Maritime Operations in Disconnected, Intermittent and Low-bandwidth Environments

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Background

- AUSCANNZUKUS and M2I2 have developed architectures for DIL environments
- Focus on operations without satellites
- Satellites are vulnerable to jamming, EMP, and direct attack from adversaries
- In 2007, China shot down one of its own satellites
- Satellites are also have limited coverage world-wide and may not be available to all potential coalition partners
Satellite Dependency

- Between Operation Desert Storm (1990-1995) and Operation Iraqi Freedom (2000-2003), the US and its allies moved from operations supported by satellites to operation which depend on satellites\(^1,2\)

- In maritime operations, this dependence manifests itself in NOC-centric architectures

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\(^1\) M. Grant, *Space Dependence – A Critical Vulnerability of the Net-Centric Operational Commander*, Naval War College, 2005

\(^2\) J. Wilson, *The Ultimate High Ground*, Armed Forces Journal, 2004
Reducing Satellite Dependence

- Deploying LOS/ELOS communications bearers
- Implementing distributed routing architectures
- Strengthening shipboard network security
- Configuring applications for distributed task group-centric operations

The goal is self-organizing, self-healing networked applications that are robust to DIL environments
Shipboard Equipment

Diagram showing the connections between various shipboard equipment systems:
- LOS (Line of Sight) with UHF Radio and Modem
- ELOS (End to Line of Sight) with HF Radio and Modem
- SATCOM with Radio and Modem

Connections further include:
- SNR Controller
- HF IP Controller
- Gateway Router
- Link Crypto
- IP Crypto
- Enclave Router
- Other LANs

 LANs:
- Coalition LAN
- Email/DNS
- CAS
- COP
- IA
- WKSTN
Line of Sight Communications

- Two systems:
  - UHF Subnet Relay (STANAG 4691)
  - HF internet Protocol (STANAG 5066)

- UHF Subnet Relay for LOS
  - TDMA MAC, Layer 2 relay in multi-hop topologies
  - Bursts to 64 kbps in 25 kHz channel
  - Bursts to 384 kbps and 1.92 Mbps in 100 and 500 kHz channels
  - >1 sec delay

- HF IP for ELOS
  - Wireless token bus MAC, routes at layer 3
  - 6.4 or 12.8 kbps in 3 or 6 kHz channel
  - Burst rates of up to 96 kbps in 25 kHz
  - >1 second delay
Strategic back-haul over HF

- Trident Warrior 11 testing demonstrated WB HF over skywave with MIL-STD-188-110C Appendix D waveform
- Trident Warrior 13 will test at sea (ship to shore)
## Security Risks and Mitigations

<table>
<thead>
<tr>
<th>Risk</th>
<th>Traffic screening</th>
<th>Packet inspection</th>
<th>Anti-virus checking</th>
<th>Intrusion detection &amp; prevention</th>
<th>Authentication</th>
<th>Access control</th>
<th>Monitoring</th>
<th>Backup &amp; recovery</th>
<th>Encryption</th>
<th>Patch management</th>
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Network Defenses

1. Cryptographic Equipment
2. Firewall
3. Access Control
4. IA server
5. Host-based defense
Distributed Applications

- Maritime coalitions employ a standard applications suite called Collaboration at Sea (CAS)
- CAS is based on Lotus Domino and Sametime
- Other applications include email, web, and Common Operational Picture (COP) tools
- For Task Group-centric operations we require applications that can continue to function without shore and dynamically adapt to changes in connectivity
Distributed Dynamic Database

Unit
- Unit ID
- UnitName
- UnitClass
- UnitType
- Country
- DNSZone
- Service Branch

LANs
- LAN ID
- Subnet
- Mask
- Gateway (RouterID)

CommBearers
- BearerID
- Type
- Capacity
- Metric
- Availability

Interfaces
- InterfaceID
- Type
- SNMP MIB Data (Name, IPAddr, Mask …)
- Stats (TBD)

Routing Protocols
- ProtocolID
- ProtocolType
- SNMP MIB Data (MetricTable, lIfTable …)

Links
- LinkID
- SourceUnitID
- DestUnitID
- localInIntPAddr
- remoteInIntPAddr
- Metric
- BearerType
- Capacity
- PerformanceData (TBD)

Routers
- RouterID
- RouterName
- Manufacturer
- Model
- IOSVersion

Servers
- ServerID
- ServerIPaddr
- ServerType
- Hostname
- Version

Domino Status
- ReplicationPartners
- LastReplicationTime

Other App Status

Red: dynamically entered
Black: statically entered
Domino Reconfiguration Logic

Start

Point at NOC

Wait Timer

Up time > threshold?

Yes

No

Is local SATCOM down?

Yes

No

Down time > threshold?

Yes

No

Neighbors with SATCOM?

Yes

No

Point at self

Point at neighbor of highest rank

Point at neighbor of highest rank among those with SATCOM

Force Replication

Is highest rank self?

Yes

No

Neighbors with SATCOM?
Conclusion

- Architectures have been developed that support coalition maritime operations without SATCOM
- LOS/ELOS links provide alternative communication paths
- Routing, security architectures, and other network services must be modified for Task Group-centricity
- C4I applications must be reconfigured to support disconnected and distributed operations
- Automation of the changes have been demonstrated in Trident Warrior sea trials