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# Maritime Operations in Disconnected, Intermittent and Low-bandwidth Environments

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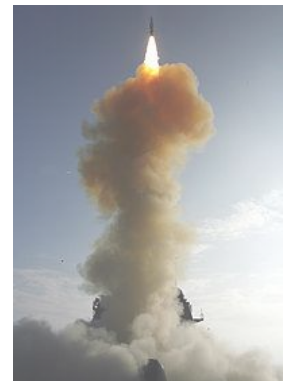
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# Background



- 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<sup>1,2</sup>
- In maritime operations, this dependence manifests itself in NOC-centric architectures

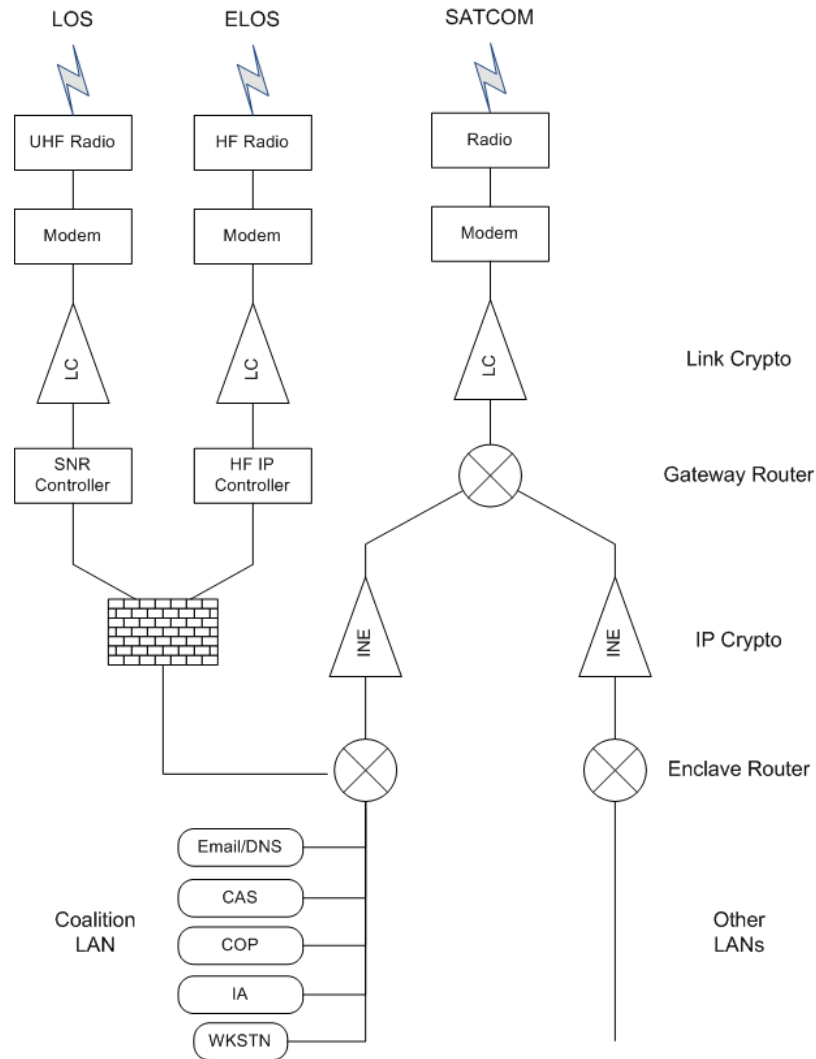
<sup>1</sup>M. Grant, *Space Dependence – A Critical Vulnerability of the Net-Centric Operational Commander*, Naval War College, 2005

<sup>2</sup>J. Wilson, *The Ultimate High Ground*, Armed Forces Journal, 2004

- 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



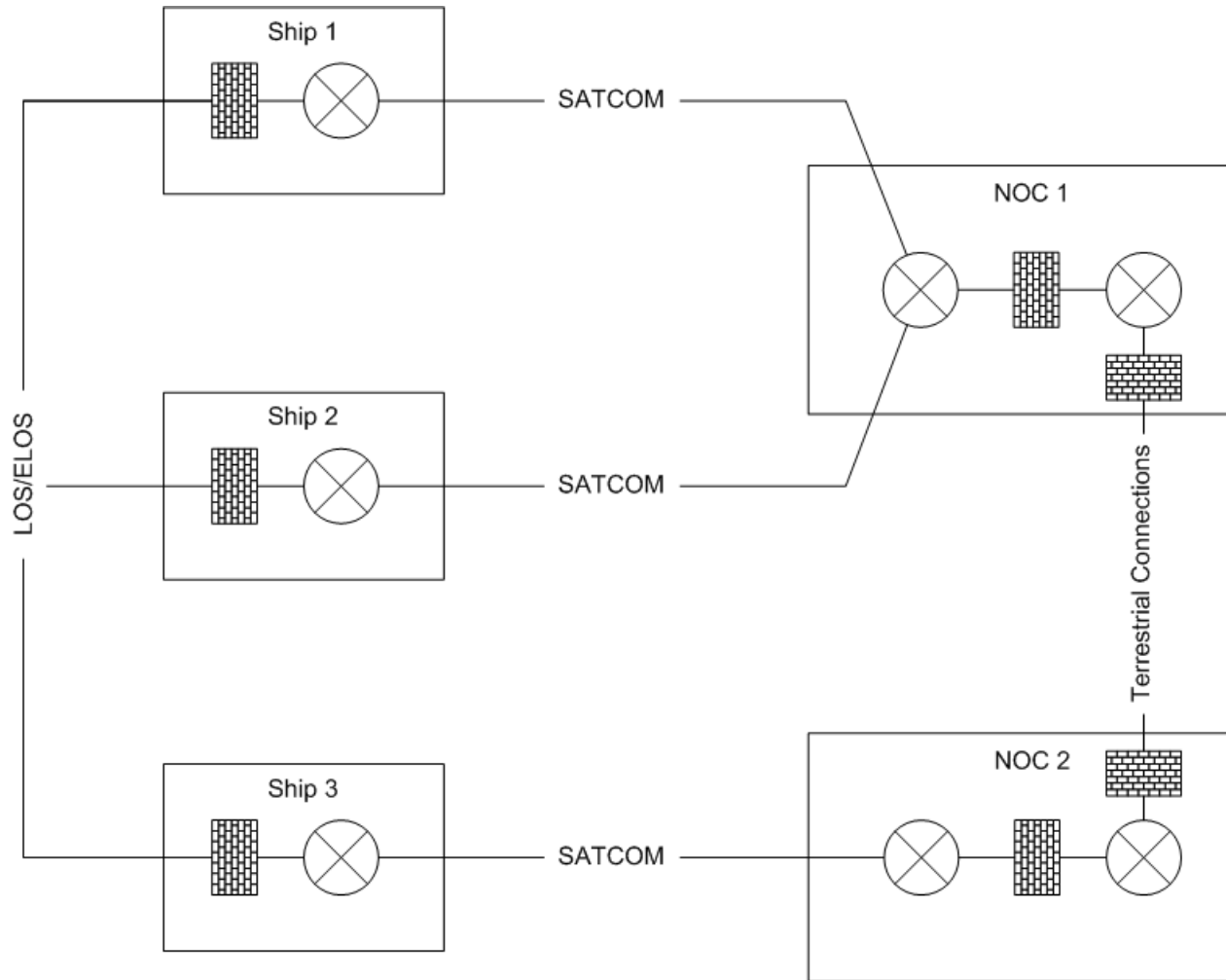
- Two systems:
  - UHF Subnet Relay (STANAG 4691)
  - HF internet Protocol (STANAG 5066)
- UHF Subnet Relay for LOS
  - TDMA MAC, Layer 2 relay in multi-hop topologies
  - Bursts to 64 kbps in 25 kHz channel
  - Bursts to 384 kbps and 1.92 Mbps in 100 and 500 kHz channels
  - >1 sec delay
- HF IP for 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



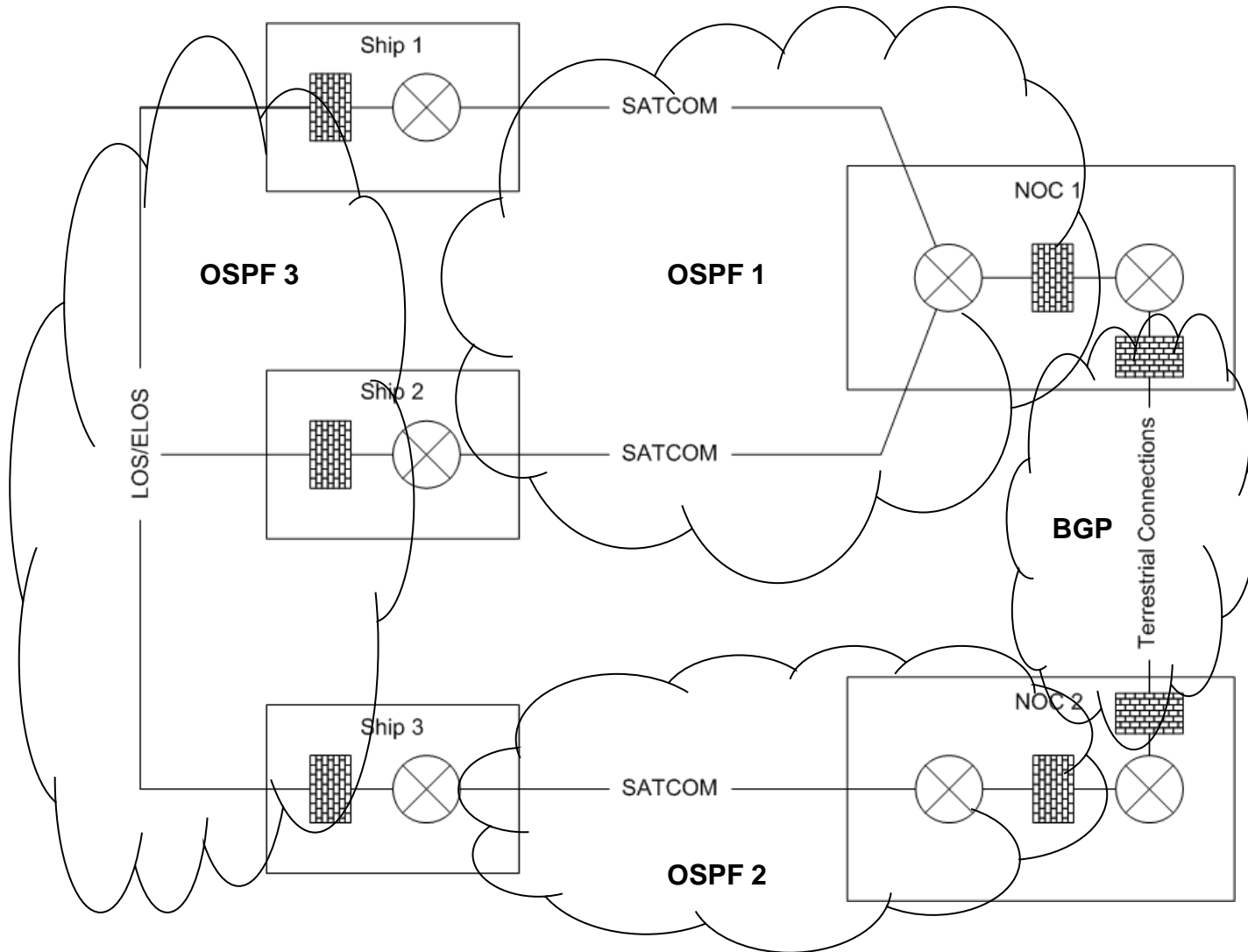
- Trident Warrior 11 testing demonstrated WB HF over skywave with MIL-STD-188-110C Appendix D waveform
- Trident Warrior 13 will test at sea (ship to shore)

# Routing Architecture





# Routing Architecture

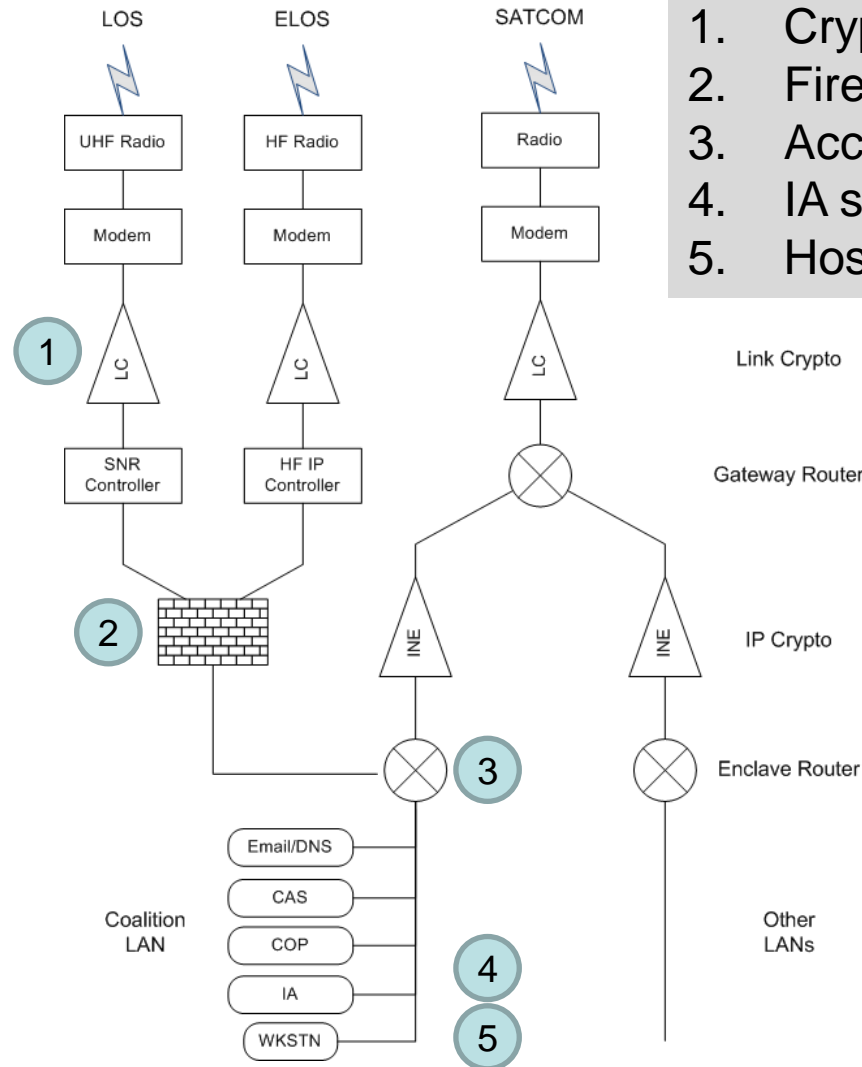


# Security Risks and Mitigations



Mitigation	Traffic screening	Packet inspection	Anti-virus checking	Intrusion detection & prevention	Authentication	Access control	Monitoring	Backup & recovery	Encryption	Patch management
Risk										
Network Penetration	✓	✓			✓	✓	✓			
Malicious logic		✓	✓	✓						✓
Data Integrity					✓	✓	✓			
Interference							✓			
Eavesdropping									✓	
Indirect exposure	✓									
Spoofing	✓	✓			✓	✓				
Human error					✓					
HW/SW error							✓	✓		
Cryptanalysis									✓	
Misuse						✓	✓			

# Network Defenses



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

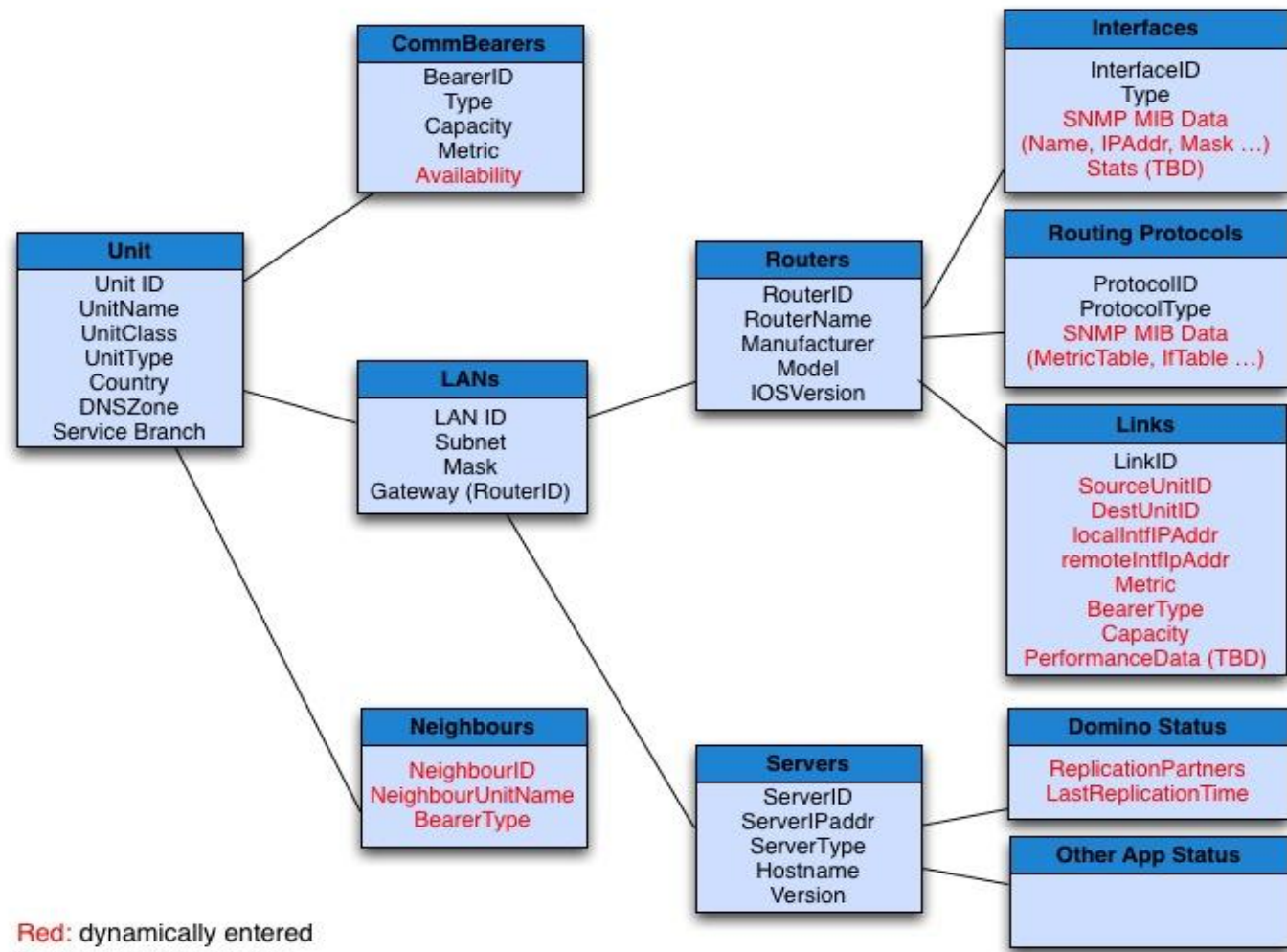
# Distributed Applications

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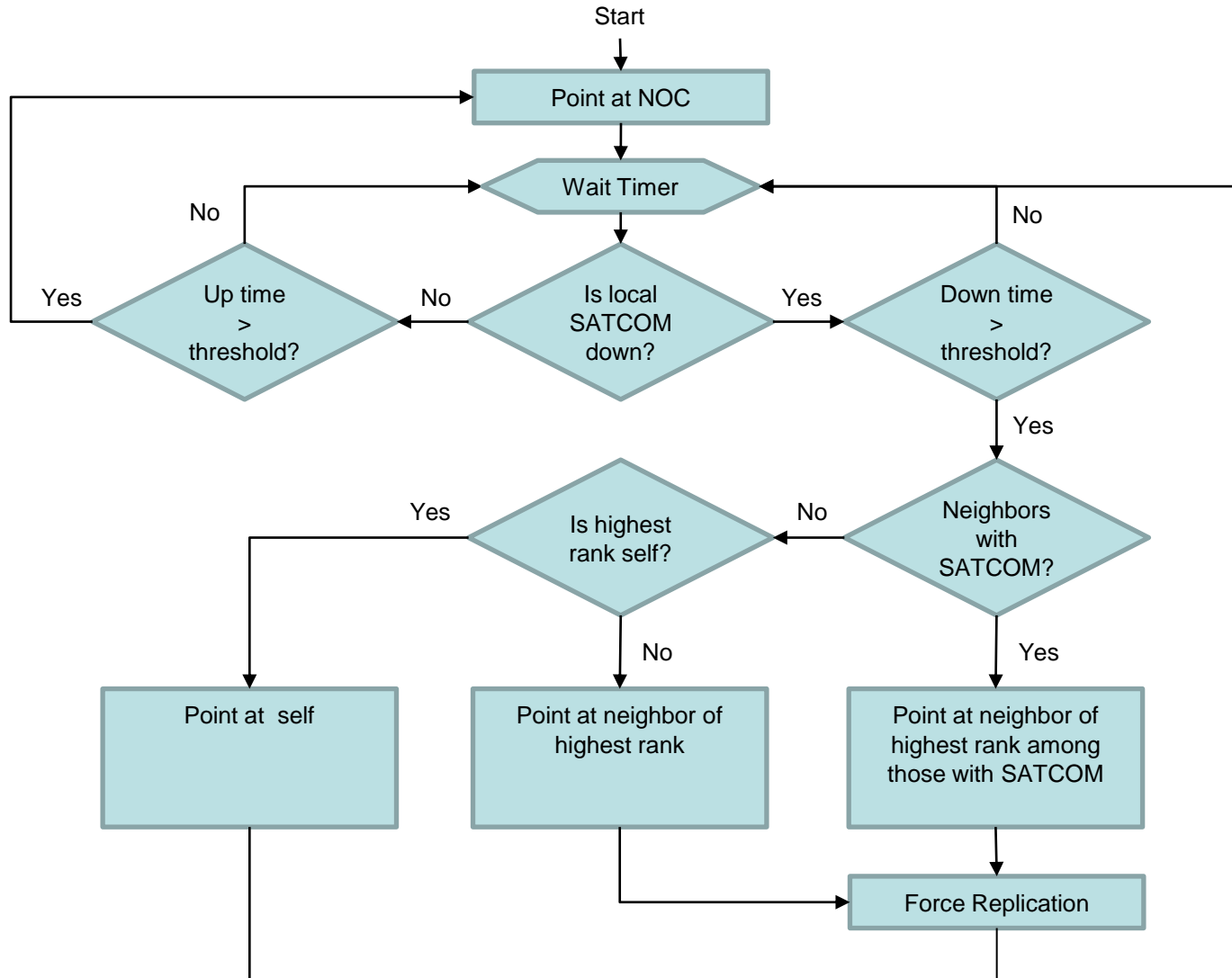


- Maritime coalitions employ a standard applications suite called Collaboration at Sea (CAS)
- CAS is based on Lotus Domino and Sametime
- Other applications include email, web, and Common Operational Picture (COP) tools
- For Task Group-centric operations we require applications that can continue to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

# Distributed Dynamic Database



Red: dynamically entered  
Black: statically entered



# Conclusion

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- 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