Cyber in a World of Plenty: Secure High-Performance On-Orbit Processing

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9 August 2017

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SmallSats are an Attractive Option …
... to adversaries
## Terrestrial vs. Space Platforms

<table>
<thead>
<tr>
<th>Variable</th>
<th>Terrestrial</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical access</td>
<td>Easy</td>
<td>Not Easy</td>
</tr>
<tr>
<td>Environmental threats</td>
<td>Power surges, spilled coffee</td>
<td>Radiation, thermal</td>
</tr>
<tr>
<td>SWaP concerns</td>
<td>Low</td>
<td>Very high</td>
</tr>
<tr>
<td>Installation method</td>
<td>Person carrying box</td>
<td>Rocket carrying box</td>
</tr>
<tr>
<td>Communications</td>
<td>Wired, wireless</td>
<td>Intermittent wireless</td>
</tr>
<tr>
<td>User specialization</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Platform specialization</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Mission duration</td>
<td>Days to Months</td>
<td>Months to Years</td>
</tr>
</tbody>
</table>

Similar systems analysis techniques apply, but the starting assumptions differ.
Adding a “Root of Recovery” to Satellites
A Representative Software Stack

Application → Middleware → Adapter → Operating System

Board Support Package → Processor → Bus → Peripheral

Design Guidelines
A Representative Software Stack

Application  Middleware  Adapter  Operating System

Board Support Package  Processor  Bus  Peripheral

Design Guidelines
Technical Solution
A Representative Software Stack

Application → Middleware → Adapter → Operating System

Board Support Package → Processor → Bus → Peripheral

Design Guidelines
Technical Solution
Familiarity by Adaptation
core Flight System
A paradigm shift in flight software development
COME TO THE DARK SIDE
WE HAVE GLOBAL VARIABLES
Operating System

- Application
- Middleware
- Adapter
- Operating System
- Board Support Package
- Processor
- Bus
- Peripheral

sel4
Processor

Application  Middleware  Adapter  Operating System  Board Support Package  Processor  Bus  Peripheral

Processor

ZYNQ

Board Support Package

Application

Middleware

Adapter

Operating System

Peripheral
Peripheral / Testing Environment

Application → Middleware → Adapter → Operating System → Board Support Package → Processor → Bus → Peripheral

NASA Operational Simulator for Small Satellites
Our Goal: Dramatically simplify the job of building secure small satellites by providing straightforward, practical to implement guidelines and ready-to-use components.
Thank You!