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Systems Center  
San Diego*

# **Integrating Usability Engineering in the Iterative Design Process of the Land Attack Combat System (LACS) Human Computer Interface (HCI)**

Presented by:

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Space & Naval Warfare Systems Center

# Overview of LACS



- Study funded by two Future Naval Capability of the Office of Naval Research
- ATTD Transition Candidate for Tactical Tomahawk Weapon Control System (TTWCS) version 6 & 7
- SSC-SD leading work of the HCI development



## LACS FNCs Team

### ■ Government Labs

- SPAWAR Systems Center - San Diego, CA
- NAVSEA - Dahlgren, VA
- NAVAIR - Orlando, FL
- Naval Submarine & Medical Research Lab, Groton, CT



### ■ Industry & Federally Funded Labs

- Johns Hopkins Applied Physics Laboratory, MD
- Pacific Science & Engineering Group Inc., CA
- Southeastern Computing Consultants Inc., VA
- Lockheed Martin Advanced Technology Labs, NJ
- Lockheed Martin Mission Data Systems, PA



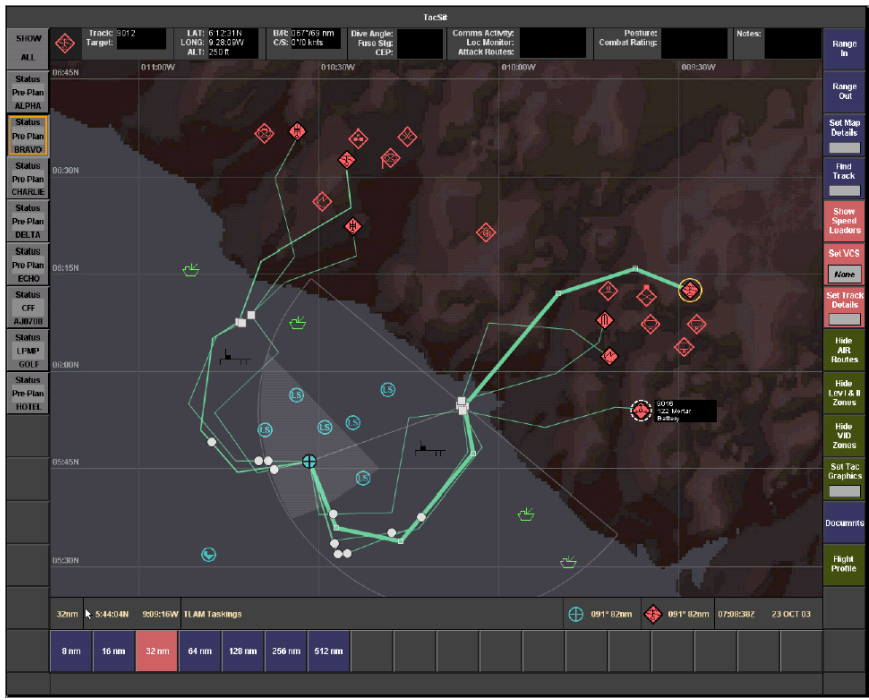
Advanced Technology Laboratories

### ■ Universities

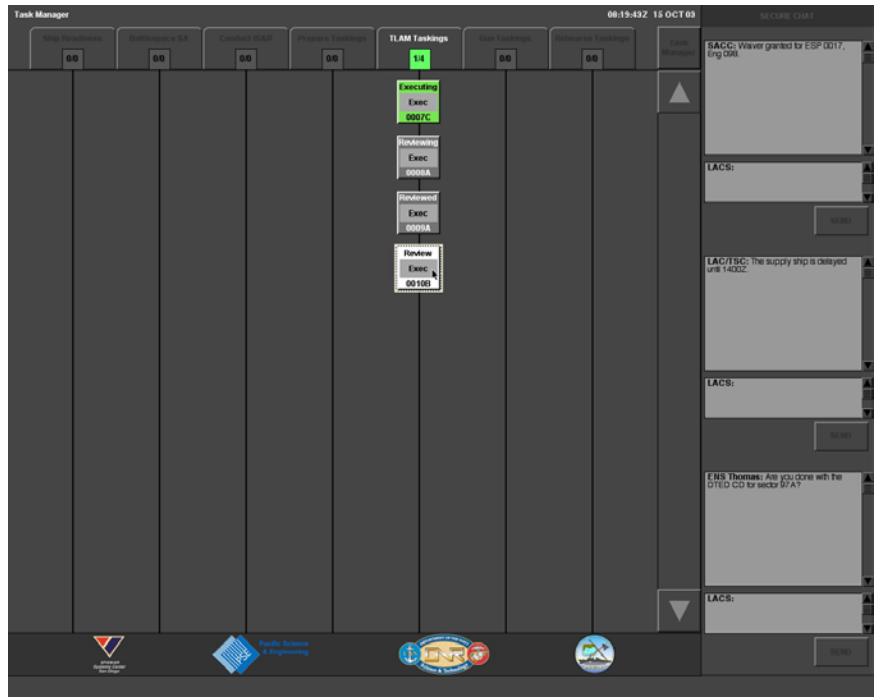
- University of Virginia
- University of Michigan



## LACS HCI



TacSit



Task Manager

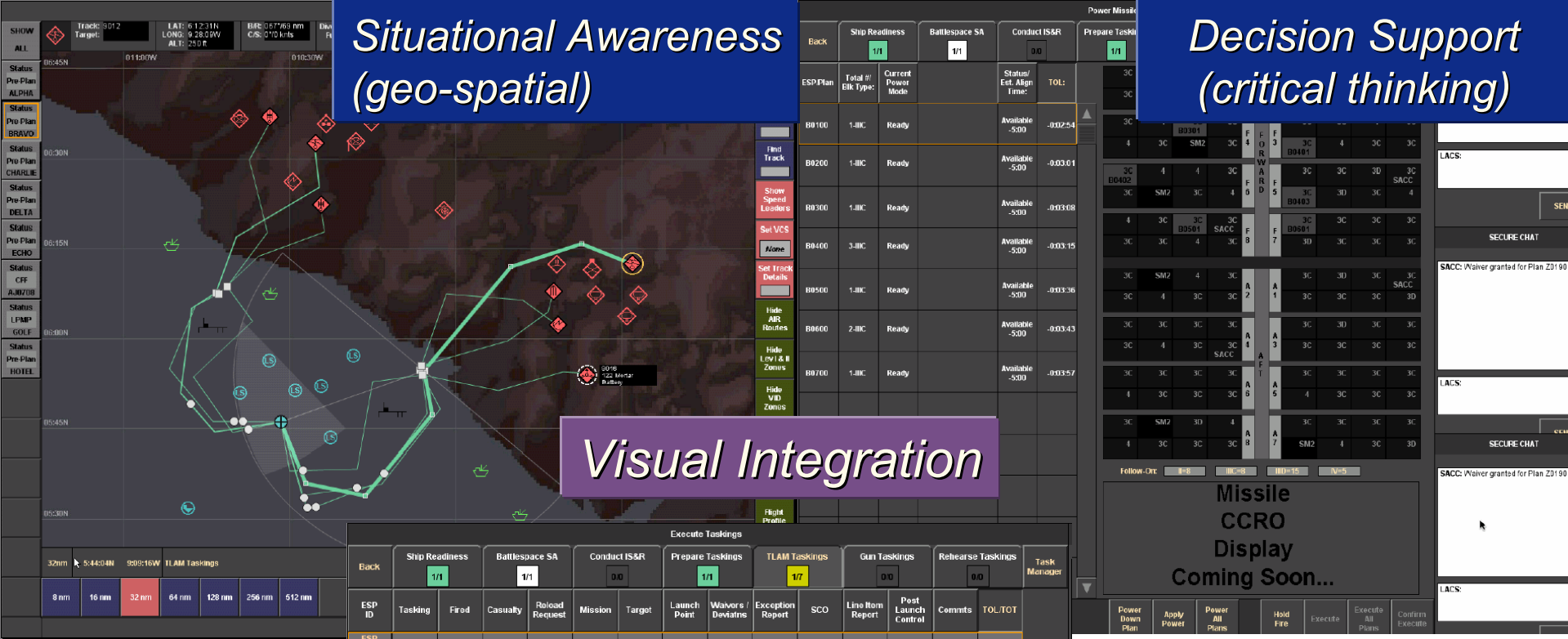
# Usability Engineering for the LACS HCI

*Situational Awareness  
(geo-spatial)*

*Decision Support  
(critical thinking)*

*Visual Integration*

*Task Management  
(Process visualization  
temporal - supervisory)*



The screenshot displays the LACS HCI interface, which is divided into several key sections:


- Map (Geo-spatial):** A central map showing a tactical area with various icons representing ships, missiles, and other assets. A green line indicates a path or mission track.
- Tasking Tables:** Multiple tables provide detailed information on mission tasks, including ship readiness, battlespace status, and tasking parameters.
- Missile Display:** A section titled "Missile CCRO Display Coming Soon..." is visible, indicating a future feature or a placeholder for missile status.
- Control Elements:** Various buttons and sliders are present for controlling the display and mission parameters.


Back	Ship Readiness	Battlespace SA	Conduct IS&R	Prepare Tasking
1/1	1/1	0.0	1/1	1/1


ESP ID	Tasking	Fired	Casualty	Reload Request	Mission	Target	Launch Point	Wavers Deviatns	Exception Report	SCO	Line Item Report	Post Launch Control	Comments	TOL/TOT
10/10	10-Prim	10-Prim	1	0	Pre-Plan	7	546.02N 10.31.31W	0	0	7	A-M	None		07:07:05Z 07:12:05Z
1/1	1-Prim	1-Prim	0	0	Pre-Plan 635249	1st Radar 9042	546.02N 10.31.31W	0	0	7	A-M	None		07:07:05Z 07:12:05Z
1/1	1-Prim	1-Prim	0	0	Pre-Plan 590735	2nd Radar 9011	546.02N 10.31.31W	0	0	7	A-M	None		07:07:12Z 07:12:12Z
1/1	1-Prim	1-Prim	1	0	Pre-Plan 781529	2nd Radio 9004	546.02N 10.31.31W	0	0	7	A-M	None		07:07:19Z 07:12:19Z
3/3	3-Prim	3-Prim	0	0	Pre-Plan 117264	Surf Missile 9015	546.02N 10.31.31W	0	0	7	A-M	None		07:07:49Z 07:12:49Z
1/1	1-Prim	1-Prim	0	0	Pre-Plan 902351	Motor Entry 0046	546.02N 10.31.31W	0	0	7	A-M	None		
2/2	2-Prim	2-Prim	0	0	Pre-Plan 570801	1st Howztr 9010	546.02N 10.31.31W	0	0	7	A-M	None		
1/1	1-Prim	1-Prim	0	0	Pre-Plan 131180	2nd Howztr 9013	546.02N 10.31.31W	0	0	7	A-M	None		




# Usability Engineering for the LACS HCI

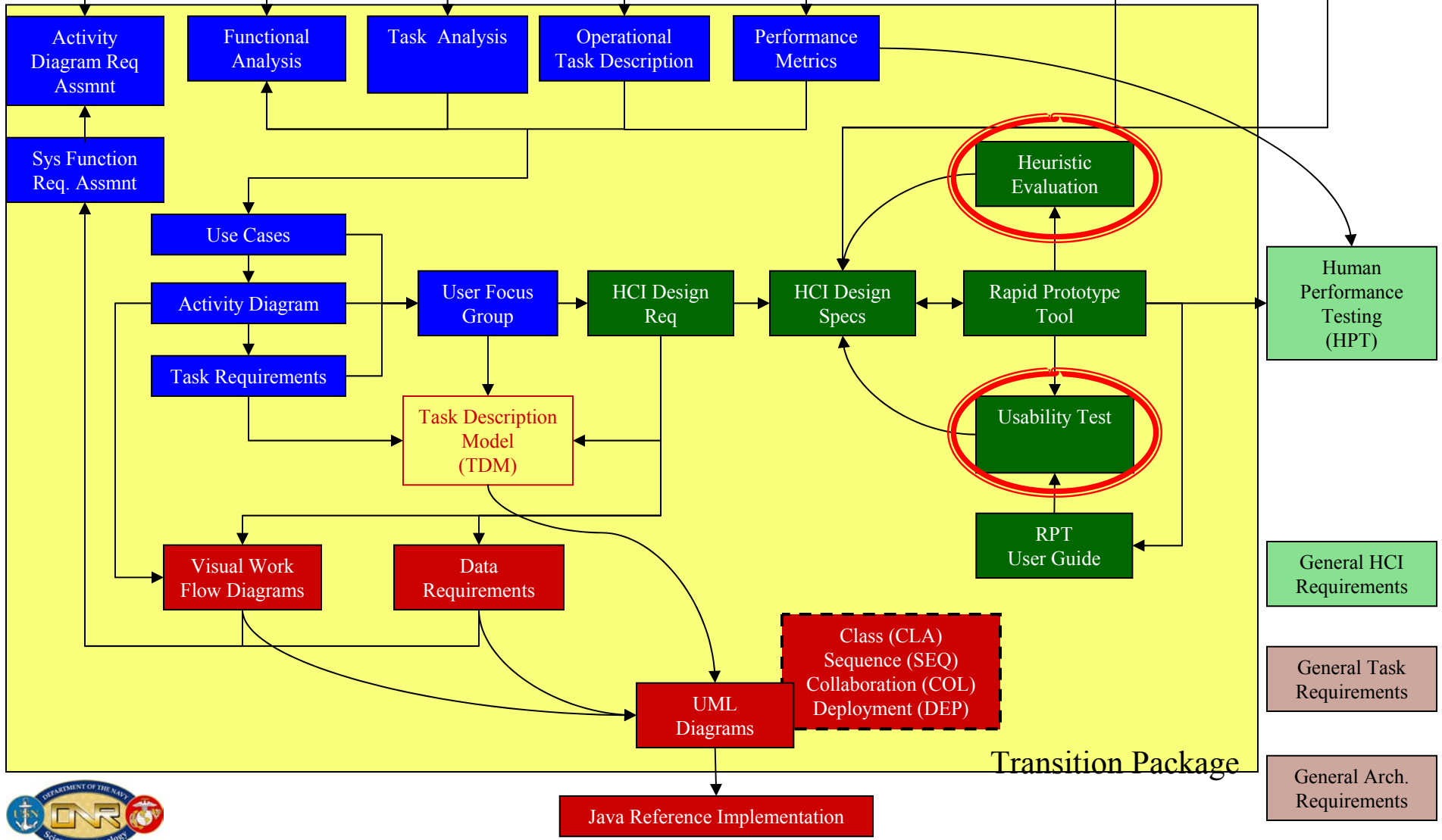
Analysis 

Design 

Implementation 

Transition 

Existing System Requirements    CONOPS & Design Reference Missions    Operational Requirements Docs    Discovery & Innovation    HCI Standards and Style Guide Docs

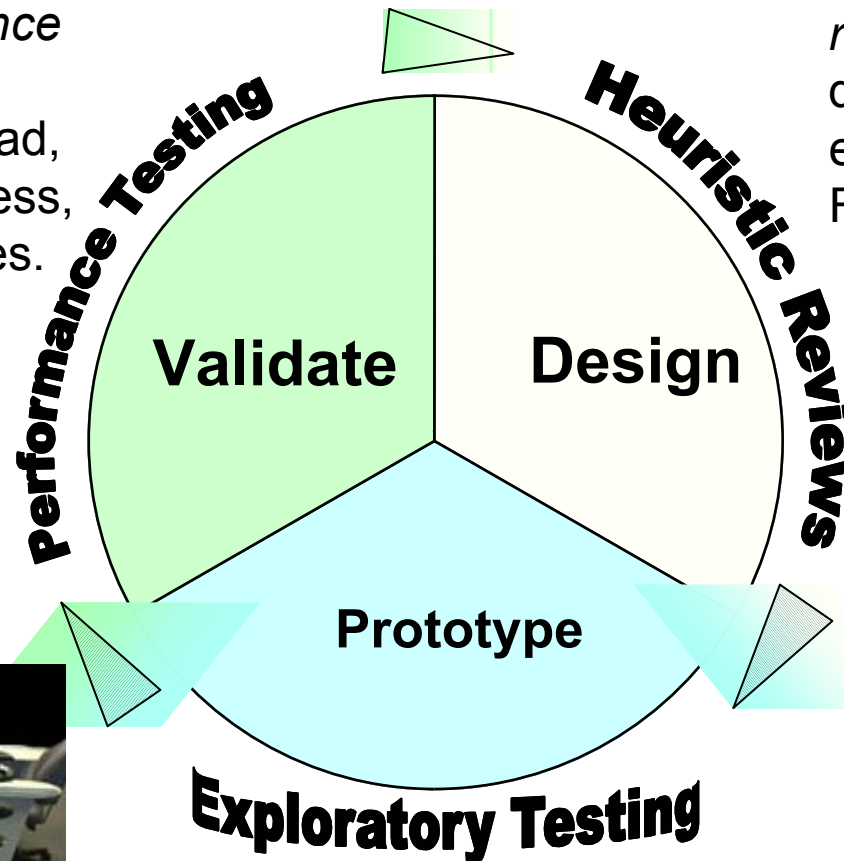




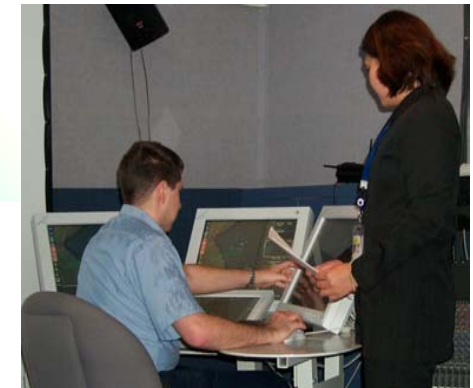
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## Usability Evaluation Within Spiral Development

Conduct *performance testing* to measure throughput, workload, situational awareness, and team processes.



Conduct *heuristic reviews* to ensure designs follow established Human Factors principles.

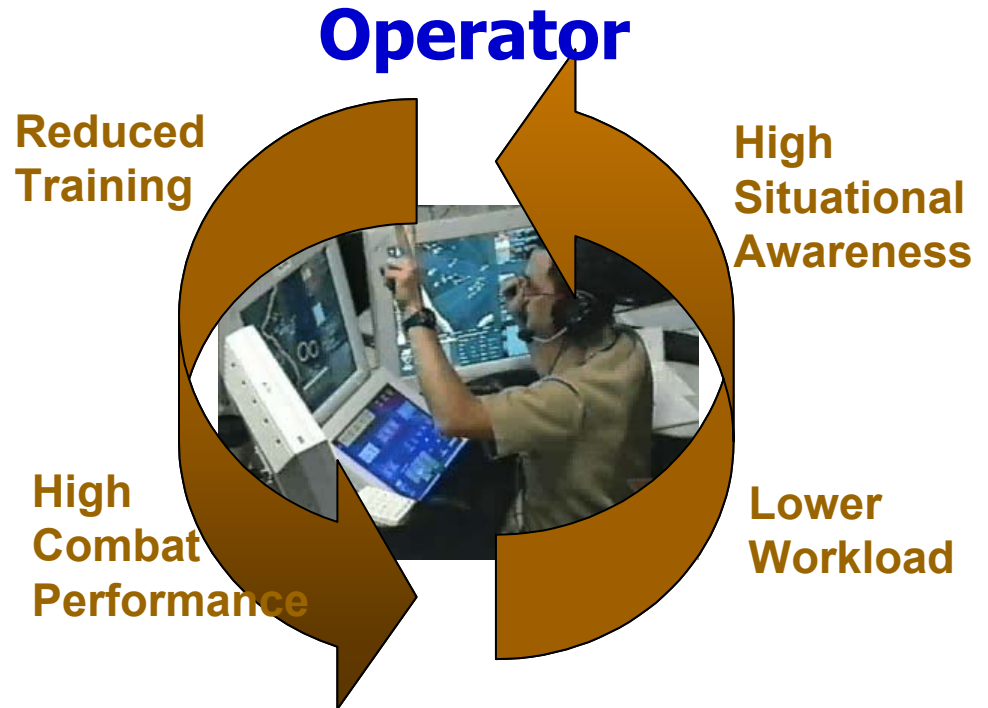


Conduct *exploratory testing* to iterate on initial designs and evaluate alternative design concepts.

# Usability Evaluation Objectives

### OPNAV Guidance

“... our ability to effectively and successfully employ Land Attack Warfare systems will directly reflect our commitment to Human Centered Design, Human Systems Integration and Optimal Manning . . .”



- ➔ Increase the combat effectiveness of Fleet Land Attack operators without increasing their workload, providing high situational awareness while reducing training time.



# Why is Usability Important?

- Systems need to be “user-friendly” to increase:
  - User efficiency
  - Productivity and Timeliness
  - Situational Awareness
  - User trust
- Workload reduction
- Training reduction
- Can determine success or failure of a system

***Fleet Buy-in!***

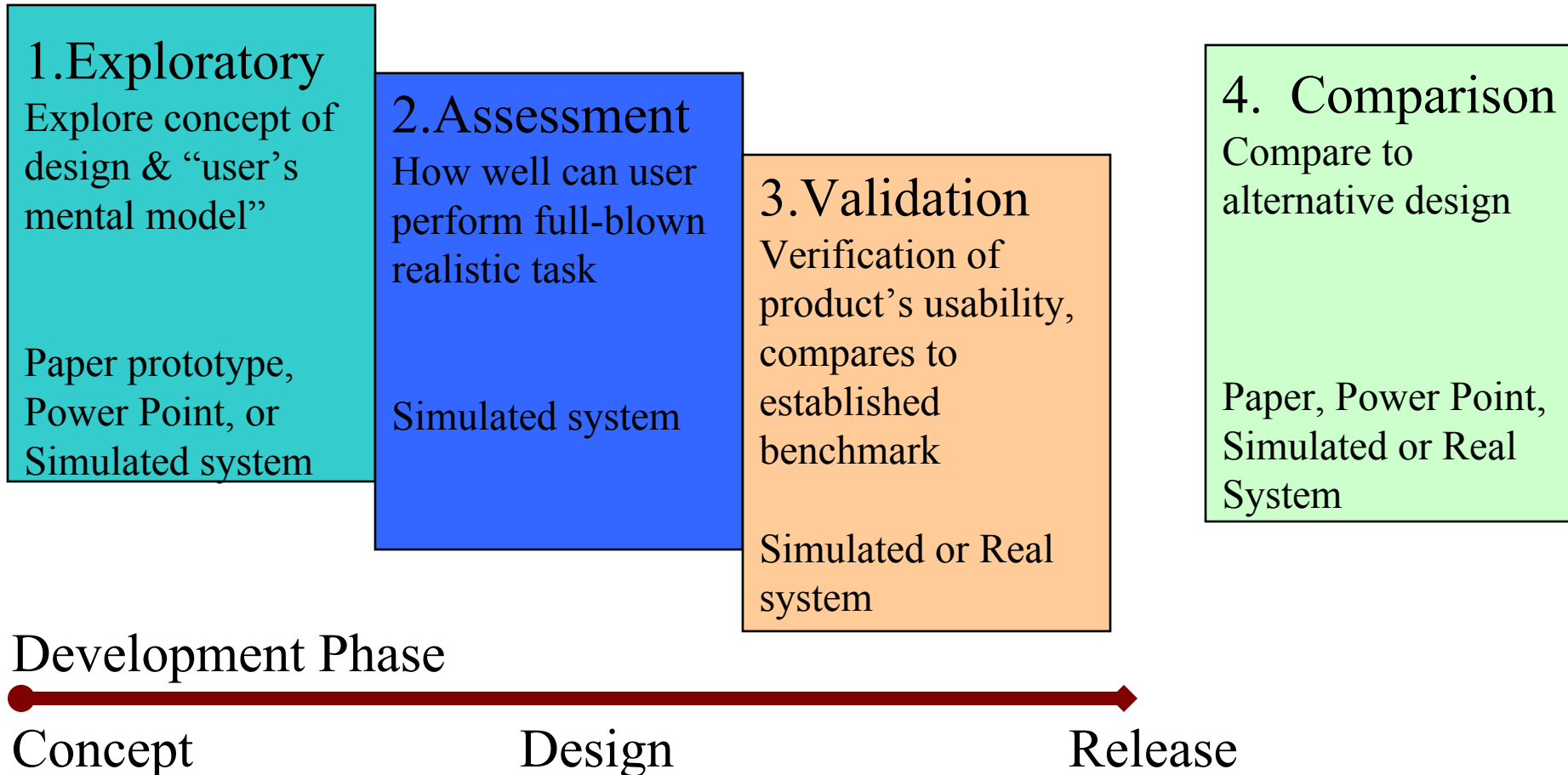
# Quarterly Usability Evaluations

- Focus of User Taskings Per Quarter
  - Q1 – Call For Fire (CFF), Mission Data Update (MDU), and a prepare pooled missiles task
  - Q2 – In-Flight Missile Health and Status monitoring screen
  - Q3 – Post Launch Monitor Phase
  - Q4 – Year-end Operability Test
- HCI constantly evaluated every quarter
- Improvements are made and re-tested the following quarter
- Validate design changes

# Usability Evaluation Methodology

- **Heuristic Evaluation (HE)**
  - HSI engineers individually evaluate the RPT against a set of usability criteria (called heuristics).
  
- **Usability Testing (UT)**
  - An inspection method of usability evaluations. Includes formal testing with fleet participants.

# Types of Usability Studies



## Heuristic Evaluation Process

- Compare the LACS interface to established usability criteria (“heuristics”)
- Conducted by HSI Engineers from SSC-SD, NSWCCD, and NAVAIR Orlando independent evaluated the LACS interface
- Report with prioritized usability issues
- Over 200 improvement recommendations
  - Many implemented and others require additional research



# Heuristics

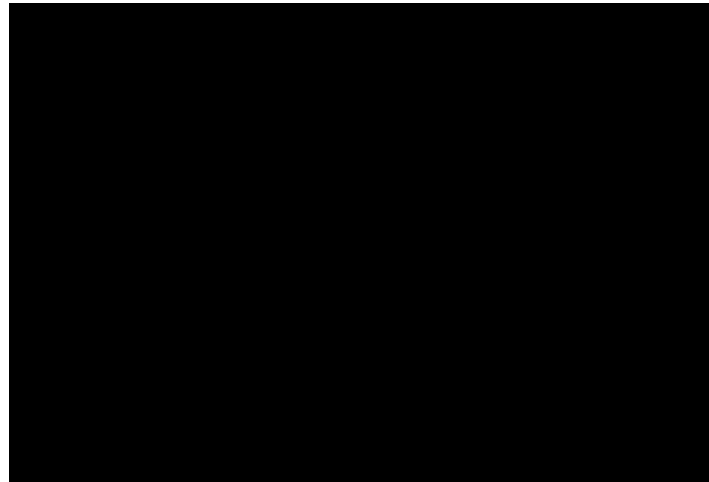
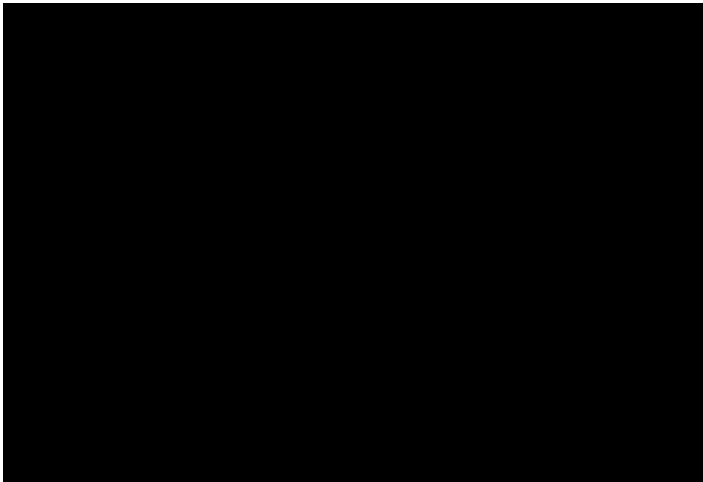
- 1. Visibility of system status**
- 2. Match between system and the real world**
- 3. User control and freedom**
- 4. Consistency and standards**
- 5. Error prevention**
- 6. Recognition rather than recall**
- 7. Flexibility and efficiency of use**
- 8. Aesthetic and minimalist design**
- 9. Help users recognize, diagnose, and recover from errors**
- 10. Help and documentation**

Nielsen, J. (1994). Heuristic evaluation. In Nielsen, J., and Mack, R.L. (Eds.), Usability Inspection Methods. John Wiley & Sons, New York, NY.

# Usability Testing Process

- Participants are real users
  - Total of 46 fleet participants individually tested. Include participants from FCTCPAC, FCTCLANT, USS Stethem DDG-63, USS Winston Churchill DDG-81, COMSECFLT
- Used real operational scenarios
  - Only 15 minutes spent explaining the scenario and minimum training on layout, symbology and color-coding
- Observed and recorded participants actions and comments
- Conducted low-fidelity usability tests using paper prototypes to explore design concepts and understand user needs
- Conducted high-fidelity usability tests using working prototypes to assess how well the sailors performed realistic tasks and to verify interface usability

# Video of Usability Tests



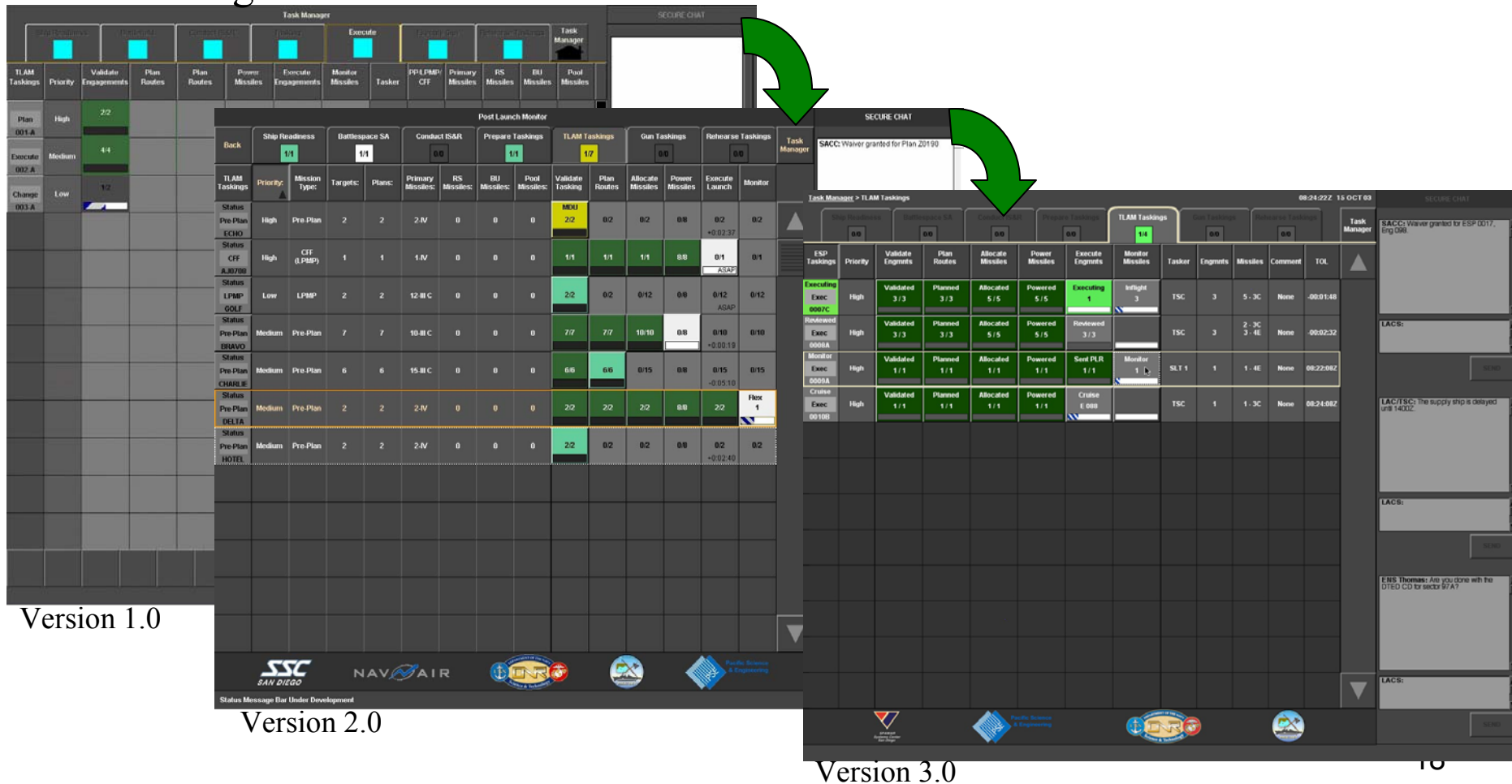
# Usability Evaluation Findings

- 9 heuristic evaluation reports
  - Tables summarized issue, location, heuristic violated, recommendation, and priority
- 6 usability testing reports
  - Tables included summary of design recommendations, and relevant operator comments

Table 1. Post Launch Monitor Interface Design Recommendations		
Rec #	Design Recommendation	Comment # Referenced
<b>Missile Timelines</b>		
1	Recommend implementing a click and drag capability on the timebars (like the hand in Acrobat with pdf files).	A1:9
2	Recommend duplicating the minute header at the bottom of the screen. It is tough to lineup timelines that are farther down on the page with the timescale at the top.	A1:9
3	Recommend that the missile timeline still show flex options even though they have been passed and were not selected. Maybe gray it out and put a black "X" through it to denote that this flex was missed or not selected.	A1:10
4	Recommend that the new timeline/aimpoint not appear on the timeline until the transmission has finished processing or . . . <b>Alternate Recommendation:</b> For any option of redirecting an in-flight missile, instead of updating the original timeline after processing a request, have a new branch split off below the original timeline. This will help show the exact point in which the missile redirects and, most importantly, it will allow for quick and easy comparison of the new branch and the original branch.	A1:10
5	Make the symbology clearer so the operator can more easily determine when the last possible second is to make a retargeting or flex decision. Is it the beginning of the tangent line?	A1:10

## Usability Testing Results

- Over 300 recommendations for new design ideas and improvements
- Implemented design changes were rolled into future builds for validation testing



The image displays three versions of the LACS HCI interface, illustrating usability testing results and design improvements. The interface is a complex task management system with multiple data tables and control panels.

**Version 1.0:** Shows a 'Task Manager' window with a 'Post Launch Monitor' section. The 'Post Launch Monitor' table includes columns for 'Ship Readiness', 'BattleSpace SA', 'Conduct ES&R', 'Prepare Taskings', 'TLAM Taskings', 'Gun Taskings', and 'Release Taskings'. The 'TLAM Taskings' table has columns for 'Status', 'Priority', 'Mission Types', 'Targets', 'Plans', 'Primary Missiles', 'RS Missiles', 'BU Missiles', 'Pool Missiles', 'Validate Tasking', 'Plan Routes', 'Allocate Missiles', 'Power Missiles', 'Execute Launch', and 'Monitor'. The 'Execute Launch' column shows a value of '01' with the text 'ASAP' below it.

**Version 2.0:** Shows a 'Task Manager' window with a 'Task Manager' section. The 'Task Manager' table includes columns for 'ESP Taskings', 'Priority', 'Validate Engmnts', 'Plan Routes', 'Allocate Missiles', 'Power Missiles', 'Execute Engmnts', 'Monitor Missiles', 'Tasking', 'Engmnts', 'Missiles', 'Comment', and 'TOL'. The 'Execute Engmnts' column shows a value of '1' with the text 'ASAP' below it.

**Version 3.0:** Shows a 'Task Manager' window with a 'Task Manager' section. The 'Task Manager' table includes columns for 'ESP Taskings', 'Priority', 'Validate Engmnts', 'Plan Routes', 'Allocate Missiles', 'Power Missiles', 'Execute Engmnts', 'Monitor Missiles', 'Tasking', 'Engmnts', 'Missiles', 'Comment', and 'TOL'. The 'Execute Engmnts' column shows a value of '1' with the text 'ASAP' below it.

Green arrows indicate design changes between versions: from Version 1.0 to Version 2.0, and from Version 2.0 to Version 3.0. The 'Task Manager' window in Version 3.0 shows a 'SACC Waiver granted for Plan 20190' message.

At the bottom of the interface, there is a 'Status Message Bar Under Development' and logos for SSC SAN DIEGO, NAVY AIR, and other organizations.



# Usability Testing Results

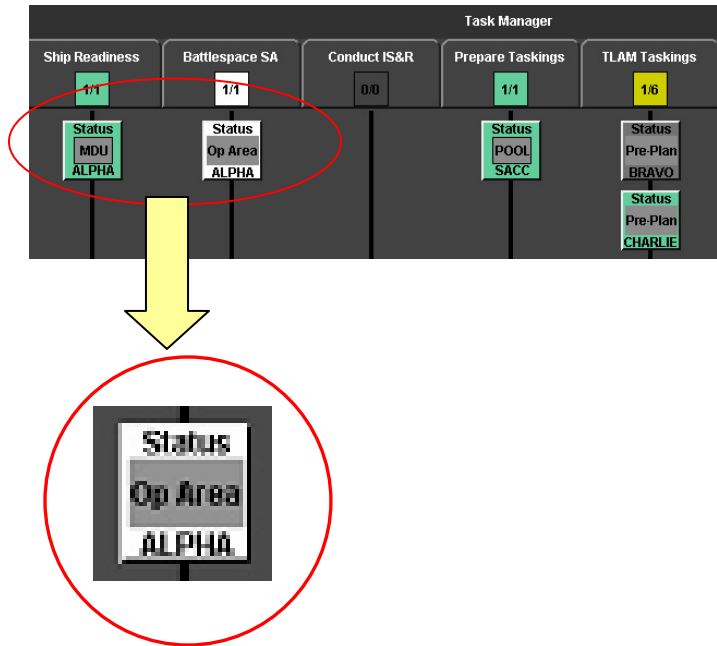
1. Indicated interface effectively supports user taskings
  - Provided needed information to complete their taskings
  - Many operators launched missiles on time
  - One operator can accomplish same taskings than that of a team of Tomahawk operators
2. Met operators' approval
  - “I like this, this is sweet.”
  - “Still impressed. Impressed every time we come out here.”
  - “Like the displays, the layouts, the colors.”
  - “A lot of data, but it's not too much, especially if there's only 1 operator. Everything is covered. Looks good to me.”
3. Raised additional research questions

# HCI Improvements

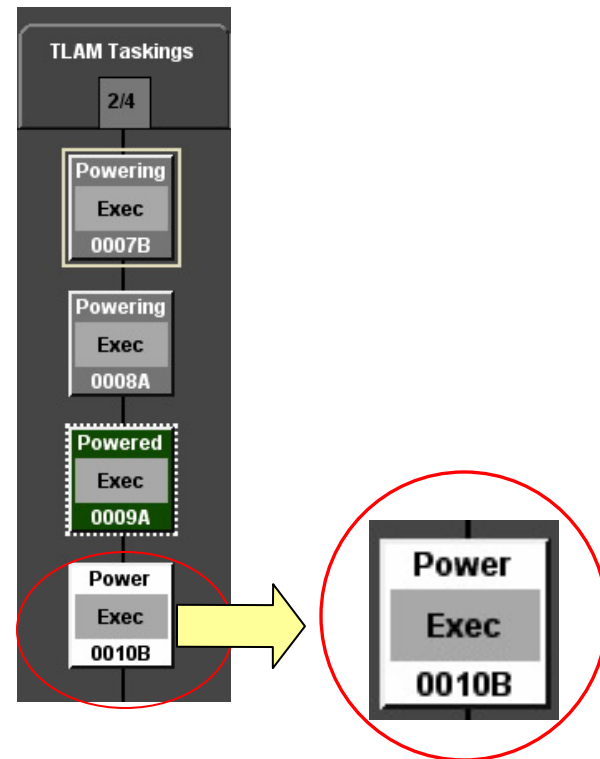
- Better understanding of operator's mental model, fleet CONOPS, and tasks
- Improved color coding scheme
- Provided better feedback as to what LACS is completing and what taskings operator needs to accomplish
- Provided needed information and better organization of information to support operator tasking
- Improved phraseology
- Improved navigation and less searching
  - Provided needed information at a higher level and detailed information in a lower level
  - Decreased number of drill down interfaces
- Provide improved attention management

## Example of Improvements

### 1. Improved color-coding



### 2. Provided better feedback as to what LACS is completing and what taskings operator needs to accomplish




## Example of Improvements

Provided needed information and better organization of information to support operator tasking

ESP XYZ: Task Manager > Execute TLAM > Validate

UNCLASSIFIED

SECURE CHAT



Plan	Ownership Role	Alternate Outcome	Tasker	Mission	Target	Duration	Range	Launch Area	Flight Profile	Avoidance	Flight Corridors	Comment	TOL
Comply 111.11	Pool	None	SACC 0708Z	LPMP 562926	Hostile 1023	IBC 350	350	N/A	N/A	N/A	N/A		-06:03:21
Comply 595.55	Backup 00:12:59	None	SACC 0708Z	LPMP 562926	Hostile 1022	IBC 350	350	N/A	N/A	N/A	N/A		-05:57:29
Comply 222.22	Backup 00:12:59	None	SACC 0708Z	LPMP 562926	Hostile 1024	IBC 350	350	N/A	N/A	N/A	N/A		-05:53:09
Comply 333.33	Ready Spare 00:12:59	None	SACC 0708Z	LPMP 562926	Hostile 1025	IBC 350	350	N/A	N/A	N/A	N/A		-05:22:19
Comply 444.44	Primary	None	SACC 0708Z	LPMP 562926	Hostile 1026	IBC 350	350	N/A	N/A	N/A	N/A		-05:03:17

ESP 0001A Engmt	OS Role/ Priority	Spare Route	Alternate Outcome	Type/ Msn Id/ Tasker	Target	Munition	Route Distance	PLP/ Direction	Route Conflicts	Avoidance Conflicts	Flight Corridor Conflicts	Remarks	TOT	TOL
Planned E 007	Primary High	RS +400 BU AS	None	Pre-Plan 31325 TSC	Radar 3	1- 3C	470 nm	ALPHA STBD	None	None	None	None	09:38:00Z	00:38:37
Planned E 008	Primary High	RS +400 BU AS	None	Pre-Plan 31326 TSC	Centrl Bldg	2- 3C	390 nm	ALPHA STBD	None	None	None	None	09:38:00Z	00:48:37
Planned E 005	P/ARS High	RS +500 BU AS	None	Pre-Plan 31322 TSC	Radar 1	1- 3C	370 nm	ALPHA STBD	None	None	None	None	09:38:00Z	00:50:37
Planned E 003	Primary High	RS +400 BU AF	None	Pre-Plan 31313 TSC	Radar 3	1- 3C	338 nm	ALPHA STBD	None	None	None	None	09:38:00Z	00:55:37
Planned E 002	Primary High	RS +400 BU AF	None	Pre-Plan 31312 TSC	Radar 2	1- 3C	279 nm	ALPHA STBD	None	None	None	None	09:38:00Z	01:02:37
Planned E 004	Primary High	RS +500 BU AF	None	Pre-Plan 31314 TSC	Centrl Bldg	2- 3C	268 nm	ALPHA STBD	None	None	None	None	09:38:00Z	01:03:37
Planned E 014	Primary High	RS +200 BU AS	None	Pre-Plan 31331 TSC	Fuel Tank 1	1- 3C	256 nm	ALPHA STBD	None	None	None	None	09:38:00Z	01:05:37
Planned E 015	Primary High	RS +200 BU AS	None	Pre-Plan 31332 TSC	Fuel Tank 2	1- 3C	254 nm	ALPHA STBD	None	None	None	None	09:38:00Z	01:05:44
Planned E 001	Primary High	RS +400 BU AF	None	Pre-Plan 31311 TSC	Radar 1	1- 3C	249 nm	ALPHA STBD	None	None	None	None	09:38:00Z	01:06:37
Planned E 018	BU Medium	--- BU AF	None	Pre-Plan 31431 TSC	Ammo St 1	1- 3C	417 nm	ALPHA STBD	None	None	None	None	---	---
Planned E 019	BU Medium	--- BU AF	None	Pre-Plan 31432 TSC	Ammo St 2	1- 3C	411 nm	ALPHA STBD	None	None	None	None	---	---
Planned E 020	BU Medium	--- BU AF	None	Pre-Plan 31433 TSC	Ammo St 3	1- 3C	417 nm	ALPHA STBD	None	None	None	None	---	---

Comply W E CANTICO

Close Modify LPMP Settings Add Manual Plan Print Validation Report Send Validation Report

Thank you for your time

Any Questions?