Monthly Satellite Burn Rate
Start of Phase A to Launch
Number of Launches & Hardware Failures
NASA SMD Missions

Failures represent failures of the spacecraft bus or instrument payload.
Hardware Failures: Planetary & Non-Planetary
NASA SMD Missions

### All Decades (1980-2014)

<table>
<thead>
<tr>
<th>Mission Type</th>
<th>Total</th>
<th>Planetary</th>
<th>Non-Planetary</th>
</tr>
</thead>
<tbody>
<tr>
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<td>6</td>
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### 1990's

<table>
<thead>
<tr>
<th>Mission Type</th>
<th>Total</th>
<th>Planetary</th>
<th>Non-Planetary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td>3</td>
<td>2</td>
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</table>

### 2000's

<table>
<thead>
<tr>
<th>Mission Type</th>
<th>Total</th>
<th>Planetary</th>
<th>Non-Planetary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td></td>
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</tbody>
</table>
Hardware Percentage Failure Rate
Planetary & Non-Planetary Missions

1990's

- 27% Planetary Failures
- 6% Non-Planetary Failures

2000's

- 8% Planetary Failures
- 0% Non-Planetary Failures
Mission Reliability Classification & NASA SMD Budget
NASA SMD Budget from 1996 to 2013

Number of Missions

Launch Year

1980
1990
2000
2010

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Conclusion

- Last 30+ years have been relatively stable in terms of cost & schedule
- SMEX program began prior to “Faster, Better, Cheaper” initiative, which was coined by Administrator Goldin
- SMEX missions stand out as being “Faster” and “Cheaper” thus making them “Better”
  - No judgement has been made on the value of science return
- SMEX program continues to be successful with low reliability missions (Class C and D) and few failures
- “Faster, Better, Cheaper” appears to be successful with lower reliability missions