



Human Factors Engineering *Mission-Centered* *Human-Computer Interfaces (HCI)*



*“Systems built to support
performance & efficiency in
support of warfighter
missions.”*

Human-Centered Design 2441

Space & Naval Warfare Systems Center San Diego

Navy Modeling & Simulation Management Office
Verification, Validation & Accreditation
Technical Working Group Workshop 16
San Diego, CA. March 3, 2004

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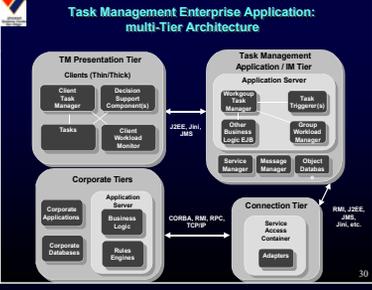
The purpose of this brief is to introduce the concept of a Goal-Explicit WIS and the benefits of such systems to the warfighter.

For more information on research that led up to these concepts refer to the following SSC-SD reports:
TR 1874 Design and Evaluation of Warfighter Task Support Methods in A Multi-Modal Watchstation. 2002
TR 1880 User-Centered Design for Land Attack Warfare: Advanced Tactical Technology Demonstration (ATTD) 2002

Summary - HFE Support for C4I Systems



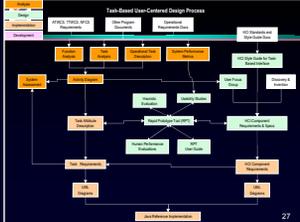
MISSION VISUALIZATION & DECISION SUPPORT



INFORMATION ARCHITECTURE



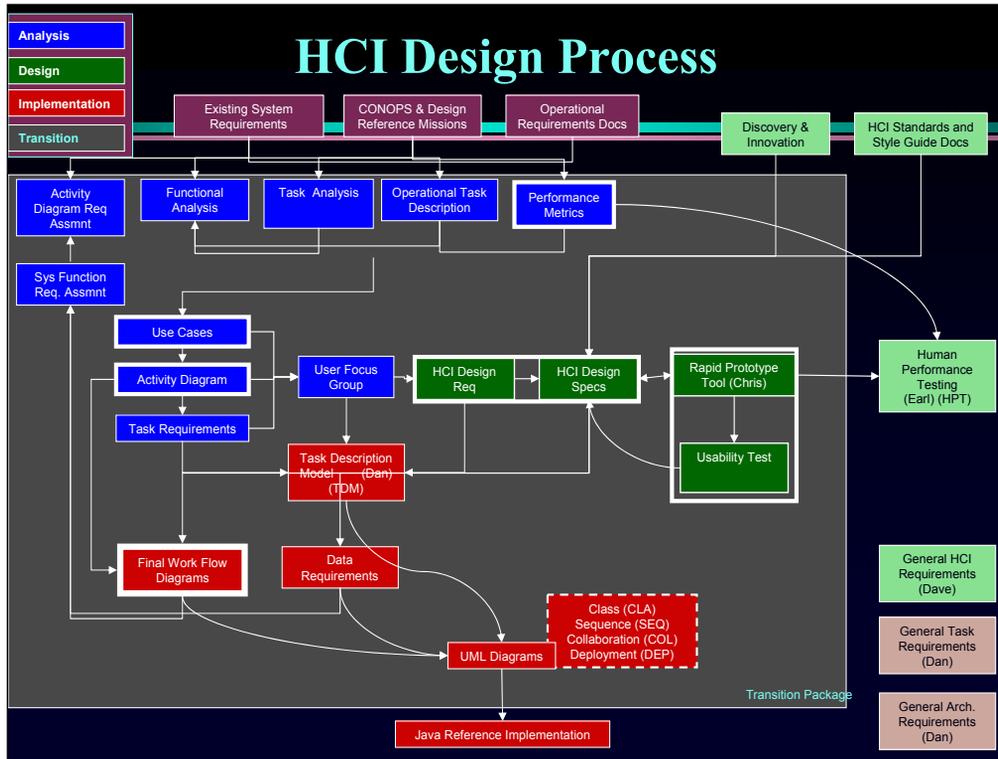
INDIVIDUAL & TEAM PERFORMANCE



DESIGN PROCESS

Beyond the current focus in Land-Attack warfare the products of the FNC apply to other Navy and joint mission domains.

1. (upper left) The Task supervision aids apply across mission domains where there is a defined and repeatable process. The procedures for HCI can be re-used to simplify training in other domains.
2. (upper right) The Task Management information architecture has a universal appeal across systems where older legacy software is mixed with newer HCI information layers.
3. (lower left) The workspace as represented by the ergonomic workstation and team layouts can be reused in other individual or team warfare areas.
4. (lower right) The design process which systematically defines tasks and a user-centered design is repeatable and the tools and products can be used by other programs to streamline the R&D process.



Human Systems Integration



Enhance Total System Performance While Reducing Life-Cycle Cost

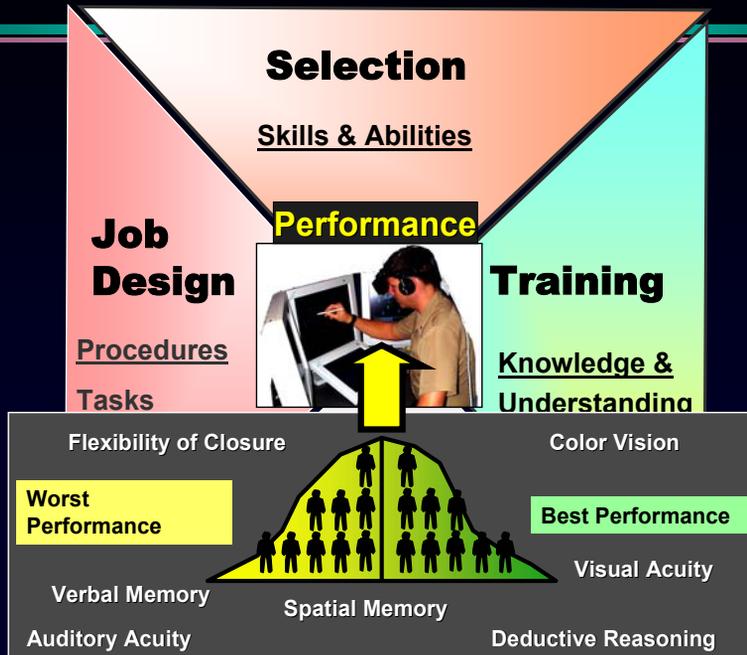


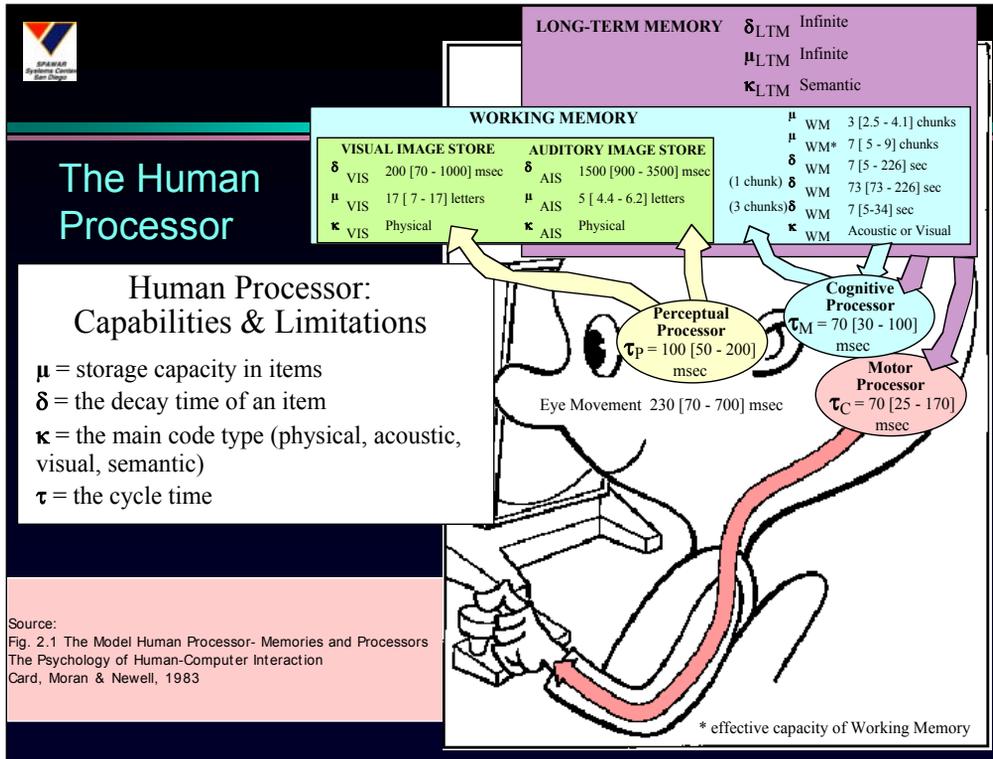
Overview

- HFE body of knowledge
- Specific HFE R&D for Naval Systems.
- What are key design properties & features?
- How to get from here to success...



HFE and H.S.I Impact





As presented by Card, Moran & Newell The Human Processor model is a set of Processors and Principles.

The perceptual, motor and cognitive subsystems all have varying cycle times, decay and storage capacities. Ave around 1/10th second time

Note that:

the visual processor is fast, visual scanning is fast, 230ms ave (70 -700) Is composed of foveal and peripheral processing coupled with head movements

Visual data in working memory decays more rapidly than audio,

The working memory cognitive processor is a critical component in combat systems task support. Chunking and grouping of data can improve storage capacity.

Long-term stores are “permanent” and can conflict with newer information where under stress the long-term data may prevail.

Learning, retrieval, choice, interference, etc. effect performance

Rationality Principle: Goals + Task + Operators + Inputs + Knowledge + Process limits = Behavior



Human Processor Support

- **VISUAL SYSTEM**
 - » Support rapid visual search through all tasks
- **VISUAL - MOTOR SYSTEM**
 - » Allow simple command movements for task shifting vs. command entry & purely visual tasks.
- **SHORT-TERM MEMORY**
 - » Provide functional support for transient info storage
 - » Provide task guidance, progress and stimulation for retrieval.
 - » Aid in retrieval where possible.
- **LONG-TERM MEMORY**
 - » Provide databases and retrieval mechanisms for tactics, ROE, procedures.



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Research Leading to Guidelines

Performance...



1980s



1990s

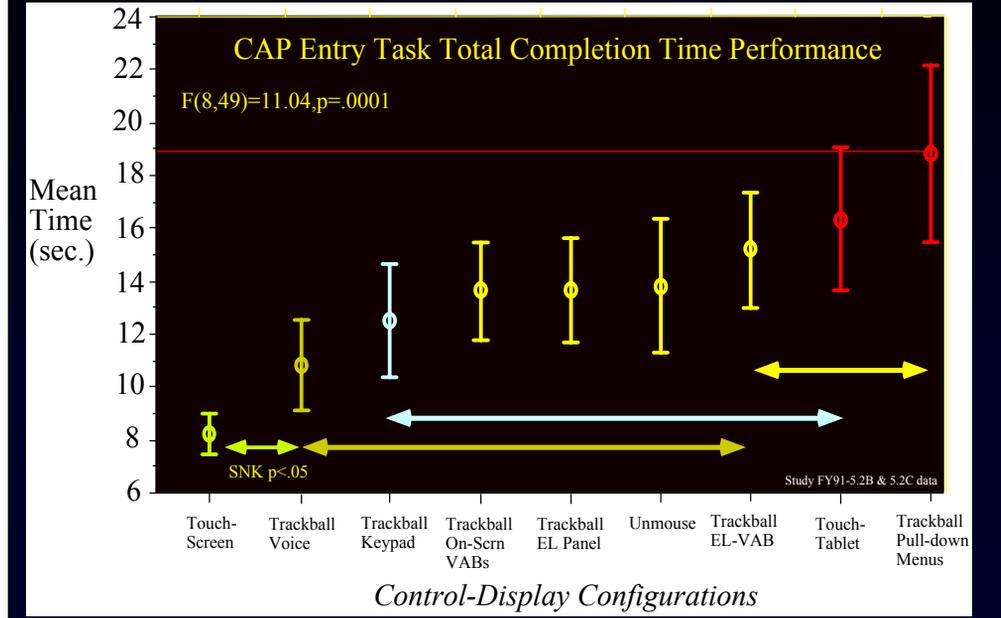


2000+

1. *Part-task performance*
2. *Whole-task performance*



Research Leading To Guidelines



This viewgraph from one of the tasks studied shows that the commonly used Trackball + Pull-down menu arrangement is a slow performer. Touch entry and voice input performed very well, with touch outperforming the next closest condition. Touch required special software HCI tool called the Advanced Hooking Algorithm which I will discuss shortly.



Conclusion

- We need to select GUI methods which afford best efficiency and performance.
- Touchscreen with on-screen buttons...
- Use pull-downs for infrequent tasks...

Osga G.A. (1995) *Combat Information Center Human-Computer Interface Design Studies*.
NCCOSC Technical Document 2828



Research Leading To Guidelines - Frequent HCI Tasks

Advanced (Track)
Hooking Algorithm (1991)
Track pre-select information (1992)
(ONR 6.2)

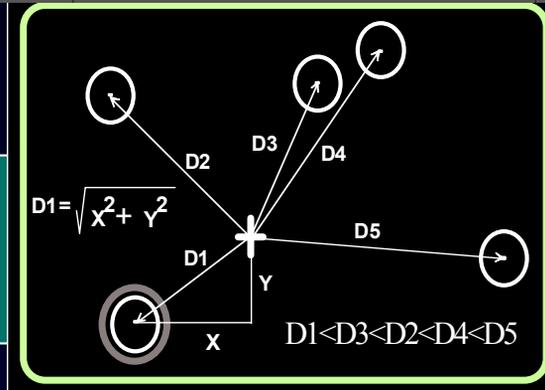
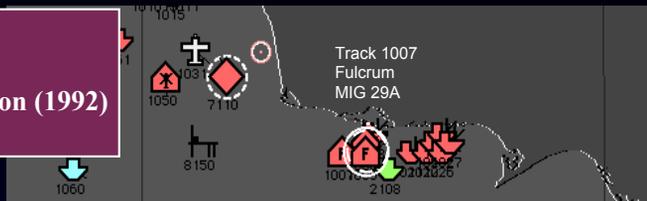
Impact:

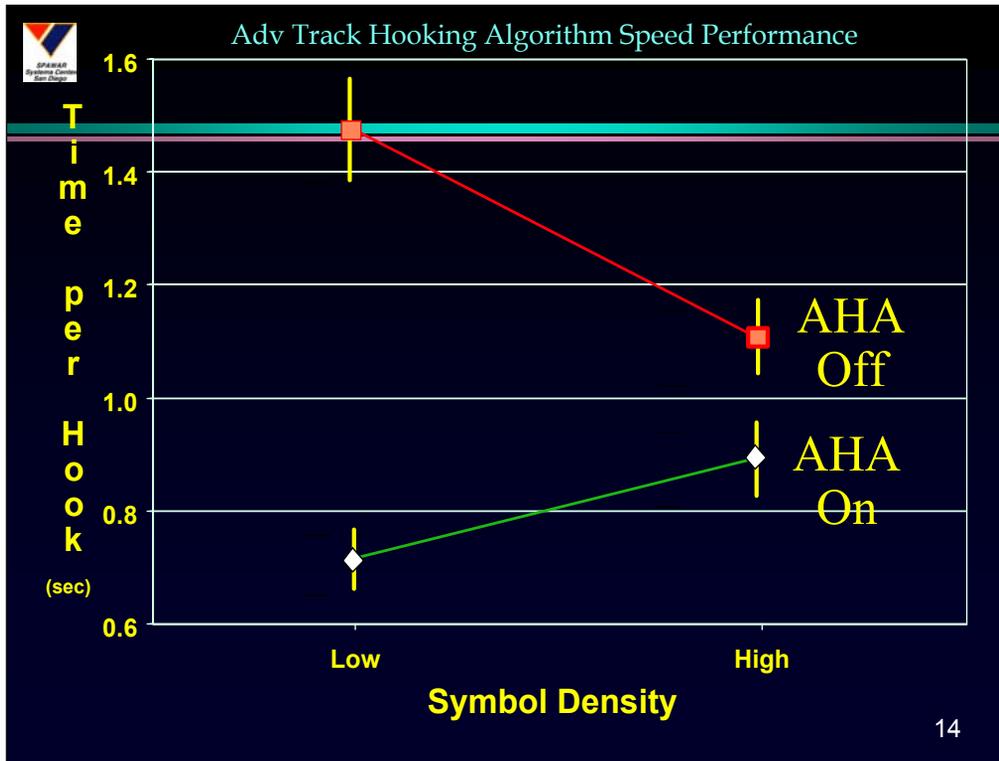
Improves track selection and information retrieval with trackball, touchscreen, mouse, touchtablet (all devices) by a factor of 2-3.

Fleet Installation:

ACDS Block 1 Software 1996
CVN69 1997

Common Display Kernel (CDK) 1995
Aegis ADS MK 6 (1998)





The performance gain for selecting tracks is significant. These results are shown for a combination of data for trackball, touchscreen and touchtablet devices.

The performance gain was significant for both low and high track densities.

Without AHA , using current shipboard trackballs, users can select 17 tracks in a 30 second period using a given track test pattern. With AHA, using a touchscreen, well over 100 tracks can be selected .



- **LEVEL 1 SA =**
 - *perception* of the elements in the environment within a volume of time and space.
- **LEVEL 2 SA =**
 - *comprehension* of their meaning,
- **LEVEL 3 SA =**
 - *projection* of their status in the near future.

Endsley & Jones (2000) "Overcoming Representation Errors in Complex Environments"
Human Factors Vol 42 (3) Fall 2000, pp 367-378



Multi-Modal Watchstation

Key Features



- Work Visualization
- Mission Plans & Goals
- Draft Task “Products” with automation support
- Consistent visual components
- Task Management
- Multi-Tasking Support

Osga, G. Van Orden K. Campbell, N. Kellmeyer, D. Lulue D. (2002) Design and Evaluation of Warfighter Task Support Methods in a Multi-Modal Watchstation. Space & Naval Warfare Center San Diego Tech Report 1874.



Shipboard Complexity

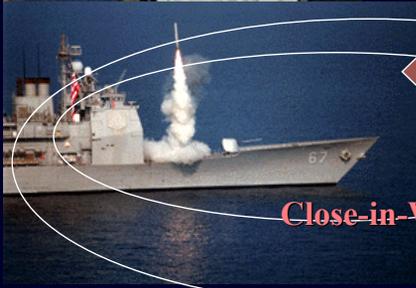




Example: Air Defense Warfare

Tactical and Communications ADW Team Tasks

- Communicate Results to Battlegroup
- Communicate Results to Allies
- Coordinate Battlegroup Defensive Counter Air
- REDCROWN - screen aircraft in battlegroup



Identify & Monitor

Query & Warn

Illuminate & Cover

Missile or Gun Engage

Chaff & Jam

Close-in-Weapons Defense



Capture Research Results

Prototypes



Guidelines



Transition Packages

HCI Style

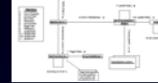
HCI Design

Tech Reports



Software Models

Collaboration Diagrams



Class Diagrams



Use Case





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MC HCI Design Qualities

- | | |
|---|--|
| 1. Expand Work Support Requirements | 1. All task types and decision phases. |
| 2. Expand Design Focus | 2. Task-Oriented Design with explicit Task Goals |
| 3. Provide Quality Mission Process Products | 3. User Review in Supervisory Mode. |
| 4. Support Naturalistic Decision Making and Critical Thinking | 4. High level and drill-down views. |
| 5. Build easy to train HCI! simple procedures. | 5. Keep procedures simple and consistent! |
| 6. Build HCI for evolution. | 6. Modern software methods. |
| 7. Provide quality information to tasks. | 7. Quality and timeliness |

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Task Goals shown explicitly mean that they are depicted by graphics, labels or both.

Work is defined as the total workload environment for the warfighter - not a narrow application.

Task-orientation simplifies the design concept for the user.

The concept of a dynamic G-WIS are important for both performance and training.



Support All Mission Task Types

1. Expand Work Support Requirements

Task Types:

- Tactical/Mission
- Work Management
- Communication
- Computer

Adv Interface Support

- Decision Aids.
- Work Management Aids.
- Communication Efficiency and Integration.
- Adv Interface Features.

*All these tasks make demands on warfighter
Cognitive - Visual - Psychomotor sub-systems*

There are similar task properties across various mission domains.



Support All Mission Task Cognitive Phases

1. Expand Work Support Requirements

Task Phases:

1. Initiation (triggering)
2. Orientation
3. Review
4. Decision & Action
5. Confirmation
6. Transition

Adv Interface Support

- Cooperative triggering
- Information sets
- Task Products
- Visualization of pros/cons
- Visual Task History/Plans
- Dynamic Work Lists

Tactical, Operational, Communication, Computer

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Tasks have dynamic (time) related properties and work function properties with two important requirements for system design:

1. Support all task phases.
2. Support all types of tasks - mission/work mgmt/HCI/communications.

The goal of design is to support ALL phases of task activity - from initiation thru transition.

These task phases EXPAND the traditional OODA loop - they cover the often missing support in task transition - a heavy cognitive load on users.



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Task Centered HCI Navigation

2. Task Oriented Design Focus

- **Functional Design** breaks the task procedure down into a set of functions often shown in complex “machine language”
- **Task-Centered Design** clarifies the task goal and intent in a simplified language.

VCR Example

Decide to record a specific program

Function Oriented

Press “Menu”
Tab down 3
Press “timer set REC lock”
Tab down 2
Select “Enter program”
Move cursor to start time
Press “Enter key” etc....

Task Oriented

Select “Record basketball game Sunday afternoon”*.

Aids Include:

- Menu of task choices on screen.
- VCR Plus task code in TV Guide.

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To illustrate the difference between function-based and task oriented systems a VCR design example is used due to it’s familiarity.

The important point is that function based systems are borne out of an engineering process that loses the concept of task goals and task needs, while satisfying engineering goals for functional flow.

Task-Centered Navigation - Tomahawk

Execute TLAM		Execute Gun		Rehearse Taskings	
1/5		2/2		0/0	
Validate Tasking	Plan Routes	Allocate Missiles	Power Missiles	Execute Launch	Monitor

Back	Maintain Readiness	Maintain SA	Conduct IS&R		Prepare Taskings	Execute TLAM		Execute Gun		Rehearse Taskings		Task Manager		
	0/0	1/1	0/0		0/0	1/5		2/2		0/0				
TLAM Taskings	Priority:	Mission Type:	Targets:	Plans:	Primary Missiles:	RS Missiles:	BU Missiles:	Pool Missiles:	Validate Tasking	Plan Routes	Allocate Missiles	Power Missiles	Execute Launch	Monitor
Status ESP ECHO	High	CFF (LPMP)	2	2	2-III C	0	0	0	2/2	0/2	0/2	0/0	0/2	0/2
Status ESP GOLF	Low	LPMP	2	2	12-III C	0	0	0	2/2	ASCM 2/2	0/12	0/0	0/12	0/12
Status ESP BRAVO	Medium	Pre-Plan	7	7	10-III C	0	0	0	7/7	7/7	10/10	0/0	0/10	0/10
Status ESP CHARLIE	Medium	Pre-Plan	6	6	15-III C	0	0	0	6/6	6/6	0/15	0/0	0/15	0/15
Status ESP DELTA	Medium	LPMP	2	2	5-III C	0	0	0	2/2	0/2	0/5	0/0	0/5	0/5

Strike Plan Overview

Task Progress

Shown is the task management display for Land-Attack with the Tomahawk task set selected. The task progress is dynamically updated - the colors and graphics in boxes change as the mission progresses - WHITE means something for user to do - GREEN means ready to go - approval needed. YELLOW OR RED indicates a minor or severe problem.



Task-Centered Navigation - Guns

2. Task Oriented Design Focus

Execute TLAM		Execute Gun		Rehearse Taskings	
2/3		0/1		0/0	
Validate Tasking	Send Engment Order	Obtain Battery Release	Send Ready	Execute	Adjust Fire/EOM
3/3	3/3	3/3	3/3	1/3	1/3

Back	Maintain Readiness	Maintain SA	Conduct IS&R	Prepare Taskings	Execute TLAM	Execute Gun	Rehearse Taskings	Task Manager			
	0/0	1/1	0/0	0/0	2/3	0/1	0/0				
Gun Taskings	Priority:	Mission Type:	Targets:	# of Rounds and Type:	Method of Control:	Validate Tasking	Send Engment Order	Obtain Battery Release	Send Ready	Execute	Adjust Fire/EOM
Status	High	CFE	3	3-ERGM	TOT	3/3	3/3	3/3	3/3	1/3	1/3
ESP											
ALPHA											

Note that the same graphic designs and task support principles apply across many mission domains. We have applied to ship propulsion and engineering also.

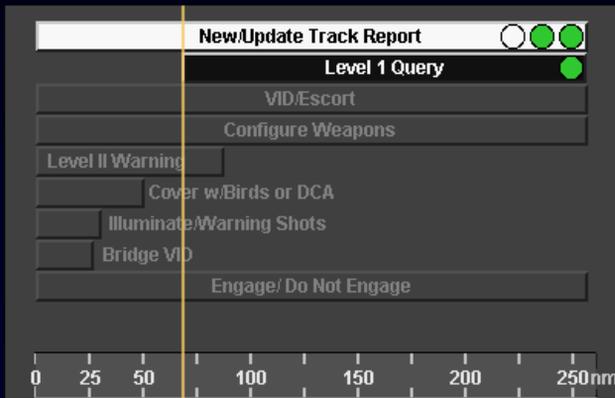


Task Visualization -Air Defense Warfare

2. Task Oriented Design Focus

ADW Response Planning Manager

Cognitive Requirements



My tasks?

Automation tasks?

Other users tasks?

What's next?

What's optional?

What's required.

What is status?

Developed under TADMUS Project

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Cognitive aids are applicable across multiple CIC task domains



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Task Products - What is "Quality" for Warfighter?

3. Quality Work Process Products

Lower Workload

Quality draft product

- Concise summary
- Drill down
- Explanation
- Easy approval or edit

- Incomplete summary
- Minimal Drill down
- Minimal explanation
- Editing inconsistent

- Incomplete summary
- No drill down
- Data dumped in windows
- No explanation

Higher Workload

No draft products

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This is a hypothetical "scale" of task product quality

Task products may be judged by their quality level, including their completeness. At the top of the scale - where the workload is lower for the warfighter - the system produces a quality "draft" product that the user can "supervise".

At the bottom of the scale - data is collected and placed into databases, maybe windows - and also may be on paper. The user has to do all the work of making the task product manually.

In between, systems may produce more of the task products but may not complete the task goal fully.



Produce Quality Mission Products

3. Quality Work Process Products

Air Defense Examples:

- New Track Reports
- Update Track Reports
- Air Contact Query
- Air Warning Level I and II
- Electromagnetic Signal contact report
- Threat summary assessment
- Threat Response Plan
- ID Basis of Assessment

High quality

1. *Task triggered*
2. *Message drafted*
3. *One-click to send*



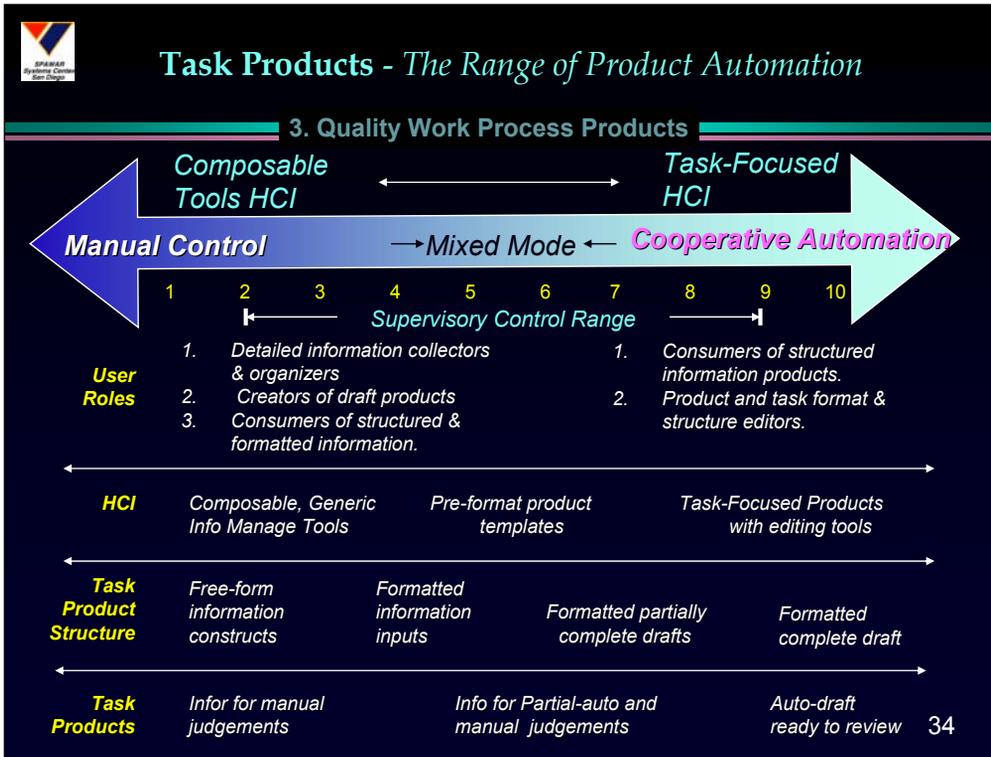
Low quality

1. *Find the track on Plot*
2. *Hook Track*
3. *Read CCRO summary*
4. *Draft message in head*
5. *Find voice circuit & connect*
6. *Read message*



33

Products are logical outputs of stages of work activity. There are “global” products that satisfy a set of related mission activities, like an entire “strike plan” or “weaponeering plan” and then there are parts of that process that produce intermediate products. In some areas, like Air Defense - products such as Track reports may be produced at the rate of several per minute.



The slide represents a range of task products that software may produce. The left side represents “manual” preparation - meaning the software provides information leading to manual product preparation. As shown the user roles are to collect, synthesize, judge, manipulate basic mission information and create results - which may include reports, briefs, orders, assessments, etc.

The center of the scale represents “mixed mode” where parts of a process may be manual and other parts with increase automation. Thus, in a 10 step mission process perhaps only steps 4 and 7 are partially automated. Another example could be threat assessment - the system can suggest threats and response tasks and users can also perform vigilance tasks to search for threats and tasks in parallel with the software search.

The right side of the scale represents task products which are produced by software and which can represent a complete mission product - a draft plan, report, message, order, assessment, etc. that is of high enough quality to be used with user approval or may require editing.

Tools which support information composition and display arrangement can support any part of this continuum. The design requirements for task product formation specify where the task resides on this continuum.

User roles are shown to vary according to what types of product creation tasks the system supports.



Produce Quality Mission Products

3. Quality Mission Process Products

Mission Process Flow

Pre-plan, plan, execute, assess



Typical Mission Products

- Tomahawk Missile water & land routes
- Missile cell allocation plan
- Flex-target missile re-allocation plan
- Strike Mission Plan
- Air Defense Battlegroup Track reports
- Target Weaponneering plan
- Ship transit & logistics plan
- Communications plan
- Force positioning plan
- Electrical/propulsion underway sequence

Products are harder to draft when multiple systems hold the information required!!

35

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Views Exist Across Levels of Control

4. Support NDM & Critical Thinking

Cognitive Requirements

What is status?
What is task progress?
What do I do next?
What are my variables?
Pros & Cons of action?
What if I...?
Action - what next step(s)
What's optional?
What's required?

Information Hierarchy

Operations View -
Across Missions

Mission View -
Across Systems

Mission View -
Specific Goals/Work Tasks

Planning	Execution
Monitoring	Re-planning

Work Task Details

Work Products

Alternatives &
Explanations

Mission and Situation Visualization



Information Sets



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Views Exist Across Levels of Control

4. Support NDM & Critical Thinking



*Multi-mission, Multi-Task View
(supervisory NDM)*



Task Information Sets



*Single-mission,
multiple tasks of various types
(Supervisory NDM)*



*Single-mission,
Single or multiple tasks
of same type
(critical thinking - action)*



Example for Air-Defense Displays

4. Support NDM & Critical Thinking

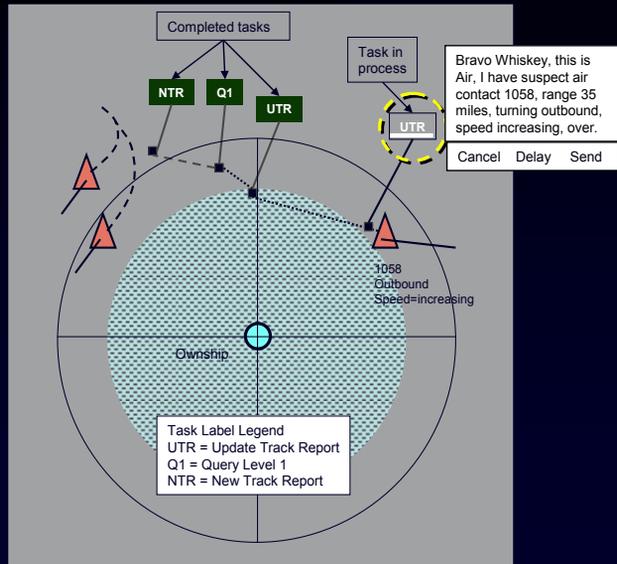
Task Management
(Process visualization
temporal - supervisory)



Visual Integration



Situational Awareness
(geo-spatial)





Information Sets for Task Drill-Down

4. Support NDM & Critical Thinking

What makes for good Human Factors of Information Sets?

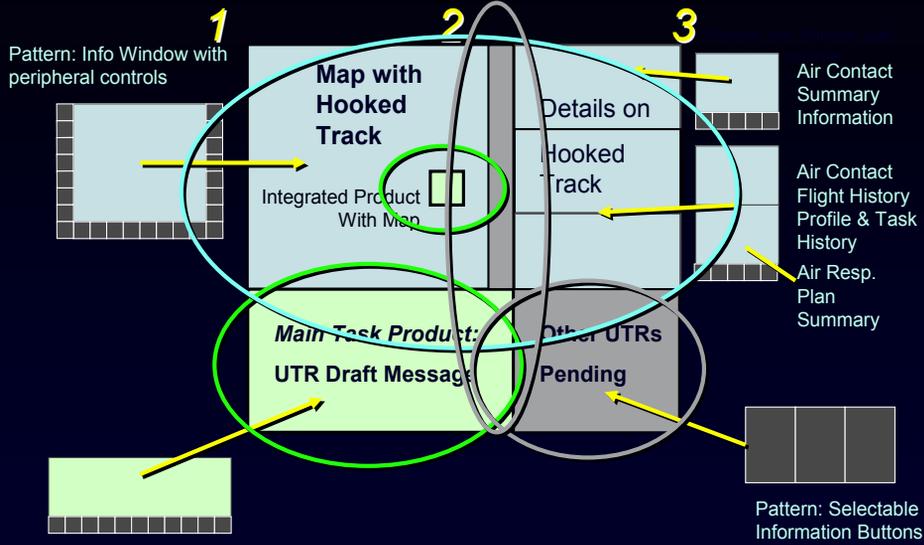
1. Concise - efficient visual search.
2. Cognitive salience.
3. Coverage of domain and completeness.
4. Clarity, brevity and consistency.
5. Proximity & Compatibility.



1. Task Product

2. Details supporting task product.

3. Task List



Type of Task: Single Object - Single Solution
Specific Task: Air Defense Update Track Report



- Metrics for Action Outcome (concise)
- Spatial awareness & qualities (saliency)
- Background factors feeding metrics (explanation)



Back	Maintain Readiness		Maintain SA		Conduct IS&R		Prepare Taskings		Execute TLAM		Execute Gun		Rehearse Taskings		Task Manager
	0/0		1/1		0/0		0/0		1/5		2/2		0/0		
Prob of Success	Ownership Role	Spare Route	Alternate Outcome	Tasker	Mission	Target	Munition	Range	Launch Area	Flight Path Decon	ASCM	Threat	TOL		
Waiver 92% G1800	Primary	RS Straight 06:20	None	SACC 0710Z	LPMP 443098	M. Inf HQ 9001	6 112	147 825	Lima -06:20 Port	WGS-84 1,000 ft	Oil Pftm	<10%	-0:15:17	▲	
Comply 94% G1900	Primary	RS Straight 06:20	None	SACC 0710Z	LPMP 592789	Base 9003	6 112	186 770	Lima -06:20 Port	WGS-84 2,000 ft	None	<10%	-0:15:59	▬	

Type of Task: Multiple Objects - Multiple Solution
Specific Task: Review Route Plan (with fault)



Back

Metrics for Action Outcome (concise)

Prob of Success

Waiver

92%

G1800

Comply

94%

G1900

Back	Maintain Rea	00	Conduct IS&R	Prepare Taskings	Execute TLAM	Execute Gun	Rehearse Taskings	Task Manager			
Prob of Success	Relationship Role	00	Mission	Target	Munition	Range	Launch Area	Flight Path Decon	ASCM	Threat	TOL
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*Spatial awareness & qualities
(saliency)*



Type of Task: Multiple Objects - Multiple Solution
Specific Task: Review Route Plan (with fault)



Background factors feeding metrics (explanation)

Maintain Readiness		Maintain SA		Conduct IS&R		Prepare Taskings		Execute TLAM		Execute Gun	
0/0		1/1		0/0		0/0		1/5		2/2	
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Primary	RS Straight 06:20	None	SACC 0710Z	LPMP 592789	Base 9003	IIC 6 112	186 770	Lima -06:20 Port	WGS-84 2,000 ft	None	<10%

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Work is defined as the total workload environment for the warfighter - not a narrow application.

Task-orientation simplifies the design concept for the user.

The concept of a dynamic G-WIS are important for both performance and training.



Keep Procedures Simple!

5. Easy to train

1. Initiation (triggering)

2. Orientation
3. Review
4. Decision & Action

Execute TLAM		Execute Gun		Rehearse Taskings	
1/5		2/2		0/0	
Validate Tasking	Plan Routes	Allocate Missiles	Power Missiles	Execute Launch	Monitor
2/2	0/2	6. Transition		0/2	0/2
				-0:00:08	

Prob of Success	Ownship Role	Spare Route	Alternate Outcome	Tasker	Mission	Target	Munition	Range	Launch Area	Deconflict	Avoidance	Flight Corridors	TOL
Comply 98% C0800	Primary	RS Straight 03:45	None	SACC 0650Z	Pre-Plan 577941	2nd Howztr 9013	IIC 1	153 99	Lima -02:45 Starboard 785	MSL 1,200 ft	None	<10%	-0:09:07
Comply 91% C0900	Primary	RS Straight 03:45	None	SACC 0650Z	Pre-Plan 278797	Motor Btry 9016	IIC 1	168 99	Lima -02:45 Starboard 770	MSL 1,800 ft	None	<10%	-0:09:14
Comply 93% C1000	Primary	RS Straight 03:45	None	SACC 0650Z	Pre-Plan 431923	1st Track 9014	IIC 3	183 99	Lima -02:45 Starboard 770	MSL 1,900 ft	None	<10%	-0:09:21
Comply ✓	Waiver W	Exception E	CANTCO ⊘					Close	Modify LPMP Settings	Add Manual Plan	Print SCO	Send SCO	

5. Confirmation



MC HCI Design Qualities

- | | |
|---|--|
| 1. Expand Work Support Requirements | 1. All task types and decision phases. |
| 2. Expand Design Focus | 2. Task-Oriented Design with explicit Task Goals |
| 3. Provide Quality Mission Process Products | 3. User Review in Supervisory Mode. |
| 4. Support Naturalistic Decision Making and Critical Thinking | 4. High level and drill-down views. |
| 5. Build easy to train HCI! simple procedures. | 5. Keep procedures simple and consistent! |
| 6. Build HCI for evolution. | 6. Modern software methods. |
| 7. Provide quality information to tasks. | 7. Quality and timeliness |

49

Task Goals shown explicitly mean that they are depicted by graphics, labels or both.

Work is defined as the total workload environment for the warfighter - not a narrow application.

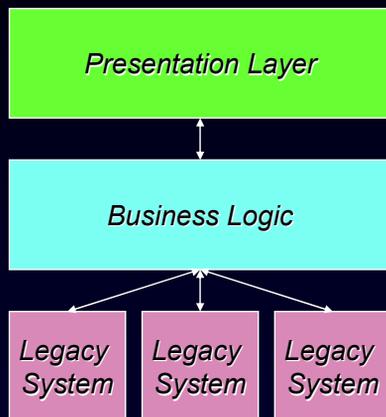
Task-orientation simplifies the design concept for the user.

The concept of a dynamic G-WIS are important for both performance and training.



Separate Presentation Layer

6. Easy to evolve



- Mods can be made to the presentation layer without effecting legacy code.
- Decision aids can be shared across legacy systems.
- Mods can be made once and apply to all legacy systems.



HCI Design Evolution - ONR FNC Project

Tactical Tomahawk Example

Mission View Current

Menu-(function based)

Window System Chart Views Comms Support Misc Hel...

V5 2006

Task (goal based)

Task ID	Task Name	Task Description	Task Status	Task Priority	Task Assigned To	Task Start Date	Task End Date	Task Duration	Task Progress	Task Comments
101	Task 1	Task 1 Description	Completed	High	John Doe	2006-01-01	2006-01-05	5 days	100%	Task 1 completed successfully.
102	Task 2	Task 2 Description	In Progress	Medium	Jane Smith	2006-01-06	2006-01-15	10 days	75%	Task 2 is currently in progress.
103	Task 3	Task 3 Description	Not Started	Low	Bob Johnson	2006-01-16	2006-01-25	10 days	0%	Task 3 has not yet started.

V6 2008

Task (goal based)

Task ID	Task Name	Task Description	Task Status	Task Priority	Task Assigned To	Task Start Date	Task End Date	Task Duration	Task Progress	Task Comments
101	Task 1	Task 1 Description	Completed	High	John Doe	2006-01-01	2006-01-05	5 days	100%	Task 1 completed successfully.
102	Task 2	Task 2 Description	In Progress	Medium	Jane Smith	2006-01-06	2006-01-15	10 days	75%	Task 2 is currently in progress.
103	Task 3	Task 3 Description	Not Started	Low	Bob Johnson	2006-01-16	2006-01-25	10 days	0%	Task 3 has not yet started.

Decision Support Data-driven windows

System	Component	Status	Value
System 1	Component 1	OK	100%
System 1	Component 2	Warning	85%
System 1	Component 3	Alert	50%
System 2	Component 1	OK	100%
System 2	Component 2	Warning	85%
System 2	Component 3	Alert	50%

Data-driven windows

System	Component	Status	Value
System 1	Component 1	OK	100%
System 1	Component 2	Warning	85%
System 1	Component 3	Alert	50%
System 2	Component 1	OK	100%
System 2	Component 2	Warning	85%
System 2	Component 3	Alert	50%

Task Decision-support

Task ID	Task Name	Task Description	Task Status	Task Priority	Task Assigned To	Task Start Date	Task End Date	Task Duration	Task Progress	Task Comments
101	Task 1	Task 1 Description	Completed	High	John Doe	2006-01-01	2006-01-05	5 days	100%	Task 1 completed successfully.
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Architecture Tier Example

Display Presentation

Console Client

Thin Display Client

Populate task with data and display to the warfighter.

Workflow Management

Task Management Tier

Understand the task, inform warfighters, track task status and produce products.

One-time Adapters

Connectivity Tier

Receive trigger notification. Notify web services to send task trigger to presentation layer.

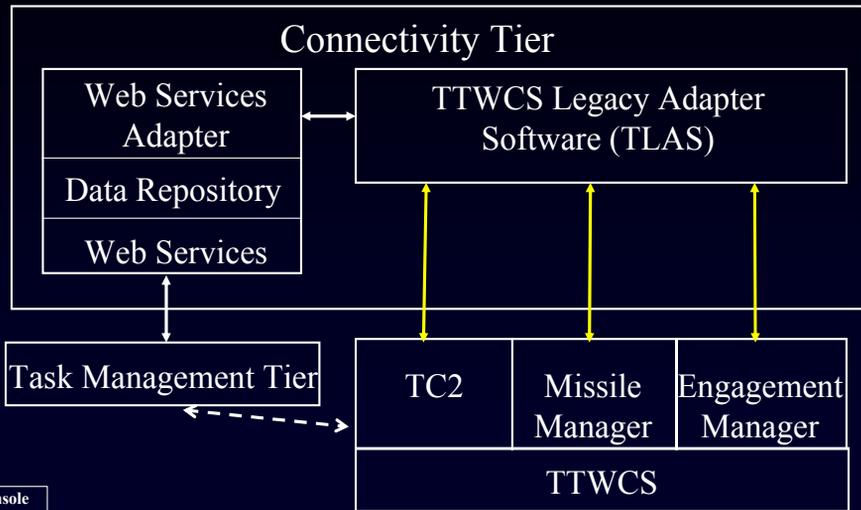
Legacy System(s)

TTWCS

Define what triggers a task in the legacy system and capture that.



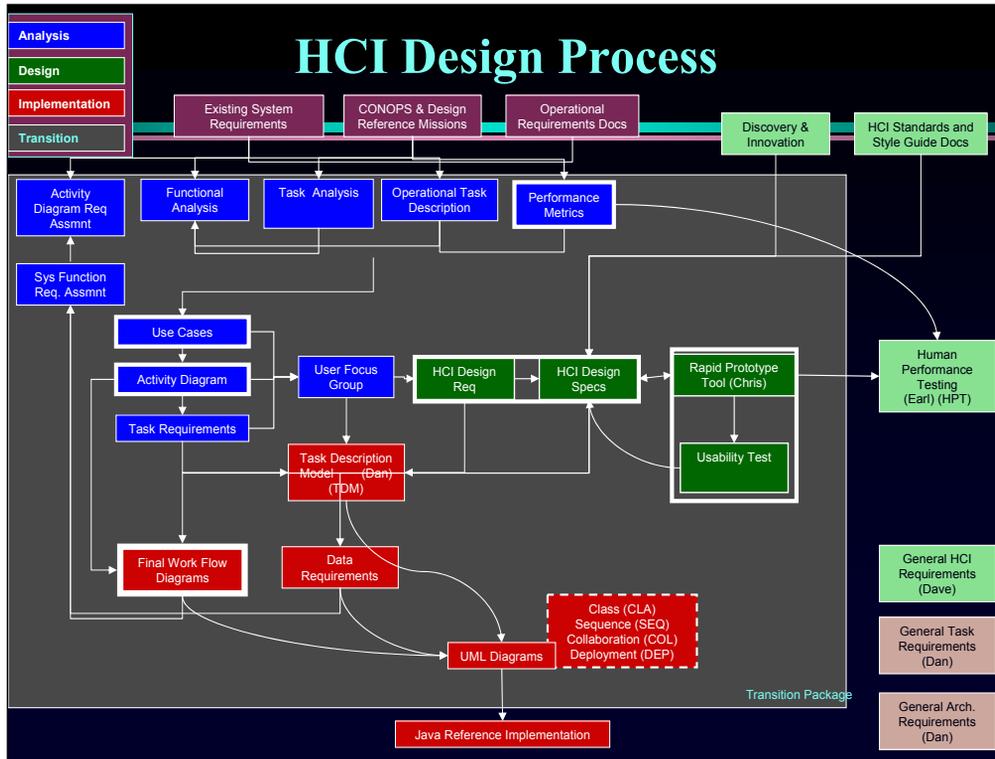
TTWCS Connectivity Demonstration





Overview

- HFE body of knowledge
- Specific HFE R&D for Naval Systems.
- What are key design properties & features?
- The Design Process towards success...





Agile Design Success

- Developed half way into the v5 development cycle.
- Small team (analyst, designer, design prototyper, users) produced a concept design in six weeks.
- Allowed for an initial comparison between the proposed and original designs.
- Formal comparison tested completed in one month.
- Initially low level documentation until design flushed out, tested, and approved for development.
- Has become the prominent feature of the v4 to v5 software upgrade.



TTWCS v4 Job Bar Design

Job Bar
Window Help

UNCLASSIFIED Enable UNCLASS

Parameters 5 Tasking 6 Planning Launch Preselection Post-Launch PML Mgt Prompts

Prompt Filters: Tasking Launch
 Planning Post-Launch

Tasking Manager

Strike Packages

Message Type	Use State	Message ID	Strike Execution Time	Time Received
T Period	Enable	031000001	1211474.00Z TGT	

Display TSN Data CIA Selection... Strike Preview... Edit Strike Package... Create Strike Package... Print Report... Delete Strike Package...

Prospective Plans

Status	ASN	MGN	PRSR	Type	Mission ID	BDI	Time Type	RS Delta
P001	001	001	Primary	Preplanned	040-001-01000		121240.00Z TGT	
P002	002	002	Primary	Preplanned	040-011-01000		121240.00Z TGT	
P003	003	003	Primary	Preplanned	040-021-01001		121241.00Z TGT	
P004	004	004	Primary	Preplanned	040-031-01001		121241.00Z TGT	
P005	005	005	Primary	Preplanned	040-041-01002		121242.00Z TGT	
P006	006	006	Primary	Preplanned	040-051-01002		121242.00Z TGT	
Waiting	007	007		CFF			121256.00Z TGT	
Waiting	008	008		CFF			121256.00Z TGT	

Select...

Mark Plan UseSupportable Send Exception/Acknowledge Message(s) Show Allowable Launch Areas Create Mission/ Engagement Call For Fire Close

Prompt

Linking Location equpt used for SP 001000001

Acknowledge Close

Button order from left to right reflects a standard Strike Execution sequence



Task Manager v5 Lo-Fi Prototype Design

DII COE Security/Menu bar															
Window System Chart Views Contents Support Misc Help															
Req'd Actions/Status		Pre-Tasking		Sys Status		Avail & Status		PML		Inventory		Cmdr Summary		Prompts	
Strike Packages															
ESP ID / Use Type	Plans (P/L/PMP/CF)	Engagement Progress	Manage Tasking	Manage Plans	Manage Missiles	Final Review	Launch	Manage Post Launch	Tasker	Time Received	Strike Execution Time	H Hour			
001-000-001-A Launch Plan	2/3/2	MREG 7	Ignored Plans	—	—	—	—	—	TSC	08/15/02	21:00:00Z	20:25:00Z	03 Nov 2002	03 Nov 2002	
001-000-002-B Launch Plan	2/1/1	Name 4	Send Exceptions 2	—	—	—	—	—	TSC	07/15/02	21:03:00Z	20:29:00Z	03 Nov 2002	03 Nov 2002	
001-000-003-C Execute	2/2/2	Save 6	Send Ack 6/6	Send SCOs 4	—	—	—	—	TSC	08/15/02	03 Nov 2002	11:25:00Z	03 Nov 2002	03 Nov 2002	
001-000-004-D Execute	2/1/2	Save 5	Send Ack 5/5	Send SCOs 5/5	Accept Allocations 2	—	—	—	TSC	08/15/02	03 Nov 2002	12:45:00Z	03 Nov 2002	03 Nov 2002	
001-000-005-A Execute	1/2/1	Mk July 4	Send Ack 6/6	Send SCOs 6/6	Select Missiles 2	—	—	—	TSC	08/15/02	03 Nov 2002	21:00:00Z	03 Nov 2002	03 Nov 2002	
001-000-006-A Execute	2/2/0	Mk July 5	Send Ack 5/5	Send SCOs 4/4	Finalized Missiles 7/7	Review Plans 1	—	—	TSC	08/19/02	11:00:00Z	08:25:00Z	03 Nov 2002	03 Nov 2002	
001-000-007-B Execute	2/2/2	Execute 4 SCOMPL 2	Send Ack 6/6	Send SCOs 6/6	Aligned Missiles 11/11	Reviewed Plans 6/6	Execute Launch 3	Monitoring Post Launch 2/2	TSC	08/19/02	03 Nov 2002	08:25:00Z	03 Nov 2002	03 Nov 2002	
Display TSM Data...		Conflict ID Analysis Selection		Strike Preview...		Create Strike Package...		Edit Strike Package...		Delete Strike Package		Display Report...		Tasking Report	
ESP 001-000-005-A Plans															
Eng ID / TLD	Tasking	Engagement Progress	Manage Tasking	Manage Plans	Manage Missiles	Final Review	Launch	Manage Post Launch	Weapon / Save	Launch Dr	PLP	Control Method	Launch Basket	MDP	
ENG 023 XXXXX	LFPB	Mk July	OK	SCO	Select 1	No	00358	—	B-C 1 Plan	Sbd	Real	FWP	In	09	
ENG 024 XXXXX	PrePlan	Mk July	OK	SCO	Select 1	No	00389	—	B-C 1 Plan	Sbd	Real	TDL	In	07	
ENG 025 XXXXX	LFPB	Mk July	OK	SCO	Select 1	No	00358	—	B-C 2 P/2 A/R	Sbd	Real	FWP	In	09	
ENG 026 XXXXX	CF	Mk July	OK	SCO	Select 1	No	00094	—	B-C 1 RS	Sbd	Real	TDL	In	07	
Select		Mark Plan Supportable		Mark Plan Unsupportable		Send Exception Message(s)...		Show Allowable Launch Areas...		Create Mission / Engagement...		Call For Fire (CFI)...		TLM Engagement...	



TTWCS V5 Task Manager Prototype

Node: TAC1A UNCLASS 121193282 Oct 08,2003

System Chart Views Config Support Misc Help

Job Bar Window Job Bar Location Help

Address Required 2 Prompts: PreDeployment BCKOP PreTake TTWCS Summary Display TSN Config PNL

Interface status: TEC-A TEC-B TEC-C TEC-D

SYS MODE: Tactical LMP Area: 000001

TDR / Use Type / Mfg Type	Plan Types / PZ / LMP /	TLD Progress	Tasking	Manage OTW/Plans	Manage Modules	Final Review	Launch Execution	Manage Post Launch	SP Preference Info: Location Code / Index / Option / Row #	OTF Tasking Info: Requester / Target #	Strike Execution Time
121162 OCT Execute Tactical	0 / 3 / 0	NONE - 3	Send Ack 1	Launch P/LP 1					Washington Planning Center 1 0000 / 0000 / 0000		121162 002 TST
121162 OCT Launch Tactical	1 / 0 / 2	NONE - 4 SAC - 4 MRSDV - 2	Send Executions 1	Make Ready 4	Preselect Modules 2				Washington Planning Center 1 0000 / 0000 / 0000		121162 002 TST

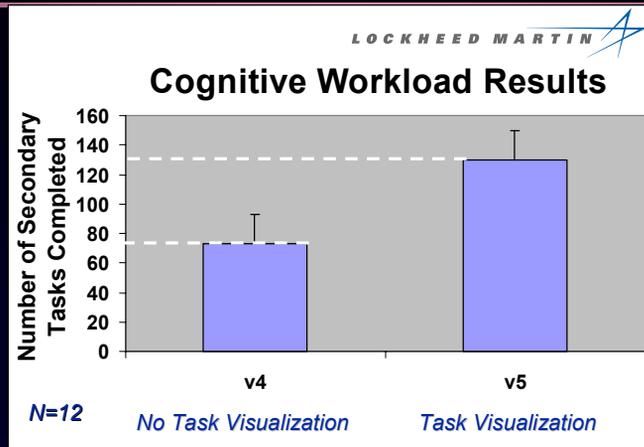
TLD Plan	MSN	Task Type	TLD Progress	Tasking	Manage OTW/Plans	Manage Modules	Final Review	Launch Execution	Manage Post Launch	TLD Type / Index	AR FRU	Weapon Type	Launch Direction	Timing Method	Launch Basket	Mission ID	Branch ID
E1019	009	PP	NONE	Send Exec							BU	STE	LACC		TDL		049-001-01003 00:00
E1018	019	PP	NONE	Sec Feat				Monitor			P	LACC	AR	PuP			049-011-01003 00:00
E1017.P001	001	PP	MRSDV	OK	Send SCD	Preselect	No	23.12	Control	P		LACC	AR	PuP			049-011-01000 00:00
E1017.P002	002	PP	MRSDV	OK	OTW List	Preselect	No	24.12	Control	P	WCH	LACC	AR	PuP			049-011-01000 00:00
E1017.P003	003	PP	SAVE	OK	Make Ready		No	24.52	Control	P	WCH	LACC	AR	TDL			049-021-01001 00:00
E1017.P004	004	PP	SAVE	OK	Make Ready		No	25.12	Monitor	RS 345		LACC	AR	TST			049-021-01001 00:00
E1017.P005	005	PP	SAVE	OK	Make Ready		No	25.42	Monitor	P		LACC	AR	TST			049-041-01002 00:00
E1017.P006	006	PP	SAVE	OK	Make Ready		No	26.32	None	P		LACC	AR	PuP			049-051-01002 00:00
007	007	OFF							Control	P		LACC					00:00
008	008	OFF							Control	P		LACC					00:00

Select TLD's

CL1 Mission Call 1 Ring Out power at status OK Vertical Navigation 45 Degree of Az



Other Recent Test Results Promising



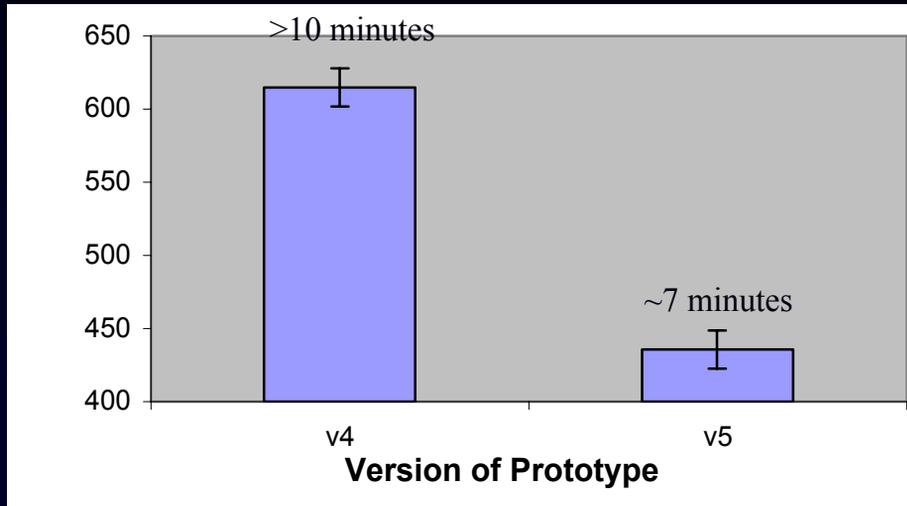
Mean cognitive workload results for launching simulated missiles

Notes: the more secondary tasks that are completed, the lower the cognitive workload. Error bars represent the standard error of the mean.

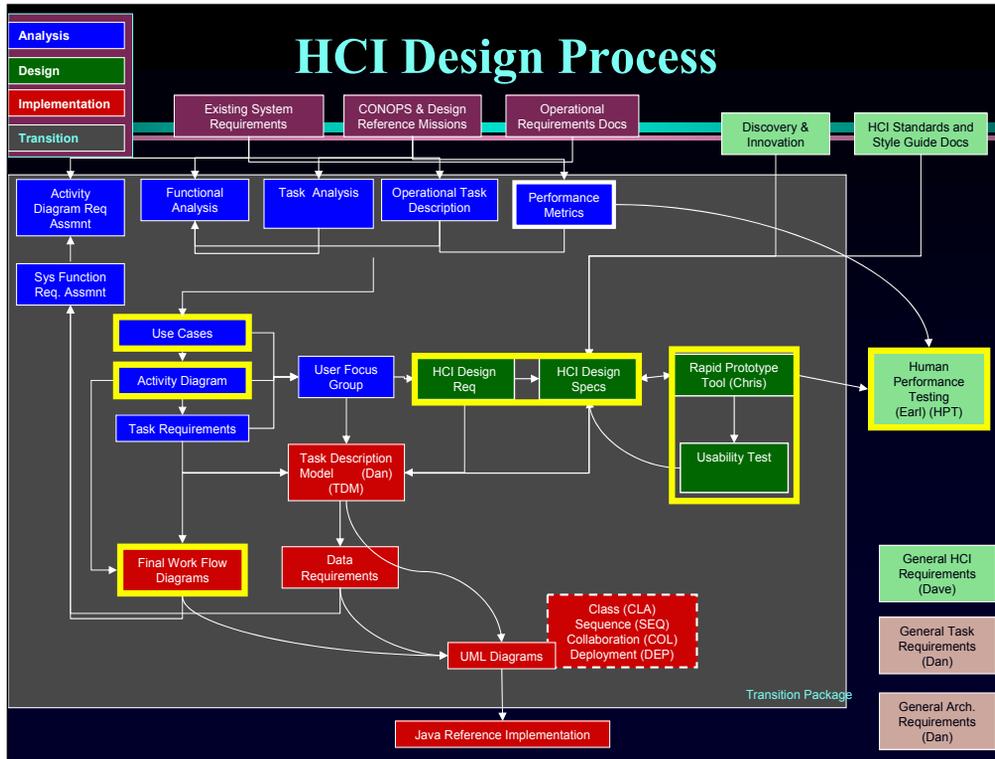


TTWCS Task Navigation Times

From Missile Selection to Completion of Plan Review & Approval



Note that there were more steps on v5. Plan approval, strike coordination overlay. (Not v4 capabilities).





Conclusions

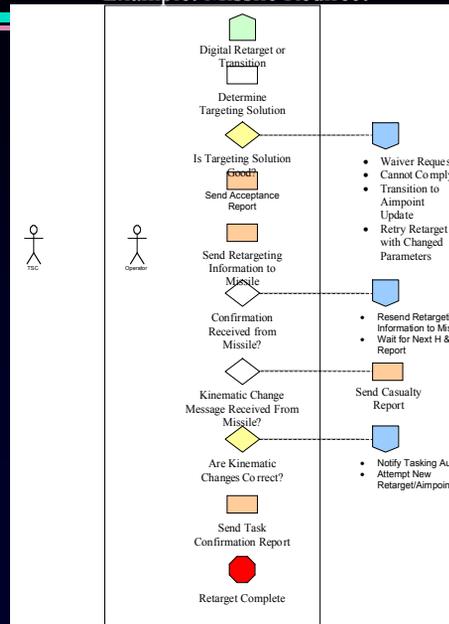
- **Mission-Centered Design** is a military example of Task or User-Centered Design.
- **Critical design features** identified through Human Factors research.
- Fleet Test Results indicate **significant improvement**:
 - » Human performance gains - situation awareness, speed/accuracy/reliability.
 - » Mission process efficiency, accuracy, responsiveness.
 - » Training simplification.
- Use **iterative design process** with frequent testing.
- Refine, capture and re-use design components.



Use Cases

Example: Missile Redirect

- Provide a basic understanding of the task
- What, not How
- Defines:
 -  Triggers
 -  Users
 -  Decisions
 -  Related Tasks
 -  Products
 -  Completion

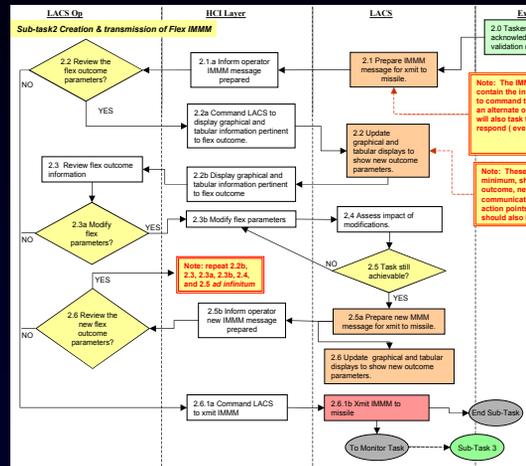




Work Flow Activity Diagrams

- Defines How, but independent of technology or HCI.
- Connect decisions and products with steps.
- Defines system allocation.
- Notes define details and decision criteria.

Example: Missile Flex





HCI Reqs & Specs

- Requirements derived from Task Analysis.
- Wire frame helps determine content, layout, and navigation w/o locking down a design.
- HCI spec provides detail figures, display coding, and interaction requirements



Example Flex Requirements

Purpose: recommend or comply w/ flex tasking

Value: allow for viewing of flex options

Product: produce missile flex message

Form: satellite data link, missile

Other: make selected msl # most prominent

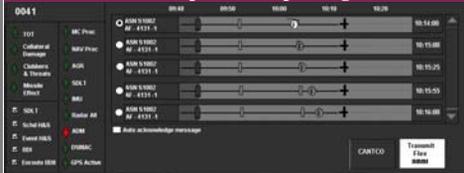
Example Wire Frame Diagram

msl
details

msl
timelines

action buttons

Example HCI Spec Figure

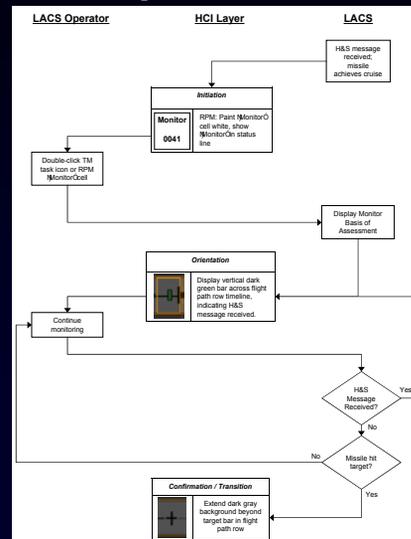




Final Workflow Diagrams

Example: Monitor Missiles

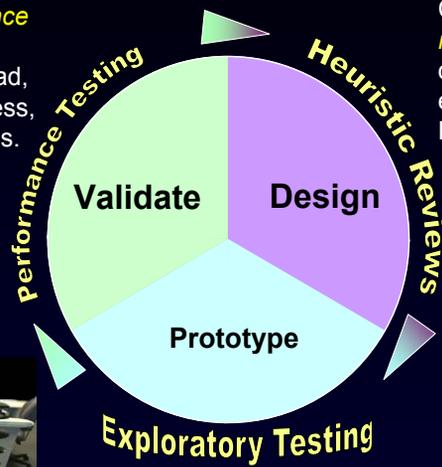
- Adds interface actions to previous task analysis -- HCI design specific.
- Assists in validating data requirements.
- Assists in performing software verification tests.
- Requires you to define exactly how the operator performs each task.
- Defines the required HCI functionality.





Fleet Usability Testing 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 Testing

- Usability Testing
 - » Find major problems quickly
 - » Looking to *improve* not prove
 - » Small subject sample size
 - » Multiple protocols
- Lo-Fi Prototype
 - » Display Layout
 - » Information Content
 - » Navigation
- Hi-Fi Prototype
 - » Event paced evaluations
 - » Discovery evaluations
 - » Free-play navigation





Performance Measures

workload



50

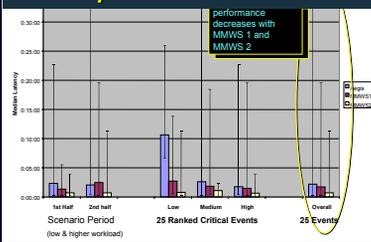
Situation Awareness

	KINEMATICS	TRK ESM	QUERY/WARN	MSL ESM	ENGAGE
Crew 1	No	Yes	No	No	No
Crew 2	No	No	No	No	Yes
Crew 3	Partial	No	No	No	Yes
Crew 4	Partial	Yes	Observed	Yes	Yes
Crew 5	No	No	No	Yes	Tracked
Crew 6	Yes	Yes	Yes	Yes	Yes
Crew 7	No	Yes	Yes	Yes	Yes
Crew 8	No	Yes	No	Yes	Would have
Crew 9	No	Late	No	Yes	Would have

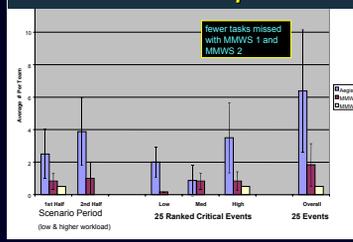
Multiple events with this critical track.
Some information passed verbally only.
Many key situation awareness incidents lost in the decision process.

49

Report Timeliness



Missed Reports



70



Performance Metrics

- Provide direction. Help define tasks and products.
- Most are operational requirements.
- Look for constraints not just ORDs.
- Let you know when you are done iterating.
- Benchmark against current system if available (Gap Analysis)

Example Missile Flexing Metrics

1. # of outcomes per mission (15 max)
2. # missiles to monitor (32 max)
3. % of faulted missiles
4. # missiles to flex (4 max)
6. Time available to complete flex
7. Accuracy of flex recommendation
8. Situational Awareness
 - a. Does the operator understand which missiles can be flexed?
 - b. Does the operator understand which outcomes each missile can be flexed to and the priorities?
 - c. Does the operator know the status of each missile in flight for a specific strike package?
 - d. Does the operator know which missiles have been flexed and to which outcome?

