

Tactical Tomahawk Interface for Monitoring and Retargeting



Missy Cummings

MissyC@mit.edu

Massachusetts Institute of Technology

Aeronautics & Astronautics



The Tomahawk , Block III



**Tactical Tomahawk Interface
for Monitoring and Retargeting**

Proposed Tactical Tomahawk Missions

Default Mission
Flex Mission
Emergent Mission

Primary (Default) Target

Preplanned Health and Status points

Guidance Waypoint

Branch Point

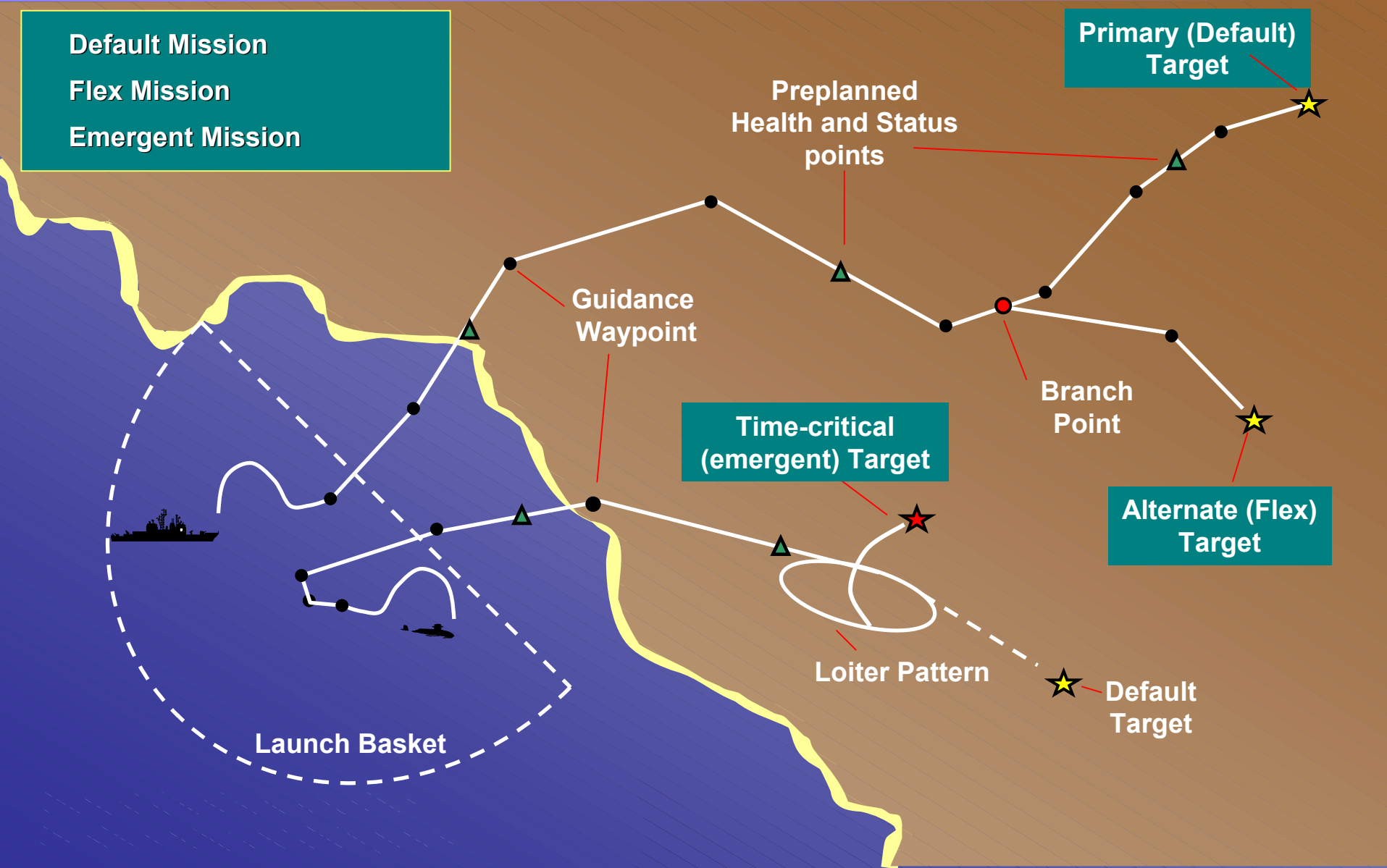
Time-critical (emergent) Target

Alternate (Flex) Target

Loiter Pattern

Default Target

Launch Basket



The TTIMR Project

- UVA FNC grant to look at human performance issues for the Tactical Tomahawk.
- Navy needs an interface to both monitor and control missiles
- Tactical Tomahawk Interface for Monitoring and Retargeting (TTIMR)
- Initial research focus - individual performance
 - What are ballpark response times?
 - How many missiles can one person be reasonably expected to control?
 - How does increasing workload affect performance and situational awareness?



TTIMR

Strike: BB UTC: 0659:37Z

	Munitions Depot	Truck Park	Barracks	Electric Grid	Training Camp	SAM Site	Oil Storage	Fuel Depot	Reactor Facility	Factory
LM029U-DL	14:29	---	---	19:35	18:58	15:33	7:44	19:13	12:42	22:08
RM030S-DM	---	34:01	29:04	14:32	24:42	---	---	---	---	---
LM031S-DL	---	---	---	---	---	0:01	---	D 07:21Z	---	19:18
RM032U-DM	---	---	---	---	---	---	---	---	---	---
RM033S-DL	---	D 07:25Z	8:11F	4:50	---	---	---	19:33	16:23F	25:29
RM034S-DM	---	1:36F	D 07:28Z	1:41	---	---	---	22:44	20:20	D 07:33Z
RM035U-DM	17:38	---	---	---	11:11	---	---	---	---	---
RM036U-DL	17:42	---	---	---	10:54	---	---	---	---	---

FF Alloc	2	0	0	1	1	1	1	0	1	0
RTG Alloc	0	1	1	0	0	0	0	1	0	1
Total Required	2	1	1	1	1	1	1	1	1	1
Shortage	--	--	--	--	--	--	--	--	--	--

0 Show: Action Messages Information Messages Health/Status Warnings

Last message received @ 0645Z

Clear Send

Target: T031U-DM
Fuel Depot
Lat: 33.80N
Long: 55.10E
Elevation: 181ft
Missile(s) targeting:
RM032U-DM (24m18s/07:21Z)

Missile: LM029U-DL
Type: Block IV -- GPS Only
From: USS Levte Gulf (CG-55)
Launch: 06:30Z
Mission # 000015
Current Target: T034U-DL
TTI: 89m57s (08:29Z)
TOIR: 91 min
Loiter: Loiter Pattern Complete
Not flex capable

Retarget:
 Retarget Missile

Strike: BB UTC: 0659:37Z

Strike Summary
Start: 0630Z
Elapsed: 29 min
Complete: 0829Z
TSC: Blue Ridge

Latest Message Traffic:
(0641Z) RM033S-DL => Passed IP. On route.
(0642Z) RM030S-DM => Passed IP. On route.
(0643Z) RM034S-DM => Passed IP. On route.
(0643Z) RM036U-DL => Passed IP. On route.
(0645Z) RM032U-DM => Passed IP. On route.

Show Map Controls

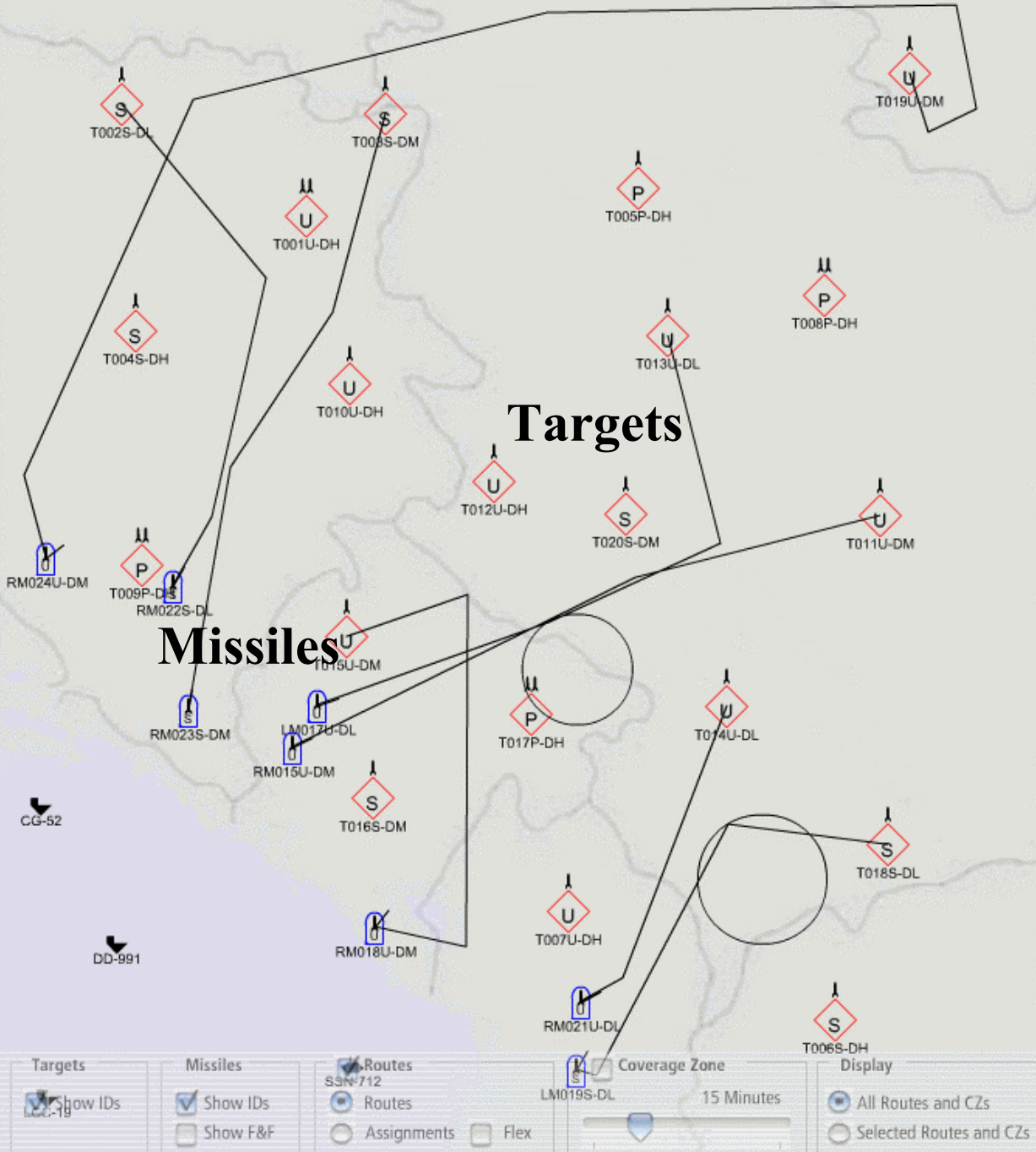
Retargeting Display

Monitor Map



Tactical Tomahawk Interface
for Monitoring and Retargeting

TOMAHAWK



	0630	0700	0730	0800
RM015U-DM			■	
LM017U-DL		▬		
RM018U-DM		■		
LM019S-DL		▬		
RM021U-DL		■		
RM022S-DL		■		
RM023S-DM			■	
RM024U-DM				■

Strike Summary

Start: 0630Z	23 Missiles	20 Targets
Elapsed: 18 min	6 R / 2 L / 15 F&F	0 Emergent Targets
Complete: 0826Z	0 Lost	0 Require Service
TSC: Blue Ridge		

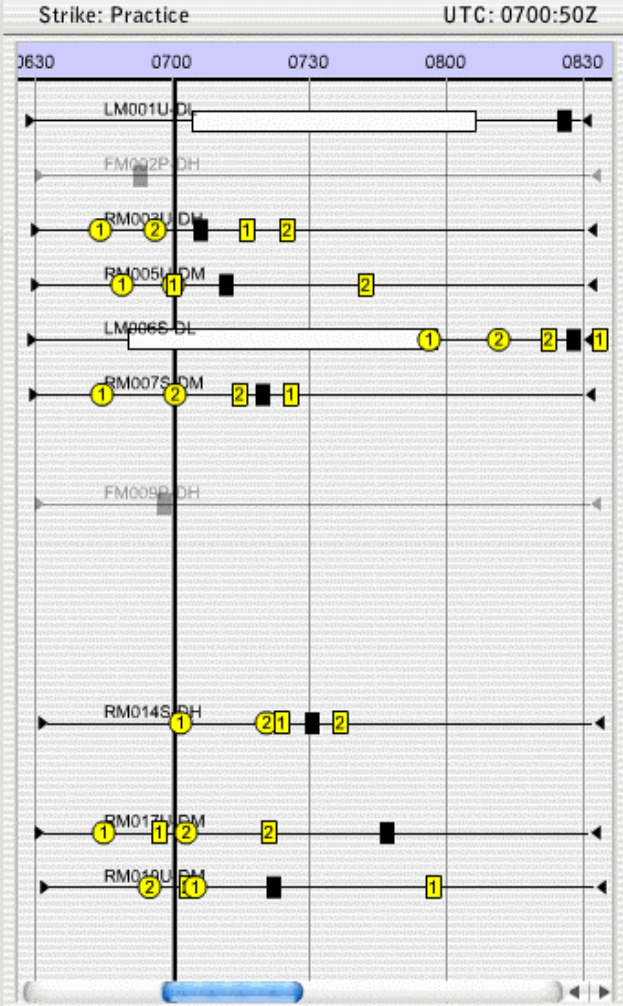
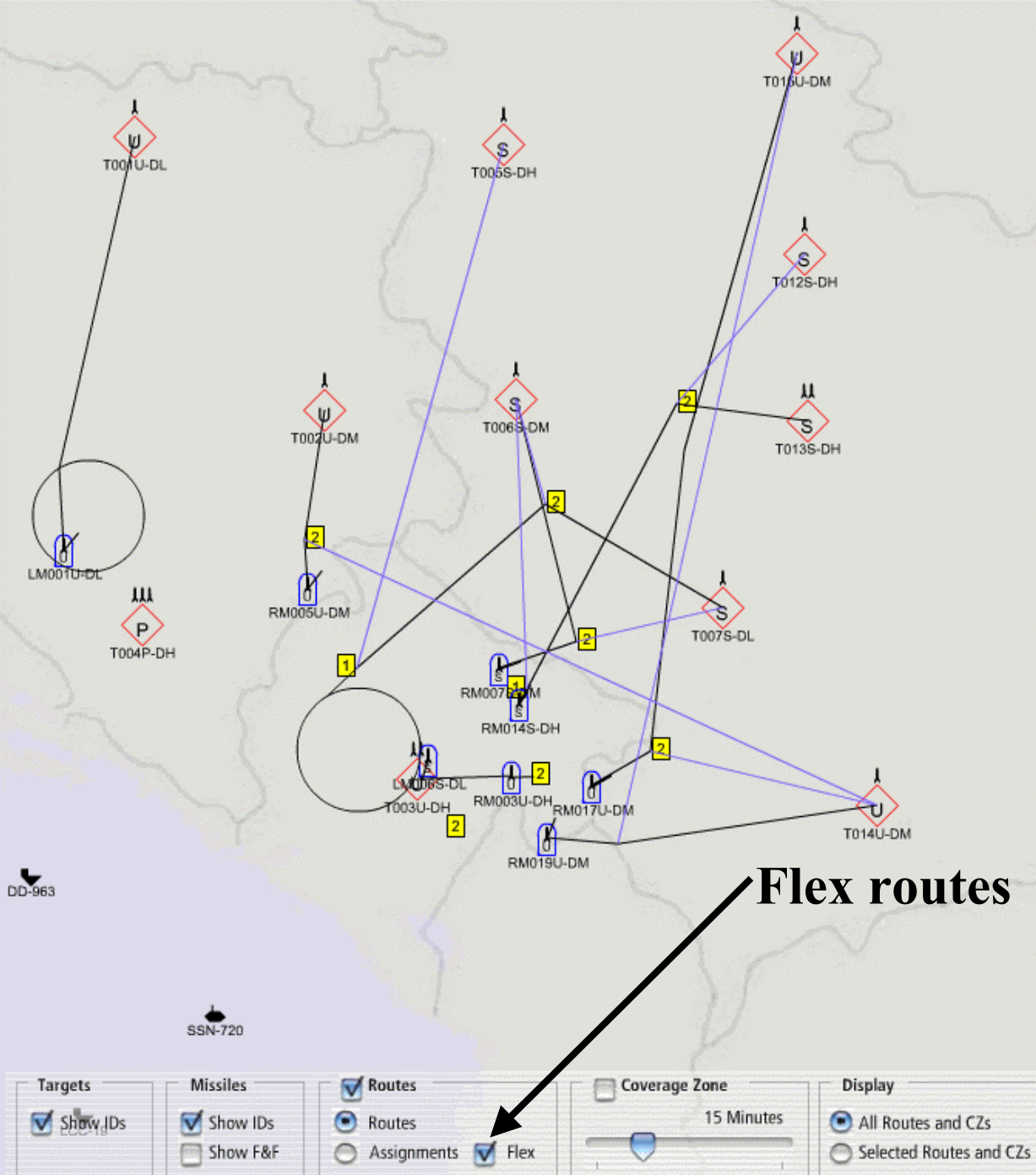
Latest Message Traffic:

- (0635Z) RM024U-DM => Passed IP. On route.
- (0636Z) LM019S-DL => Passed IP. On route.
- (0638Z) RM015U-DM => Passed IP. On route.
- (0638Z) RM023S-DM => Passed IP. On route.
- (0639Z) RM021U-DL => Passed IP. On route.

Targets Missiles Routes Coverage Zone Display
 Show IDs Show IDs Routes Flex All Routes and CZs
 Show F&F Assignments Flex Selected Routes and CZs

SSN-712 15 Minutes

Show Map Controls



Strike Summary

Start: 0630Z	14 Missiles	11 Targets
Elapsed: 30 min	6 R / 2 L / 6 F&F	0 Emergent Targets
Complete: 0827Z	0 Lost	0 Require Service
TSC: Blue Ridge		

Latest Message Traffic:

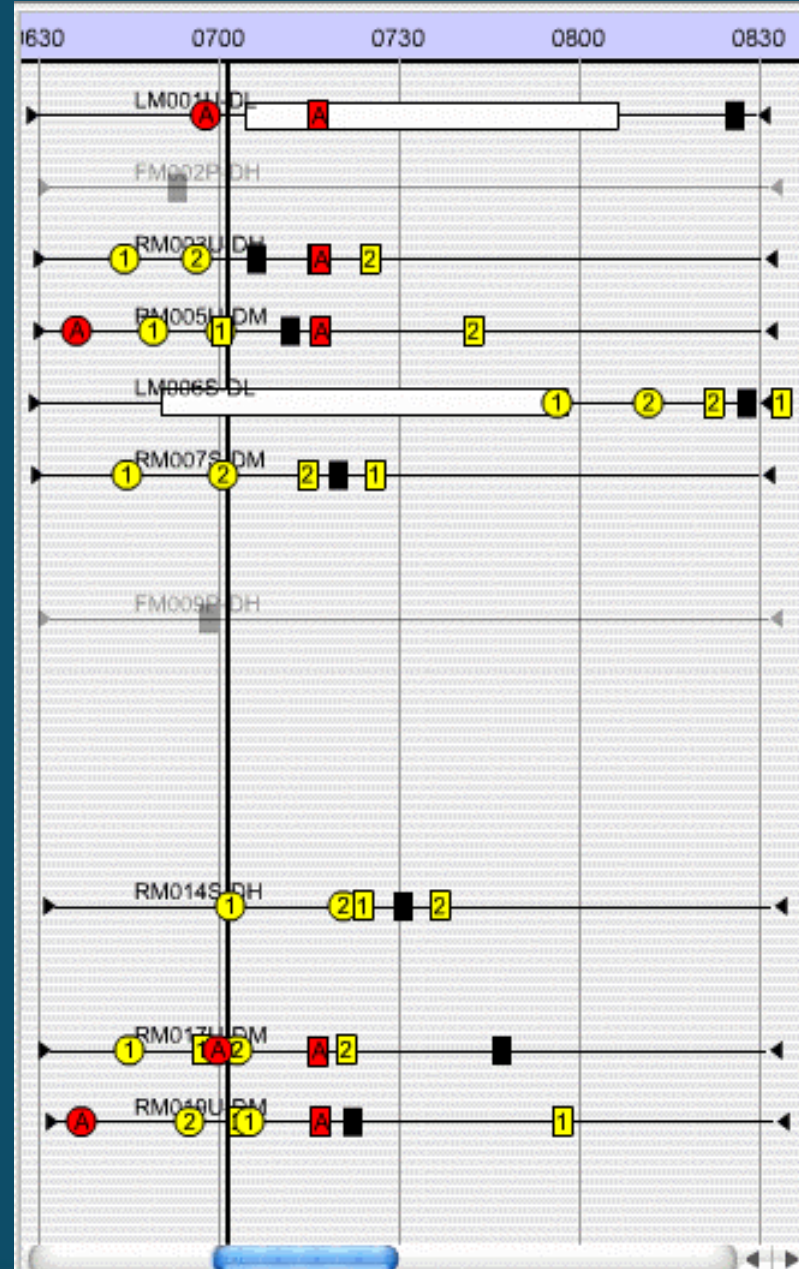
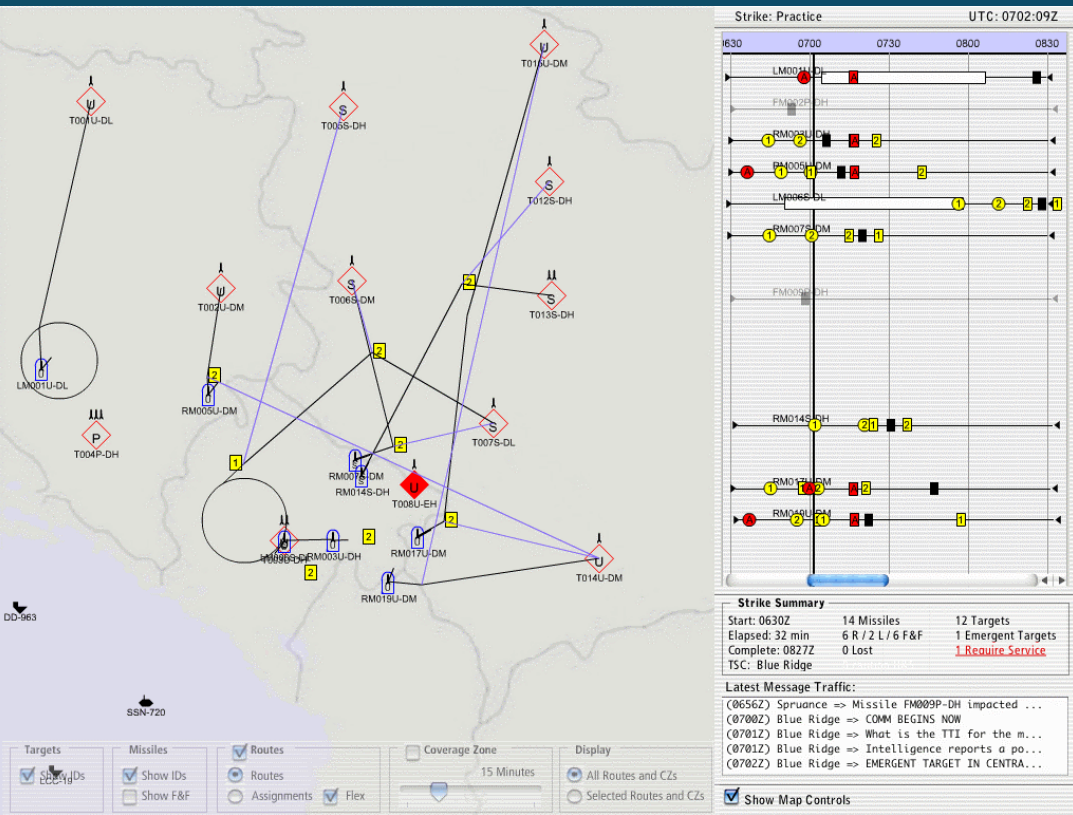
- (0642Z) RM019U-DM => Passed IP. On route.
- (0644Z) LM001U-DL => Passed IP. On route.
- (0652Z) Spruance => Missile FM002P-DH impacted ...
- (0656Z) Spruance => Missile FM009P-DH impacted ...
- (0700Z) Blue Ridge => COMM BEGINS NOW

Flex routes

Targets <input checked="" type="checkbox"/> Show IDs	Missiles <input checked="" type="checkbox"/> Show IDs <input type="checkbox"/> Show F&F	<input checked="" type="checkbox"/> Routes <input type="checkbox"/> Routes <input type="checkbox"/> Assignments <input checked="" type="checkbox"/> Flex	<input type="checkbox"/> Coverage Zone 15 Minutes 	Display <input checked="" type="radio"/> All Routes and CZs <input type="radio"/> Selected Routes and CZs
--	--	---	--	--

Show Map Controls

Time Bar



Tactical Tomahawk Interface for Monitoring and Retargeting

Basic Layout

Strike: B8 UTC: 0659:37Z

	Munitions Depot	Truck Park	Barracks	Electric Grid	Training Camp	SAM Site	Oil Storage	Fuel Depot	Reactor Facility	Factory
LM029U-DL	14:29					15:33	7:44	19:13	12:42	22:08
RM030S-DM				19:35	18:58					
LM031S-DL		34:01	29:04	14:32	24:42					
RM032U-DM						0:01		D 07:21Z		19:18
RM033S-DL		D 07:25Z	8:11F	4:50						
RM034S-DM		1:36F	D 07:28Z	1:41						
RM035U-DM	17:38					11:11		19:33	16:23F	25:29
RM036U-DL	17:42					10:54	13:19	22:44	20:20	D 07:33Z

FF Alloc	2	0	0	1	1	1	1	0	1	0
RTG Alloc	0	1	1	0	0	0	0	1	0	1
Total Required	2	1	1	1	1	1	1	1	1	1
Shortage	--	--	--	--	--	--	--	--	--	--

Show: Action Messages Information Messages Health/Status Warnings

- (06342) LM029U-DL => Passed IP. On route.
- (06392) RM035U-DM => Passed IP. On route.
- (06402) LM031S-DL => Passed IP. On route.
- (06412) RM033S-DL => Passed IP. On route.
- (06422) RM030S-DM => Passed IP. On route.
- (06432) RM034S-DM => Passed IP. On route.
- (06432) RM036U-DL => Passed IP. On route.
- (06452) RM032U-DM => Passed IP. On route.

Last message received @ 0645Z

Clear Send

Target: T031U-DM

Fuel Depot
 Lat: 33.80N
 Long: 55.10E
 Elevation: 181ft

Missile(s) targetina:
 RM032U-DM (24m18s/07:21Z)

Missile: LM029U-DL

Type: Block IV -- GPS Only
 From: USS Levite Gulf (CG-55)
 Launch: 06:30Z
 Mission # 000015

Estimated Position
 Lat: 34.17E
 Long: 51.75W
 Altitude: 4853.56 MSL

Current Target: T034U-DL
 ITR: 89m57s (08:29Z)
 TOFR: 91 min

Loiter: Loiter Pattern Complet
 Not flex capable

Retarget:
 Retarget Missile

Strike: B8 UTC: 0659:37Z

0630	0700	0730	0800	0830
FM022U-DH				
FM023S-DM				
FM024S-DM				
FM025S-DH				
FM026U-DH				
FM027U-DH				
FM028U-DH				
LM029U-DL				
RM030S-DM				
LM031S-DL				
RM032U-DM				
RM033S-DL				
RM034S-DM				
RM035U-DM				
RM036U-DL				
FM044S-DH				

Strike Summary

Start: 0630Z 24 Missiles 20 Targets
 Elapsed: 29 min 6 R / 2 L / 16 F&F 0 Emergent Targets
 Complete: 0829Z 0 Lost 0 Require Service
 TSC: Blue Ridge

Latest Message Traffic:

- (06412) RM033S-DL => Passed IP. On route.
- (06422) RM030S-DM => Passed IP. On route.
- (06432) RM034S-DM => Passed IP. On route.
- (06432) RM036U-DL => Passed IP. On route.
- (06452) RM032U-DM => Passed IP. On route.

Show Map Controls

Retargeting Display



Monitor Map

Tactical Tomahawk Interface
 for Monitoring and Retargeting



Target:
 None selected
 Lat: --
 Long: --
 Elevation: -- ft

Missile(s) targeting:
 None

Missile: RM0235-DM
 Type: Block IV -- GPS Only
 From: USS Fife (DD-991)
 Launch: 06:32Z
 Mission # 000015
 Current Target: T003S-DM
 TTI: 26m43s (07:24Z)
 TOFR: 93 min

Estimated Position
 Lat: 34.71E
 Long: 49.88W
 Altitude: 584 MFL

Loiter:
 Not Loiter Capable
 2 flex targets

Retarget:
 Retarget Missile

Retargeting command sent

0700:37Z

idge	Truck Park	Troop Camp	Chemical Plant	Barracks
1	0701	0826	0814	0711
0736	0701 0716	0811 0830	0759 0829	0701 0726
5U-DM	T016S-DM	T018S-DL	T019U-DM	T020S-DM
14			---	
16			---	
:20Z			---	
04	---	---	---	---
	---	---		16:39
	---	---		6:49F
40			D 08:14Z	
0	1	0	0	1
1	0	0	1	0
1	1	1	1	1
--	--	>> 1 <<	--	--

Show: Action Messages Information Messages Health/Status Warnings

(0656Z) RM019S-EH => Has been successfully retargeted to T021S-EH
 (0657Z) Blue Ridge => EMERGENT TARGET IN NORTH CENTRAL SECTOR
 (0657Z) TTIMR => Retargeting RM022S-DL to T022S-EH
 (0658Z) Blue Ridge => How many targets can RM021U be retargeted to in 20 minutes?
 (0659Z) FM011S-DM => Missed a reporting waypoint.
 (0700Z) Blue Ridge => How many minutes do you have left to flex RM023s to T020S?
 Last message received @ 0700Z

Clear
 Send

Target:
 None selected
 Lat: --
 Long: --
 Elevation: -- ft

Missile(s) targeting:
 None

Missile: RM0235-DM
 Type: Block IV -- GPS Only
 From: USS Fife (DD-991)
 Launch: 06:32Z
 Mission # 000015
 Current Target: T003S-DM
 TTI: 26m43s (07:24Z)
 TOFR: 93 min

Estimated Position
 Lat: 34.71E
 Long: 49.88W
 Altitude: 584 MFL

Loiter:
 Not Loiter Capable
 2 flex targets

Retarget:
 Retarget Missile

Retargeting command sent



Strike: AB

	Oil Storage	Fuel Depot	Reactor Facility
	0706	0724	0708
	0701	0721	0701
	0709	0739	0723
	T010U-DH	T011U-DM	T012U-DH
RM015U-DM	12:26	0 07:23Z	4:49
LM017U-DL	12:35	16:46	3:54
RM018U-DM		15:47	14:41
RM019S-EH			
RM021U-DL	---	4:04	---
RM022S-DL			
RM023S-DM			
RM024U-DM	10:46	---	---

FF Alloc	1	0	1
RTG Alloc	0	1	0
Total Required	1	1	1
Shortage	---	---	---

Show: Action Messages Information Messages Health/Status Warnings

(0656Z) RM019S-EH => Has been successfully retargeted to T021S-EH

(0657Z) **Blue Ridge => EMERGENT TARGET IN NORTH CENTRAL SECTOR**

(0657Z) TTMR => Retargeting RM022S-DL to T022S-EH

(0658Z) **Blue Ridge => How many targets can RM021U be retargeted to in 20 minutes?**

(0659Z) FM011S-DM => Missed a reporting waypoint.

(0700Z) **Blue Ridge => How many minutes do you have left to flex RM023s to T020S?**

Last message received @ 0700Z

Clear

Send

Show: Action Messages Information Messages Health/Status Warnings

(0656Z) RM019S-EH => Has been successfully retargeted to T021S-EH

(0657Z) **Blue Ridge => EMERGENT TARGET IN NORTH CENTRAL SECTOR**

(0657Z) TTMR => Retargeting RM022S-DL to T022S-EH

(0658Z) **Blue Ridge => How many targets can RM021U be retargeted to in 20 minutes?**

(0659Z) FM011S-DM => Missed a reporting waypoint.

(0700Z) **Blue Ridge => How many minutes do you have left to flex RM023s to T020S?**

Last message received @ 0700Z

Clear

Send

Target:

None selected

Lat: --

Long: --

Elevation: -- ft

Missile(s) targeting:

None

Missile: RM023S-DM

Type: Block IV -- GPS Only

From: USS Fife (DD-991)

Launch: 06:32Z

Mission # 000015

Current Target: T003S-DM

TTI: 26m43s (07:24Z)

TOFR: 93 min

Estimated Position

Lat: 34.71E

Long: 49.88W

Altitude: 584 MFL

Loiter: Not Loiter Capable

2 flex targets

Retarget:

Retarget Missile

Retargeting command sent



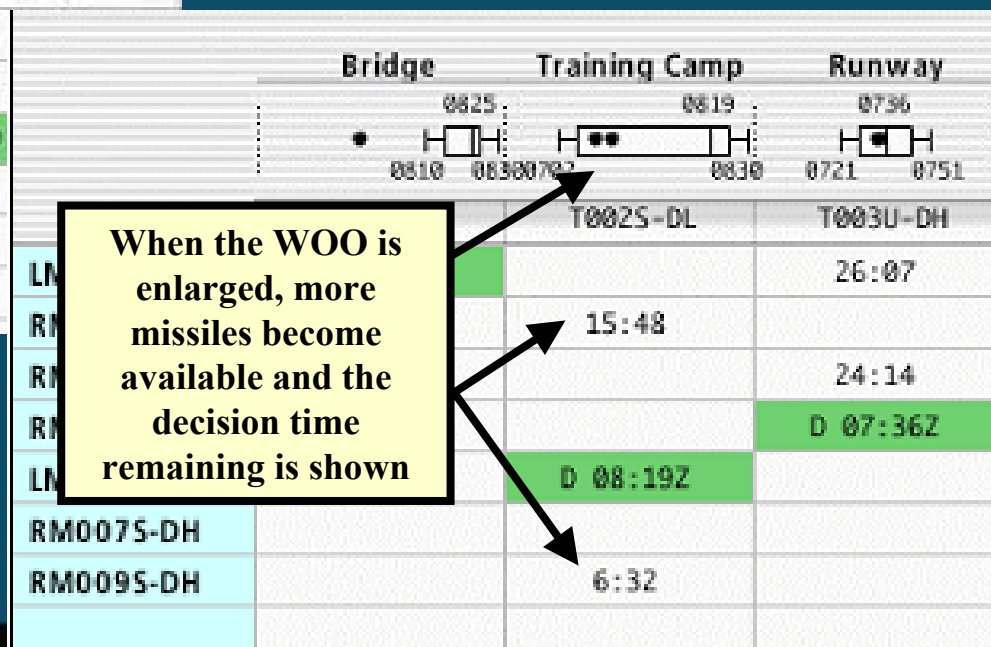
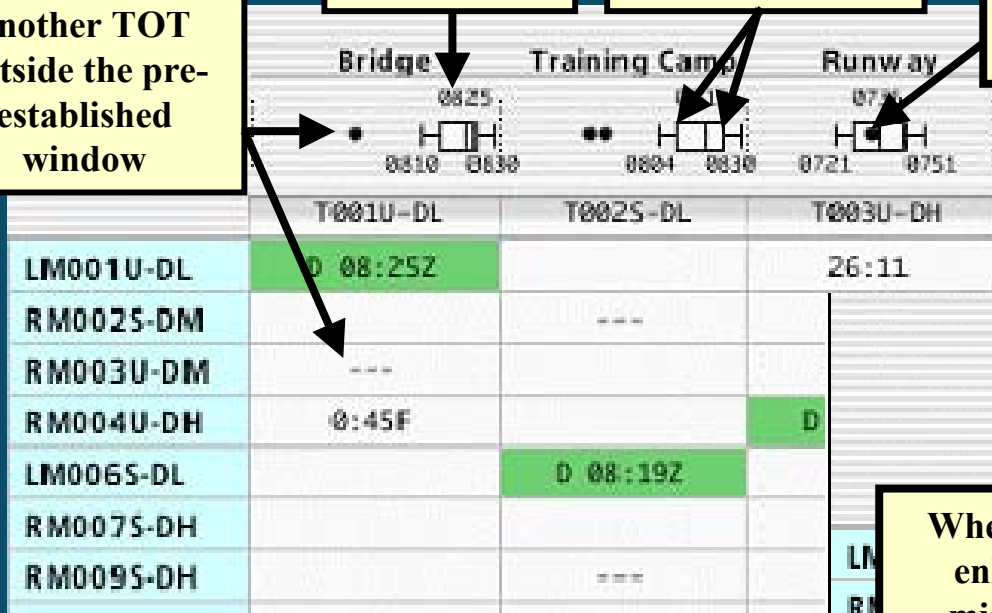
A Flexible Decision Space: The WOO

A candidate missile exists for another TOT outside the pre-established window

Preplanned TOT

The current window limits

A candidate missile exists for the current window around the TOT



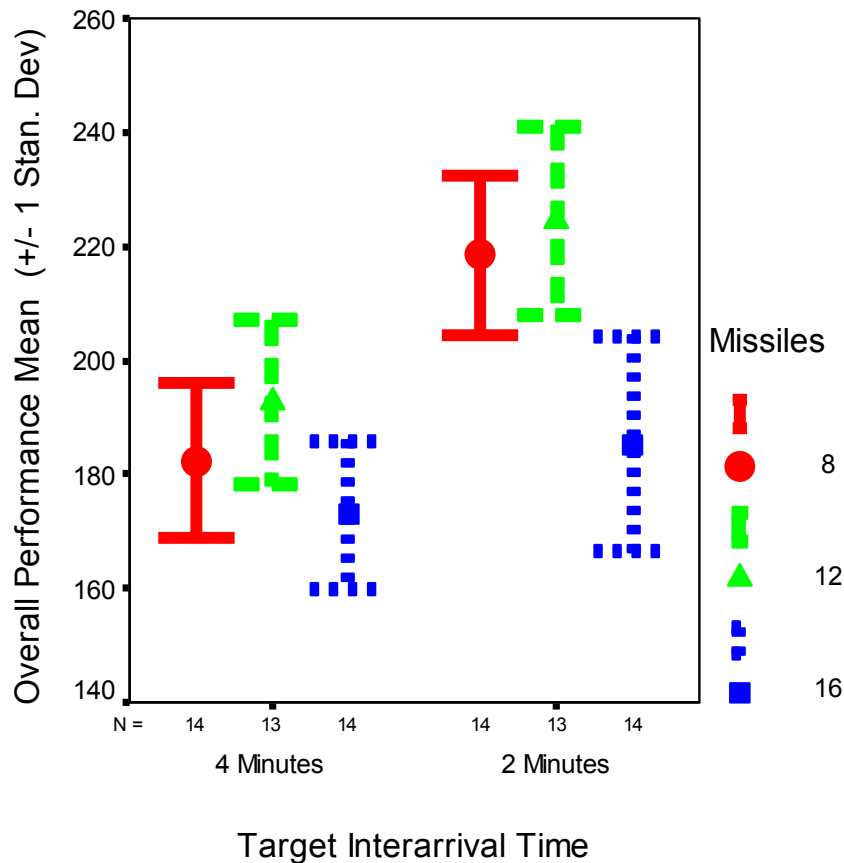
When the WOO is enlarged, more missiles become available and the decision time remaining is shown

Subject Testing

- 42 Subjects
 - ManTech & Damneck
 - 29 active duty, 13 retired personnel
- Factors under Investigation:
 - Missile levels: 8/12/16
 - Tempo: Slow/fast target arrival (4/2 minute interarrival times)
- Development of simulation model



Missile Level Results

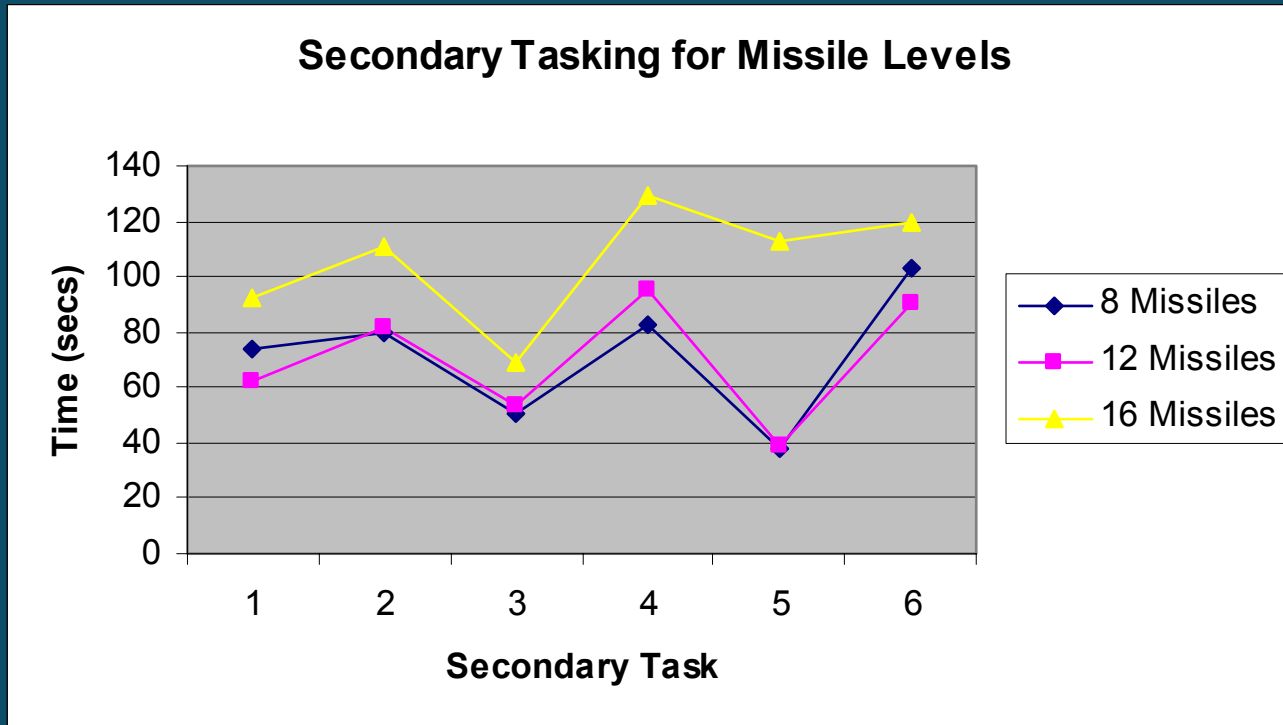


8 & 12 missiles were statistically significantly different than 16 missiles on the following measures:

- Decision Time
- Figure of Merit (overall performance)
- Utilization



Missile Levels & Secondary Tasking



Secondary Tasking - communications introduced through chat box



Tactical Tomahawks vs. UCAVs

- Mixed operations
 - Loiter patterns
 - Cost benefit analysis
- Supervisory control issues of multiple vehicles
 - Increasing autonomy of control
 - Automation bias
- Network Centric Warfare
 - Swarming UAVs
 - Visualizing cost functions

