‘Production engineering a low cost video imaging constellation’

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Small satellite trends

“Modern” Small satellite revolution

Military and techdemo

Comms and EO Constellations

Cubesats and nanosats

Nano

Micro

Mini

Small Satellite are the only way to deliver low latency global EO & comms services

Commercialisation

Commercial ventures.
The opportunity......

SSTL – satellites produced per launch used
Introduction

• Since 2012 have been running an Internal R&D programme (designated ‘FIREWorks’) to develop the next generation of SSTL small satellite Platforms

• SSTL have introduced a new range of small satellites to the market – the X-Series

• The X-Series Satellites build on nearly 30 years of small satellite engineering experience

• The X-Series offer commercial level performance at extremely low recurrent cost, through a number of approaches:
  – Use of modern technologies, processes and protocols
  – Focusing on design for Automated production and Test processes and techniques
New Challenges and Opportunities

• Motivation and Stimulation
  – New Market Entrants, Extra competition, Need to Adapt & Evolve
  – New Technologies, protocols and techniques available from other Sectors
    • Automotive Especially
  – The Emergence of more Competitive Service based Models in the Markets – low data product prices required
  – The evolution and Growth of SSTL
    • High Capital Investment in New Capabilities & Facilities
    • Experience in the successful use of COTs Technologies on Small Satellites
Introducing the SSTL X-Series

• A new range of platforms with common core features

• A single system architecture and technology designed to meet all mission applications and requirements across the entire range.

• Common, modular and expandable specification

• available on all platforms and missions:
  – Dual redundant systems
  – Data storage up to Terabytes capacity
  – Data bus transfer rates of Gigabits per second
  – Onboard real-time processing of Giga-instructions per second
  – High speed X-Band downlink
Majority of LEO SSTL Platforms will be X-Series in next 3-5 years
Design Principles

• Retain Core SSTL Design Principles, built up over 30 years
  – Simplicity
  – Robustness
  – Hands off Operations
  – Simple Safe Modes
  – Use of COTs Technologies

• Make Use of New Techniques & Technologies
  – Automated Manufacture
  – Automated Test

• Employ Card Frame Based Core Avionics Architecture
  – Provide Modularity & Flexibility
Modularity & Flexibility

SSTL-X300 – S1 Block Diagram

- Common Building Blocks
- Configurable to suit different capacity & capability requirements
What could you fly?

- Low cost constellation platform
- Configurable structure and solar arrays
- User focuses on the mission and payload

Figure shows the volume available for payload instruments on the SSTL-X50 Platform.

From 45kg
From 35W OAP
From 85W peak

SSTL-X50 Platform
Space avionics production line

- To take advantage of the evolution of component technology
- Reduces possibility of damage to SMT devices from hand soldering
- Reduce the schedule and cost of manufacturing
- Reduces manufacturing cost of PCA’s
- Build into stock

- Process design and space qualification has required extensive effort

* Equipment type for illustrative purposes
Production Cost Efficiency

- Step Change in Production Costs achieved through use of:
  - Component Pick & Place
  - Automated Solder (Re-flow)
  - Automated Inspection
  - Automated Test
- Automated Testing of system at Platform Level

<table>
<thead>
<tr>
<th>Production Phase Durations</th>
<th>Approach Scenario</th>
<th>Traditional/Bespoke</th>
<th>COTS Manual</th>
<th>COTS Automated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procurement</td>
<td></td>
<td>Weeks</td>
<td>Days</td>
<td>Days</td>
</tr>
<tr>
<td>Assembly</td>
<td></td>
<td>Weeks</td>
<td>Weeks</td>
<td>Hours</td>
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<tr>
<td>Inspection</td>
<td></td>
<td>Days</td>
<td>Days</td>
<td>Hours</td>
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<tr>
<td>Test</td>
<td></td>
<td>Weeks</td>
<td>Weeks</td>
<td>Hours</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td>Months</td>
<td>Weeks/ Months</td>
<td>Days</td>
</tr>
</tbody>
</table>
First Products to Market - The X-50 Series

- Essentially Re-Packages the current SSTL-100 in to a smaller, lower cost package
- Add improved capabilities
Series of x50 Platforms

- Many Applications and three reference products:
  - Medium Resolution EO (‘Earthmapper’)
  - 2.5m EO (‘Precision’)
  - Medium Resolution Multispectral & SWIR (‘True Colour’)
X50 microsat systems

Earthmapper
- 22m GSD
- 600km swath
- "Earth landmass, daily"

TrueColour
- 5m GSD
- 390km swath

Precision
- 0.7m GSD
- 1m HD video

Training and Development
- Hands-on
- On-the-Job

Launch and Insurance

Mission Control Centre
EarthMapper

- Never miss an image – always on over sunlit land
- 660km swath, 22m resolution
- One satellite covers the earth in 5 days, five satellites in one day, guaranteeing an image before and after every event on the ground
- For agricultural and disaster monitoring, water, national, global and urban mapping
TrueColour+

- Imagery typically only found on Large Institutional Missions
- High 5m Resolution Imagery, with 19m SWIR
- Wide 390km Swath for large area coverage
- For Mapping, Vegetation, Land Cover, Floods and Water, Disaster Management, Urban and Geological Mapping
Precision

- Very High 0.7m Resolution Imagery
- 1m HD Full Motion Video
- Existing Markets – Mapping, Agriculture, Security, Insurance
- Emerging Markets – Financial and Economic Modelling, Consumer Media, Competitor Analysis
## Precision – Colour HD Video

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Spectral Bands</strong></td>
<td>HD Video: PAN or colour, Still: Red, Green, Blue, NIR</td>
</tr>
<tr>
<td><strong>GSD</strong></td>
<td>HD video: 1 m, Still imagery: 0.7 m, Both modes from the same payload</td>
</tr>
<tr>
<td><strong>Swath</strong></td>
<td>Video mode in 2.5k2k HD format, Still image mode 17 km swath</td>
</tr>
<tr>
<td><strong>Field of Regard</strong></td>
<td>+/- 40°, Equivalent to 750 km on the ground</td>
</tr>
<tr>
<td><strong>SNR</strong></td>
<td>All bands &gt; 100:1</td>
</tr>
<tr>
<td><strong>Data Products</strong></td>
<td>Radiometrically and geometrically calibrated, 12 bits/pixel</td>
</tr>
<tr>
<td><strong>Compression Ratio</strong></td>
<td>Lossless up to 2.5:1, Lossy at higher ratios</td>
</tr>
<tr>
<td><strong>Mass</strong></td>
<td>60 kg to 160 kg dependent on configuration</td>
</tr>
<tr>
<td><strong>Redundancy</strong></td>
<td>Dual redundant systems</td>
</tr>
<tr>
<td><strong>Reference Orbit</strong></td>
<td>500km, SSO, 10.30am LTAN</td>
</tr>
<tr>
<td><strong>Data Storage</strong></td>
<td>Up to 1 Tbyte</td>
</tr>
<tr>
<td><strong>Downlink</strong></td>
<td>80-500 Mbits per second</td>
</tr>
<tr>
<td><strong>Design life</strong></td>
<td>5 years+</td>
</tr>
<tr>
<td><strong>Revisit</strong></td>
<td>2 times daily above lower latitudes for 5 satellite constellation</td>
</tr>
<tr>
<td><strong>Data capacity</strong></td>
<td>640 – 960 image scenes per day (17x17km)</td>
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<tr>
<td></td>
<td>185,000 to 280,000km^2 per day</td>
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Conclusions

• The next generation of SSTL small satellite platforms has been described, the X-Series, designed for automated manufacture and test.

• The SSTL-X50 “Precision“ mission addresses the need for commercial operational constellations providing high resolution imaging and video.
Thank You
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Changing the economics of space

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