A Heuristic Analysis: DSP and MSTI

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Final Integrated Project
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Agenda

- System Overview
  - DSP
  - MSTI
- Heuristic Analysis
  - Open Architecture
  - Political Environment
  - Cost
- Conclusion
System Introduction

- Defense Support Program (DSP)
  - Strategic missile defense, 40+ years
- Miniature Sensor Technology Integration (MSTI)
  - Proof of concept 1992-1996, mid-wave infrared space based sensor
Defense Support Program (DSP)

- Mission – TBM/ICBM launch, mid-course, and re-entry warning & track
- Architecture
  - Geostationary Earth Orbit (GEO)
  - Focal plane array sensors detect IR events
  - Whole earth scans 6 x minute
  - Operated from Buckley AFB, CO (460th Space Wing)
- Acquisition
  - USAF/SMC
  - $400M/unit
DSP/SBIRS Architecture
Miniature Sensor Technology Integration (MSTI)

- **Mission** – TBM coast track
- **Architecture**
  - Low Earth Orbit (LEO)
  - 3 successful launches (MSTI-1, 2, 3: 1992 – 1996)
- **Acquisition** – “Faster, Better, Cheaper”
  - SDIO/BMDO commissioned, AFRL program management (JPL/Spectrum Astro)
  - Rapid development < 12 months from ATP
  - Cost < $50M/unit
R1 SDIO was the precursor to BMDO, so should it be reversed? Also, PM was through AFRL, correct?

So, maybe "SDIO (BMDO) commissioned, AFRL program management"

Ryan, 2/17/2012
MSTI-1, -2 and -3

- **MSTI-1**
  - 150 kg
  - LEO
  - $19M, < 12 months
  - > 100,000 frames of background data in MW

- **MSTI-2**
  - Theater ballistic missile tracking demo
  - LEO, Sun-synchronous
  - Tracked a Minuteman III launch from Vandenberg AFB
  - 3M SWIR and MWIR images
  - 170 Kg, < $25M

- **MSTI-3**
  - One year mission to gather extensive MWIR background clutter statistics
  - Proved tracking ballistic missiles in the coast phase against warm background is achievable
  - Collected 600,000 SWIR/MWIR images (used by SBIRS for simulations)
  - < 24 months, $50M
Heuristic Analysis

- Selected heuristics to compare behavior in DSP and MSTI
  - Use Open Architectures. You will need them when the market starts to respond
  - If the Politics don’t fly, the system never will
  - Timing is everything
  - Cost Rules
Heuristic #1: Use Open Architectures

DSP and MSTI
Use Open Architectures. You will need them when the markets start to respond.

- Cold War drove need for larger/exquisite national space systems
- "Space Race" underlies legacy and future systems
  - Open-standards, Interoperable, Interchangeable, Portable, Modular, Scalable
  - Currently not adopted by DoD large programs
DSP – Open Architecture Successes

- Technology upgrades allowed DSP relevancy for 40+ years
  - Ground processing, additional infrared detectors, power and operational life, whole earth coverage, improved resolution for theater coverage (response to Yom Kippur and Vietnam wars)
  - ALERT – tactical upgrade for in-theater processing
- Although not developed according to OSSA, remained flexible to mission needs
  - Post Gulf War, DoD sought to expand DSP’s mission to theater
DSP Evolution

1970 - present

- DSP-1
  - 2000 detectors
  - Design life - 1.25 yrs.

- Phase II
  - Increased sensor sensitivity
  - Polar coverage
  - Increased survivability
  - Increased power
  - Two color infrared detection - ATH
  - Multi-Orbit Capability

- MOS/PIM (Multi-orbit Satellite/Performance Improvement)

- Phase II Upgrade-SED (Sensor Evolutionary Development)
  - 3,960 lbs.
  - 6000 detectors
  - Design life - 3 yrs
  - (goal - 5 yrs)
DSP – Open Architecture Demise

- Built around tight requirements for strategic mission
- Design constraint in rotating telescope
  - More targets detected in faster spinning telescope, but result in less sensor sensitivity
- Air Force leadership deemed DSP design insufficient to meet threat of dim, short-burning missiles
  - Primarily operates in the short wave which limits capability to track booster burn (need mid-wave exploitation)
- DSP performed “too well” to survive
MSTI – Open Architecture

- “Lincoln Log” Modular Bus Design
  - Adaptive architecture to accommodate new payloads and technology at low cost and rapid schedule
- Typical 3 year development cycle; condensed to 12 months
- Allowed increase in complexity without major re-design from MSTI-1 to MSTI-3
MSTI – “Lincoln Log” bus design

Nadir Antenna
Filter Wheels
Solar Array
Payload
Star Tracker
E-Bay (VME Backplane)
EDMM
Reaction Wheel (1 of 3)
PCU
Thruster Cluster
TARA (2-axis gyro)
Zenith Antenna
Adapter (Battery Inside)

A-Bay (Reaction Wheels, IRUs)
MSTI – Open Architecture Foundation

- Take advantage of industry capability
- Avoid major re-design
- Industry partners use familiar standards
- Lowered risk as identical components flown before
- Optimal for single mission focus, small spacecraft with 1-2 year lifetime
- Allowed for optimization at whole system vs subsystem
Conclusion – Open Architecture

- Although size and complexity of DSP and MSTI very different, “Open Architecture” played key role
  - DSP – long term open architecture success, then desire for major re-design to address new threat ultimately led to contract award for follow-on program, SBIRS
  - MSTI – open architecture the foundation for development, yet ultimately program cancelled due to other factors
Heuristic #2: If the politics don’t fly, the system never will.

DSP and MSTI
DSP Political Challenges

- Sub-heuristic: “Perception is often more important than the truth.”
  - “Dissenters” vs. Gen Schnelzer GAO, Aerospace and Institute for Defense Analysis (IDA) concluded DSP upgrade would satisfy 85-98% requirements at cheaper cost
  - Testimony to Congress about Air Force “Disinformation” campaign
  - “DSPII: Preserving the Air Force’s Options” backlash against Aerospace – study recanted
DSP Follow-On Options

- Political fight that led to congressional hearings and testimony, accusations of "disinformation campaign" and bias, and firing of Aerospace employees....
  - DSP ++
  - DSP II
  - FEWS
  - ALARM
DSP Follow-On - SBIRS

- Space Based Infrared System (SBIRS) congressionally approved as DSP follow-on in 1995
  - National and theater missile warning, Battlespace Awareness (BA), Technical Intelligence (TI)
- “High Now, Low Later” – four GEO (1st launch – 2002), two hosted in HEO, combined with constellation of 20 LEO satellites
- 2 Nunn-McCurdy breaches, more than decade schedule slip
- Closing of OCONUS ground stations (1999) – consolidation of ground processing in US (completion 2001)
Original SBIRS schedule

Integrated Program Schedule

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<th>Year</th>
<th>D17</th>
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<th>D20</th>
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DSP

SBIRS Ground

SBIRS High (GEO/HEO)

SBIRS Low (LEO)

Baseline

Increment 1 (DSP Ground Consolidation)

SBIRS (GEO/HEO) Ground

LEO Increment Availability

2 Contractors

1 Contractor

H1*

G1

H2* G2

G3

G4

G5

ATP

Down-select

Flight Demo Launch

Launch

DAB

Pre-EM activity

EMD

Continuously Evolving System of Systems to Meet Diverse User Needs

* Sensor delivery for integration
DSP - Political Facts of Life

- Program advocacy and funding
  - Strong, coherent constituency is essential
  - “Gold plating” multi-mission
    - Examples: Transformational Satellite Communication System (TSAT), Space Based Radar (SBR), Future Imaging Architecture (FIA)
- Difficult to prove bias in political decisions
MSTI Political Environment

- Program execution could “fly below the organizational radar”
  - Rapid handling of political and program management decisions (small program under large office)
  - Lacked program advocacy
- Large programs tend to be “threatened” by smaller programs
  - Example: Third Generation Infrared Surveillance (3GIRS) vs. SBIRS, Tier II Imagery vs. National Imagery Intelligence (IMINT) Systems
  - MSTI – 3 payload camera vast improvement over DSP’s resolution (92 ft across vs football field)
MSTI Cancellation & Politics

- **Official**: MSTI-3 de-orbited as its MWIR cloud and background phenomenology experiment was completed

- **Unofficial**: MSTI-3 de-orbited since “the Brilliant Eyes SPO at USAF/SMC (which evolved to SBIRS Low, then STSS) wanted MSTI-3 de-orbited “at all costs” as it was a major thorn in their ability to substantiate a multi-billion dollar acquisition when MSTI-3 was performing key pathfinding MWIR collections (including missile launches, track, in addition to the cloud and background collections)
MSTI - Conclusion

- Presently smaller satellites and sensors “en vogue” yet the technology in existence for two decades
- Nature of small programs often do not satisfy Rechtin’s political heuristics, which is why they are more affordable
  - However, given this, they are higher risk
- “Best engineering solutions are not necessarily the best political solutions”
Heuristic #3: Cost Rules.

DSP and MSTI
Cost Rules

- Cold War “blank check” approach to space development propagated gold plating
- 1990s’ – challenge how to remain “space race” victor while reducing cost
- DSP projected life cycle costs to exceed $20B due to H/W & S/W obsolescence
## DSP vs. Follow-On Cost Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>DSP</th>
<th>DSP ++</th>
<th>FEWS</th>
<th>ALARM</th>
<th>SBIRS</th>
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<td>Satellites</td>
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<td>5</td>
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<td>4 Geo + 2 Heo</td>
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<td>Theater detection</td>
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<td># Areas of Interest</td>
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<td>Satellite cross links</td>
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<td>No</td>
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<td>Messages direct to users</td>
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<td>Nuclear detection system</td>
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<td>Onboard attack detection</td>
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<td>Mobile ground segment</td>
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<td>Projected total cost</td>
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<td>$12B-18.4B</td>
<td>$7B</td>
<td>$1.6B</td>
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DSP Cost Considerations

- SBIRS $1.6B vs. $10-20B
- Two decades later = two Nunn-McCurdy Breaches and projected $15B costs to complete SBIRS “High” and cancellation of SBIRS “Low”
- $10B to achieve upgraded strategic missile warning and questionable utility to BA/TI missions
- Ultimately, known, grossly erroneous cost projections won the follow-on contract
MSTI

- Cost ceiling ($20M) drove capability vs. requirements development
- "Acceptable" performance instead of tightly bound specifications at each subsystem level
- Solar panel example:
  - Cost: $230,000 for AF rejected versions that were within +/-11% performance specs, instead of 10%
  - Traditional solar panels cost $2-3M (1992)
## MSTI Design Process Cost Comparison

<table>
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<tr>
<th>Subsystem / Major Cost Area</th>
<th>Hardware Driven</th>
<th>Requirements Driven</th>
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<tr>
<td>Power</td>
<td>$1,069,000</td>
<td>$5,345,000</td>
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<tr>
<td>Command &amp; Data Handling</td>
<td>$806,000</td>
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<tr>
<td>Telemetry Tracking &amp; Command</td>
<td>$2,989,000</td>
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<td>Attitude Determination &amp; Control</td>
<td>$1,230,000</td>
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<td>Software</td>
<td>$872,000</td>
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<td>Structure Thermal &amp; Cable</td>
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<td>Payload</td>
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<td>Reliability &amp; Quality Assurance</td>
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<td>Safety</td>
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<td>Systems Engineering</td>
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<td>Total</td>
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Cost Conclusion

- Customization and tight requirements drive cost.
- Cost projections do not need to be accurate for large programs.
- Program funding has to be won every year for small programs.
- Smaller programs with narrower constituency have to operate within "discretionary" lower level funding lines.
Heuristic Analysis Conclusion

- Political and cost environment continues to favor large programs
- Rechtin’s heuristics remain true regardless of size or complexity of program
- Innovation for technology suffers under current political and budget environment
- Politically unpopular to question if large programs could be accomplished differently or more affordably
Questions?