Agenda

• **MS2 Tactical Systems**

• **Motivation for Survivable Networks: C4ISR**

• **A Framework for cost-effective survivable network design**

• **Summary/Discussion**
MS2 Tactical Systems – C4ISR Products and Solutions

Maritime Surveillance

Networked Systems (C4ISR)

Global Support Services

Advanced Computing

Communications and Networking

System Integration

C2 Solutions

MS2 Tactical Systems Delivers and Supports Complex C4ISR Solutions
Motivation: Complexity of C4ISR and Battle Management

- **Sensors:** They are everywhere on many networks
  - Lots of data in many types and formats
  - Diverse capabilities: range, modality, maneuverability
  - Networks are poorly integrated

- **Communications and dissemination**
  - Inter and intra networking
  - Networking platforms have different characteristics: mobility, power, line-of-sight, latency, bandwidth
  - Network-to-network adaptation: adaptive data rate and waveforms

- **“Always-on”**: Connectivity anytime, anywhere, anyhow

Objective: Reliable information transfer under dynamic conditions with QoS
What is a Survivable Network?

A survivable network has the characteristic that essential services are preserved under disruption and recover full services in a timely manner.

- **Disruption can result from many factors**
  - Congestion resulting from excess offered load
  - Protocol Interworking failure (configuration)
  - Physical disruption
  - Security failure (Denial of service)

- **Service recovery**
  - Priority of restoral
  - Automated vs manual
  - Efficiency (recover full service in a timely manner)
Survivability Framework: Three levels of Network Integrity during undesirable events

- **Network availability (planned)**
  - Normally associated with maintenance and configuration faults (single fault)
  - Represents the majority of faults
  - Automated recovery or inherent reliability in the design

- **Single, worst case failure (node, link, etc)**
  - Environmental failure
  - Accident
  - Manual recovery (minutes/hours)

- **Disaster-based event: Several links or nodes fail simultaneously**
  - Natural or man-made event
  - Manual recovery (lengthy-hours/days/weeks)

Logical Layer recovery (Application and traffic layer)

Physical Layer recovery
Network Level Emergent Behavior: System View

- **System Requirements need to be integrated with survivability requirements at node and network level**
  - Organize into essential and non-essential services
  - Organize by user or business function

- **Survivability imposes new types of requirements**
  - Emergent behavior: collective behavior of node services communicating across the network
  - Adaptive behavior, function, and resource allocation

**Example:** Functions and resources devoted to non-essential services could be reallocated to essential services
Sample Survivability Measures

• **Connectivity based measures**
  – Route availability ratio
  – Probability of node isolation

• **Traffic based measures**
  – Average network blocking given a failure
  – Average number of lost calls given a failure

• **Desirable characteristics of measures**
  – Technology independent
  – Measure survivability under the three described levels of failure
  – Can be applied to a subnetwork of the network
  – Can measure the customer/user impact
### Survivability Framework: Analysis

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<thead>
<tr>
<th>Survivability Level</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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<tbody>
<tr>
<td>System Criteria</td>
<td>Network Availability</td>
<td>Single, Worst Case Event</td>
<td>Disaster-based Event</td>
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<td>Performance</td>
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<td>(Fault Tolerance + Security)</td>
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<td>Availability</td>
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<td>Recovery Time</td>
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<td>(Modifiability)</td>
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<td>Life Cycle Cost</td>
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Optimization Techniques

• **Architectural trade analysis using design patterns and styles**
  – DoDAF modeling
  – Exhibit 300

• **Formal methods using Markov modeling and simulation**
  – Hamiltonian Cycle based analysis
  – Generalized graph methods for clustering
  – Minimum-cost vertex-connectivity analysis

• **Scenario based methods**
Service Recovery and Efficiency

- **Maintainability: Fewer unique installations**
  - Default configurations
  - Training
  - Logistic support

- **Operational availability**
  - Faster restoral
  - Swap like components
  - Priorities: Know when I need a service

- **Life cycle cost management**

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Objective: Commonality across the Enterprise
Summary

• *The emphasis on net-centric operations makes it essential that we create effective methods for survivable network design*

• *We can apply system engineering methodologies similar to those we apply to other systems in order to define “essential” services*

• *We can use spiral model of analysis and design with appropriate measures to obtain desired properties*
Questions?

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