Microsatellite M3MSat Ground Systems – Mission Planning System and related VPN and Ground Segment Augmentation

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What’s M3MSat?
(Maritime Monitoring and Messaging Microsatellite)

M3MSat (Low-Earth Orbit)

- Ground Station (GS) DRDC Ottawa
- TT&C (S-Band)
- TT&C (VPN)
- Mission Operations Center (MOC) DRDC Ottawa
- AIS Data (C-Band)
- AIS Data (VPN)
- Data Processing (Ground Segment Augmentation, GSA)
- Correlated AIS Data (VPN)
- Mission Planning System (MPS)
- Payload Operation Centre (POC)

- Earth Station Svalbard, Norway
- AIS Data
- Share AIS Data
- Tasking
- Correlated Data
- Tasking

- AIS Transmitting Ships
- AIS Signal (VHF)
- AIS Raw Data
- NMEA Data

- R&D Science Users
- Recognized Maritime Picture (RMP)
- M3MSat Clients
- Data Processing Centre (DPC) (Toronto, ON)
- Tasking

- DRDC Ottawa
- Earth Station
- AIS Data
MPS - Mission Planning System

CSIAPS: Commercial Satellite Imagery Acquisition Planning System

- MPS Front-end
- Web-based GUI
- DRDC existing system
- Generate user tasking reports

- MPS work engine
- AIS database
- Specially developed
- Generate spacecraft macro commands
CSIAPS FrontEnd - User Tasking
CSIAPS FrontEnd - User Tasking (Cont’d)
CSIAPS FrontEnd - User Tasking (Cont’d)
CSIAPS FrontEnd - User Tasking (Cont’d)
M3MSat MPS Uplink and Downlink

**MPS Engine**
- Macro Command Generation
- Final Task Validation
- MPS Admin

**Web GUI**
- User tasking
- Schedule/Report generation & submission

**Web GUI**
- M3MSat Clients/Users

**CSIAPS FrontEnd**
- Tasks (Macro Commands)
- Tasks (Macro Commands)

**MPS Engine**
- MPS Database
- AIS Message Processing

**MPS Engine**
- GOV-Net

**MPS Engine**
- Clients, Users, e.g.

**M3MSat Clients/Users**
- Schedule/Report generation & submission

**Ground Segment Augmentation (GSA)**
- Raw AIS

**Ground Segment Augmentation (GSA)**
- S-Band link
- C-Band link

**TT&C**
- M3MSAT

**Satellite coverage region**
- Satellites

**M3MSAT**
- Satellite coverage region

**MPS Engine**
- Macro Command Generation
- Final Task Validation
- MPS Admin

**MPS Engine**
- MPS Database
- AIS Message Processing
Mission Planning System – some thoughts

• **System function requirements** should be complete and accurate, and detailed.

• **Planning:** good plan – good system delivered on time.

• **Fund management** – very important. Fund issue could affect the system developed.

• Complicated system requires **expertise in different areas** and good handover.
AIS Raw Data

- AIS spectrum signal
- In AU (Acquisition Unit, 99 seconds AIS signal, 32MB file)

GSA

AIS data processing system
Management Server (Windows 2008) and AÎS de-collider (Beowulf cluster) (head node & computing nodes).

AIS Messages

- Readable AIS messages
- in NMEA0183 format with UNIX timestamp appended.

Initial GSA, legacy, unreliable:
- 12 rack mounted computers,
- limited processing capability.
- The system O&M problematic.

Improved GSA, virtualized, reliable:
- Cluster: Cisco Unified Computing System (UCS) with VMware virtual machines and NetApp RAID 5 storage
- Increased GSA processing capability
- Simplified system O&M (e.g. hardware)
GSA - Initial and Improved System

Cisco UCS (Shared chassis)

NetApp (Shared storage)
GSA Lessons Learned and Next Step

- **Lessons learned:**
  - **Virtualization:** reduce cost, reduce implementation and O&M efforts.

- **Next Step:**
  - **Improve system control and management:** migrate the cluster system to physically independent hardware (not shared)
  - **Increase GSA processing capability** (the bottleneck) through cluster expansion - add new UCS blades for more virtual machines – compute nodes.
M3MSat VPN Network

• **Goal (M3MSat and MPS):** Automation, for users and services.

• **Challenges:** multiple sites, complicated networks, security concerns.

• **Solution:** VPN network. Secure transfer data, e.g. user tasking, macro commands, telemetry and operation data, AIS data.

• **VPN design:**
  – Architecture: Hub (DRDC lab) and Spokes (other sites).
  – IPSec VPN using Cisco routers.

• **Two VPN links implemented:**
  – DRDC lab to Ground Station (MOC, Ottawa)
  – DRDC lab to AIS Data Processing Centre (DPC, Toronto).
M3MSat MPS VPN Architecture

Connections between sites use a Secure VPN link. All inter site traffic goes to the HUB. Spoke to spoke traffic is limited and under HUB control.
M3MSat VPN Implementation Lessons Learned

- **Good network design, mature technique**, compliant with security and performance requirements. **But expensive.**

- **Implementation**: lots of effort, e.g., site survey, design, follow rules and policies, obtain various approvals. Installation and testing.

- **VPN network C&A** (Certification and Accreditation) took long time (> 1 year) and cost much, should plan well and in advance.

- **Technical knowledge sharing, backup** of people (expertise).
Summary and Conclusion

- **M3MSat**: microsatellite, space-based AIS, interesting, and challenging.

- **Mission Planning System**: automation, key software system in ground segment. *Good requirement specification and design.* System completion is underway.

- **Ground Segment Augmentation (GSA)**: key for readable AIS message. *Virtualization - excellent implementation, O&M and expansion, and better performance.*

- **M3MSat VPN**: good architecture and design, expensive, implementation - lots of work.

- **Lessons learned**: good planning and management, new technologies, people backup and knowledge sharing.