The potential impact of future constellations on current large space systems: A case study

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The context

Will future EO and Telecomm constellations have an impact on the current industrial scenario?

- DATA CLASSIFICATION AND RANKING
- DEALING WITH MISSING DATA
- ASSESSING THE POTENTIAL INTERACTIONS
## SOME NUMBERS

- **20 Earth Observation constellations**
  - 17 imaging missions
    - 12 optical imaging
    - 3 SAR imaging
    - 1 SAR/optical
  - 3 weather missions

- **11 Telecommunication missions**
  - 8 Broadband internet
  - 3 Automated identification systems (AIS)

## THE COLLECTED DATA

For each mission:
- Data product (GSD, coverage, spectral bands)
- Downlink specs
- Orbital details, constellation details
- Launch mass
- Deployment date (expected)
- Manufacturer
Success likelihood index ranking

<table>
<thead>
<tr>
<th>Mission name</th>
<th>Company dimensions</th>
<th>Funding</th>
<th>Operative satellite</th>
<th>Mission development level</th>
<th>PERCENTRANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALPHA</td>
<td>30 employees</td>
<td>10 mln $</td>
<td>2</td>
<td>54%</td>
<td>0.125</td>
</tr>
<tr>
<td>BETA</td>
<td>180 employees</td>
<td>91 mln $</td>
<td>2</td>
<td>70%</td>
<td>0.75</td>
</tr>
<tr>
<td>GAMMA</td>
<td>35 employees</td>
<td>2 mln $</td>
<td>0</td>
<td>75%</td>
<td>0.5</td>
</tr>
</tbody>
</table>

PERCENTRANK
The numbers in the tables are converted into values from 0 to 1.
Dealing with missing data

The goal
A methodology to estimate missing data about future missions

The solution
Such estimation was performed through a correlation between the satellite’s payload mass and the offered product’s complexity

The product
Product complexity for OPTICAL IMAGING satellites is determined by:
- Image size
- Number of detected spectral bands
- SWIR capability
The P factor computation

**P stands for Product**

\[ P = \left( \frac{SWD}{GSD} + k \right) \times h \]

- \( k \) is a coefficient that represents the number of spectral bands above 4
- \( h \) is a coefficient that increases by 20% the value of \( P \) in case of SWIR capability

\[ f(m) = 0.5786 \cdot m^{0.784} \]

Payload mass

\[ f(m) = 0.5786 \cdot m^{0.784} \]
Notes on the use of P

- **Statistical population for P evaluation:**
  - Optical imaging, GSD under **10 m**
  - Launch date after Jan, 1\textsuperscript{st} **2013**

- The approach could be adapted, for instance, to SAR

Number of spectral bands

SWIR capability

\textbf{COULD BE SUBSTITUTED BY}

Polarization modes

Radar wavelength
Exploitation of P factor as an instrument for impact assessment at product level

P -- potentially offered product complexity

Specific P -- capabilities trends

Combinations of P, specific P and others
Impact assessment: Complexity

P factor for constellations and traditional systems

- Planet
- Aquilaspace HD
- Satellogic
- Terra Bella
- Sentinel 2
- Pleiades
- Landsat
- Deimos 2
- DubaiSat 2
- GaoFen 2
- KazEOSat
- GokTurk 2
Impact assessment: Complexity density

Complexity density for constellations and traditional systems

- Planet
- Aquilaspace HD
- Satellogic
- Terra Bella
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Complexity density (P/m) [1/kg]
Impact assessment: Revisit vs. P

Revisit rate vs. complexity factor

- Traditional missions
- Constellations
Regarding the revisit time

Traditional systems:
Time required to image the whole globe

Most constellations:
potential time to re-image any point of the globe.
Innovative lifecycle approaches

MAIN FEATURES OF NEW LIFECYCLE APPROACHES

- LAUNCH EARLY, LAUNCH OFTEN
- IN ORBIT TESTING
- JUST BARELY GOOD ENOUGH
- REDUNDANCY INTO THE CONSTELLATION
- MINIATURIZED COMPONENTS

INSPIRED FROM SOFTWARE INDUSTRY

Lifetimes will be reduced from years to weeks/months

Within ONE traditional lifecycle, the technology of a constellation is updated TENS of times

Current technology will be matched and overcome in a few satellite generations.

Traditional industry will be forced to adapt to such evolution.
Conclusion

Constellation payload complexity levels are likely to match complexity levels of traditional system payloads within the next 10 years at much higher complexity density levels.
Thank you

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