



Design Insights and Lessons Learned for an Express-Class Operational Pathfinder

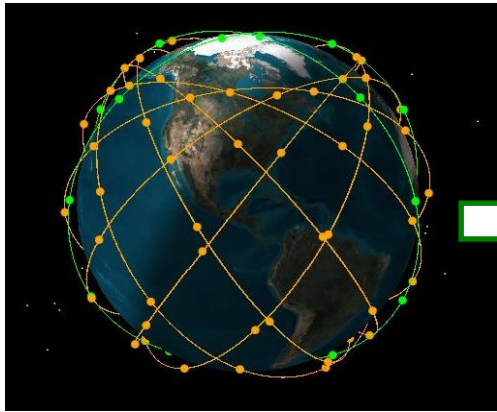
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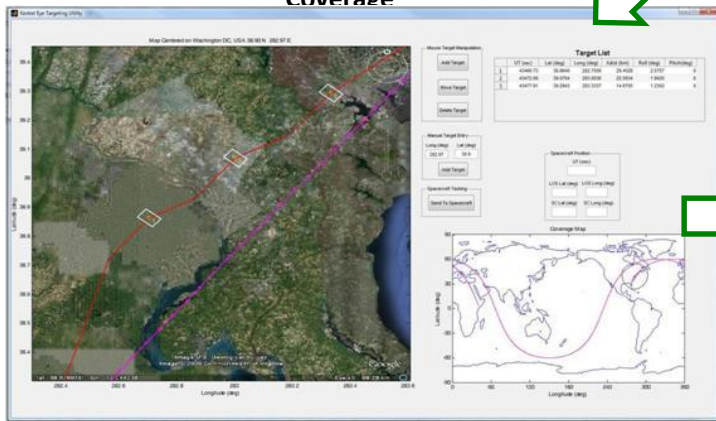
HERITAGE + INNOVATION



Nanosatellites in Orbit or Launched on Demand Provide more Persistent Coverage



Use Existing Hardware for Mobile and Simple Ground Station



Intuitive, Simple Laptop Application "Point & Click" Tasking



Imagery Distribution to the Individual Soldier on an Already Fielded Hand Held Device



Kestrel Eye generated image (conceptual sample)



Size	15" X 15" X 38"
Mass	~50 kg
Telescope	10" Aperture
GSD	1.5m (at 500km)
Image Size	~4 km X 6 km (at 500km)
Pointing Knowledge	< 0.05° 3σ (450m at 500km)
Field Of Regard	±30° Roll from nadir
Transmitter	>10 watts, S-Band
Downlink data rate	>1 Mbps
Encryption	Software Encrypted
Delta V	≈ 16.3 m/sec (Nitrogen cold gas)
Imaging Capability	On-board storage for 600 Images

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- ◆ Kestrel Eye Block II (KE IIM) is a high priority SMDC program
- ◆ KE IIM went through the Space Experiment Review Board (SERB) process, resulting in KE IIM being rated very high priority for launch. Based on this rating, the Space Test Program (STP) worked to provide launch for KE IIM
- ◆ Initial surveys for available launch options focused on sun-synchronous orbits
 - Co-manifested in a RideShare configuration on an Expendable Launch Vehicle
- ◆ The cost of co-manifested launches to orbit was higher than STP could accommodate; SMDC customer was asked to support part of the cost
- ◆ Ultimately, STP offered launch to the International Space Station (ISS) within the pressurized cargo module of a commercial cargo service launch to the ISS
 - **NanoRacks** was selected to provide launch to the ISS
 - KE IIM is launched inside a **Crew Transfer Bag** inside of the pressurized volume
 - Launch services provided via Orbital Cygnus or **SpaceX Dragon** (current plan)
 - Deployment from ISS uses Kaber including the NanoRacks Separation System; KE IIM will be deployed from the Japanese Experiment Module (JEM) airlock

- ◆ Cost of launch fully covered within existing STP funding structure
 - Launch is "free" to US Army SMDC
 - "Free" launch was a key enabler for this program
- ◆ Ability to recycle to next launch is a HUGE benefit
 - KE IIM had late-breaking issues at time of initial planned delivery; launch was changed from Orbital launch 2Q to a SpaceX launch in 3Q
- ◆ Launch environment for ISS cargo launch extremely benign
 - For selected payloads, this can be a major benefit
- ◆ For captive payloads, launch to ISS can be extremely beneficial
 - Captive payloads can take advantage of ISS infrastructure for cost savings
 - Easy to recover from design issues due to support of ISS infrastructure

- ◆ "Free" Launch to ISS drove many unanticipated additional costs
 - ISS Safety Rules drove significant redesign, fabrication, and test costs
 - Dual fault-tolerant EPS inhibit system (hardware inhibits preferred)
 - Dual fault-tolerant propulsion system
 - Safety-compliant Lithium-Ion Battery design (capacity over 80 W-Hr)
 - ISS Safety Rules required ISS Payload Safety Review Panel (PSRP) Process
 - Multiple levels of review and significant documentation and analysis including RF Hazard Assessment, Materials and Processes Assessment, Sharp Edges, Frangible Materials, Fracture Control Plan, etc.
- ◆ "Free" Launch drove schedule impacts (and associated costs)
 - ISS Safety drove redesign, fabrication, test, and PSRP Reviews
- ◆ Very short lifetime due to low altitude deployment and resulting drag forces
 - KE IIM could not satisfy PSRP concerns on propulsion use in reasonable time, therefore KE IIM not permitted to employ propulsion to mitigate short lifetime
- ◆ Launch environment for ISS cargo launch extremely benign
 - Launch to ISS does not necessarily qualify payload for launch on ELVs; it would be necessary to develop qualification process to envelope both needs

- ◆ There is no free launch
- ◆ Not clear if there was an overall cost savings to US Government or even the DOD
 - Part of launch cost built into NASA budget vs. DOD budget
 - Savings in STP budget balanced against costs in SMDC budget
- ◆ There is a significant issue involving propulsion systems for ISS deployments
 - Despite a major overhaul of KE IIM propulsion system to be dual-fault tolerant and eventual PSRP approval of the propulsion system for launch to the ISS, KE IIM could not satisfy safety concerns in a reasonable time for approval to use the Propulsion system after deployment from the ISS
 - The key concern was "recontact" with ISS after deployment
 - KE IIM is leaving fill valves of the cold-gas system open to space
 - This issue must ultimately be solved for the optimal use of ISS deployments
- ◆ If at all possible, it is best to know launch plans and associated requirements early in the design process to avoid the impacts of redesign and remanufacture
- ◆ Would we use ISS deployment launch if offered again?
 - It depends...
 - If ISS was the only "cost compliant" path to launch, absolutely

Delivery Day at NanoRacks – Looking Forward to Launch!



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