Comparative Analysis of C2 Structures for the Global Ballistic Missile Defense

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Outline

Unique Characteristics of Global Missile Defense Warfare

Essential Messaging Requirements

Analysis of Existing C2 Structure

Alternative C2 Structures

Discussion of Simulation Results

Conclusion
Global Ballistic Missile Defense

A new type of warfare
- Large complex global battle space
- Fast tempo
- Little force movement

Battle commanders need to
- Rely on high degrees of automation of all aspects of decision-making with manual override
- Local engagement decision with real-time global threat assignment
- Dynamic, real-time, allocation/re-allocation of resources
Global Ballistic Missile Defense

Need new C2 structures to streamline real-time coordination of battle responsibilities and engagement resources
Our Methodology

- Identify the essential message types passed between commands
- Establish if-then types of responses to these messages
- Establish random probabilities for success and fixed delay times for message processing
- Build simulation models for different C2 structures
- Run the models under three different scenarios:
  - Single Missile/Single AOR
  - Multiple Missiles/Single AOR
  - Multiple Missiles/Multiple AORs
Essential Messages

1. Cueing Data
2. Sensor Tasking
3. Track Data
4. Weapon Assignment
5. Weapons Order Acknowledgement
6. Weapons Order Refusal (CAN'T CO)
7. Weapons/Sensor Pairing
8. Weapons Inventory Update (weapon fired)
9. Engagement Status (subordinate to senior)
Existing C2 Structure (Hierarchical)

Note:
Global Authority – NORTHCOM
Supporting Command –
  Missile Defense Authority (STRATCOM, NORAD)
AOR – Supporting Regional COCOM
Sub-Unit –
  Units under tactical control of Regional COCOM
OMNeT++ Model for the Hierarchical C2 Structure
Simulation Results

Simulation runs show that the amount of messages will overload the network in anything more complex than a single missile/single AOR scenario.
Compressed C2 Structure

Missile Event
Reported by
DSP/SBIRS

Regional CC

NORTHCOM

Engagement
Messages

Missile
Defense
Forces
Flattened C2 Structure

- Missile Event
  - Reported by DSP/SBIRS

- USSTRATCOM
  - Advisory Messages
    - NMCC & Joint Staff
    - Regional CC
    - CJTF or JFACC
  - Engagement Messages
    - Missile Defense Forces
OMNeT++ Model for the Compressed Structure
OMNeT++ Model for the Flattened Structure
Simulation Results

The flat structure sends less messages, BUT...
Simulation Results (cont’d)

It is actually the slowest…
Conclusions

- Removing a layer of command from the existing C2 structure improves the overall performance of the structure in response to missile threats in various scenarios.
  - Elimination of the middle layers of a C2 structure may lead to reduction of the number of essential message classes.
- The message reduction in a flattened structure may be offset by the heavy workload imposed upon the centralized global authority.
- More refined models are needed to fully understand the impact of different C2 structures on missile defense.
For further study...

- Build a model with greater detail in which success is not random, but a function of other factors such as track data latency
- Investigate other alternative C2 structures
- Better model the “current structure,” as soon as we have a better idea of what that means
Questions?
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Description</th>
<th>Time (in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX_SIMTIME_FOR_FINAL_ENGAGEMENT</td>
<td>Maximum time for the entire scenario</td>
<td>600</td>
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<tr>
<td>TIME_TO_CONSIDER_INTEL</td>
<td>Routing time for each command to forward intel to the next lower level in seconds</td>
<td>10</td>
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<tr>
<td>TIME_TO_PROCESS_NOGO</td>
<td>The delay between a commands receipt of a “can’t co” message and the re-assignment of the target track to another weapon (if available) in seconds</td>
<td>2</td>
</tr>
<tr>
<td>TIME_TO_EVALUATE_KILL_NO_KILL</td>
<td>Time required for a sensor to determine if a weapon fired at a track was successful in seconds</td>
<td>20</td>
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<tr>
<td>TIME_TO_PAIR</td>
<td>Time required for a sensor to find the corresponding weapon once ordered to pair with that weapon in seconds</td>
<td>8</td>
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<tr>
<td>PERCENT_CHANCE_OF_DETECTION</td>
<td>The percentage chance that a sub unit will detect a threat weapon. The primary sensor will always pick up the threat weapon, but in cases where both sensor and sub-units detect the target, a fuzed track will be produced and sent to the next level of the chain of command</td>
<td>40</td>
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<tr>
<td>TIME_TO_DETECT</td>
<td>The delay time in seconds between sensor tasking and detection of the threat weapon</td>
<td>20</td>
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### Back-up Slides

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>MAX_SIMTIME_FOR_BOOST_ENGAGEMENT</td>
<td>The time in seconds after which a target has been detected that the engagement may take place at the lowest level. After this time, national assets stateside must be brought to bear on the threat weapon.</td>
<td>120</td>
</tr>
<tr>
<td>SPINUP_TIME</td>
<td>The time in seconds required for a weapon to fire after being tasked for the first time.</td>
<td>10</td>
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<tr>
<td>MAX_SALVO_SIZE</td>
<td>The maximum number of weapons a single weapons battery can fire</td>
<td>15</td>
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<tr>
<td>PERCENT_CHANCE_OF_KILL</td>
<td>The percentage chance that a single weapon will be effective</td>
<td>15</td>
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<tr>
<td>TIME_TO_PROCESS_STATUS</td>
<td>The time delay in seconds required by command to evaluate a status message</td>
<td>1</td>
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<tr>
<td>TIME_BETWEEN_THREAT_WEAPONS</td>
<td>The time delay in seconds between launches of enemy weapons</td>
<td>130</td>
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<tr>
<td>GLOBAL_SENSOR_TRACK_HITS</td>
<td>The number of opportunities for the national sensor to detect the track</td>
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<tr>
<td>GLOBAL_SENSOR_TRACK_DELAY</td>
<td>Delay in seconds between global sensor track opportunities</td>
<td>70</td>
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interceptors fired per threat missile

Interceptors Fired Per Threat Weapon

<table>
<thead>
<tr>
<th></th>
<th>Scenario #1</th>
<th>Scenario #2</th>
<th>Scenario #3</th>
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<tbody>
<tr>
<td>Hierarchical Structure</td>
<td>9.57</td>
<td>7.62</td>
<td>4.69</td>
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<tr>
<td>Compressed Structure</td>
<td>9.1</td>
<td>6.91</td>
<td>4.45</td>
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<tr>
<td>Flat Structure</td>
<td>9.14</td>
<td>7.64</td>
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