

# HCI Design Patterns for C2

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**SPAWAR**  
*Systems Center*  
*San Diego*

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User-Centered Design

C2 Technology & Experimentation Division

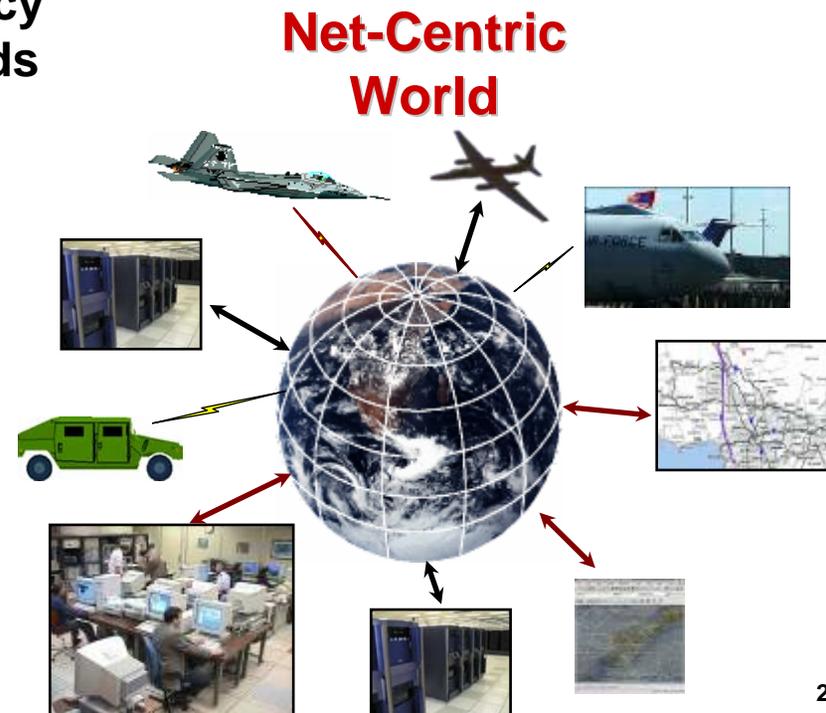
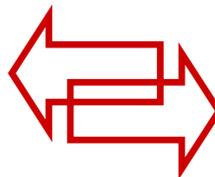
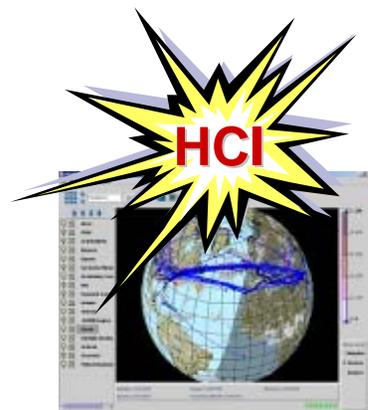
Space & Naval Warfare Systems Center San Diego

# DoD Requirement

- **Command & Control (C2)**
  - Planning, coordinating, executing, monitoring, replanning
- **Network-Centric Operations**
  - Increased information access for C2
  - Can increase effectiveness & efficiency But introduces new cognitive demands
  - Human Computer Interface (HCI) critical element of system



Operator



# Two Interaction Domains in HCI Design

## Work / Mission Domain



The Operator Accomplishes Mission-Relevant Goals within the Work Domain

- Human-Work Interoperability

Work-Centered  
HCI Guidelines

The Operator Acts within the IT Domain

- Human-IT Interoperability

## Information Technology Domain



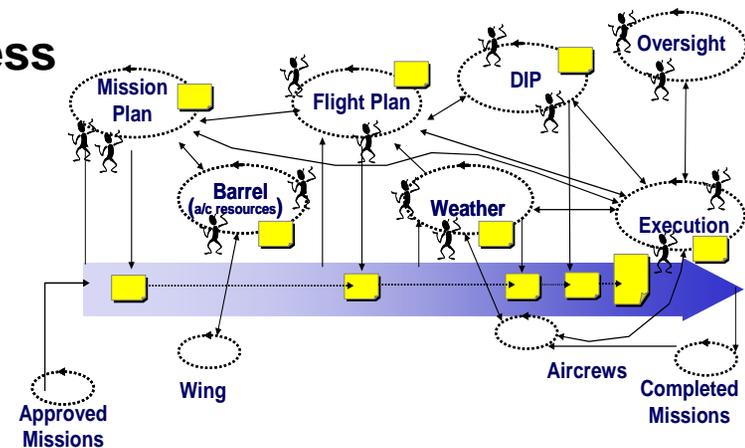
Existing HCI  
Guidelines

MIL-STD-1472E  
MIL-STD-1801  
ISO 9241

# What Do We Mean by Work and Work-Centered?

- *Purposeful activity performed in a context*
- Activity performed by organic (human) and inorganic (technology) entities to achieve organizational objectives
- Individuals, groups, organization
- Human work benefiting by Information Technology (IT)

- Building & Maintaining Situation Awareness
- Team Coordination & Collaboration
- Decision Making
- Problem Identification & Resolving
- Work (Load) Management
- Product Development



- Effective IT mechanisms for aiding human work
  - Visualizations reflecting operator's mental models of own work
  - Automated data retrieval, fusion, and alerting

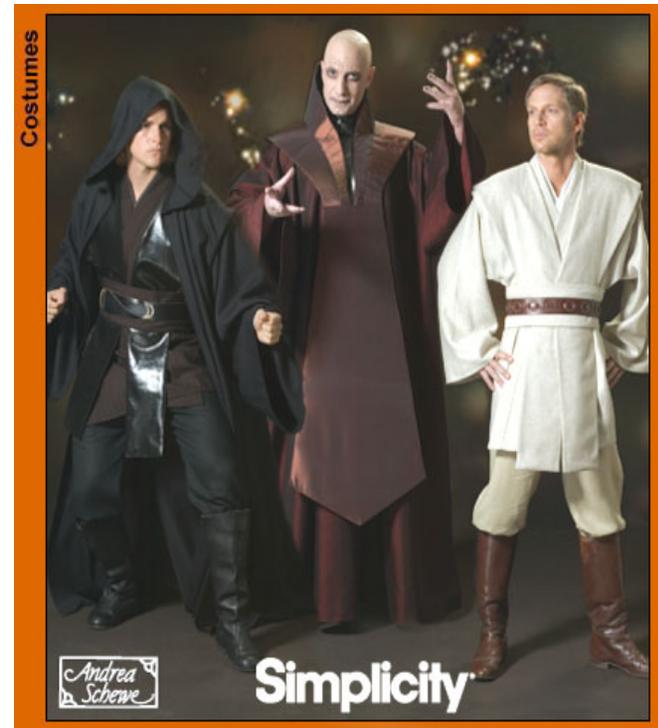
## Off-the-Shelf



## Custom Design



## Design Pattern



# Three Paths to Work-Centered HCI



## Off-The-Shelf

- Modern approach
- **Low-Cost**
- **Low Risk (short term)**
- **Clumsy Fit to Work**

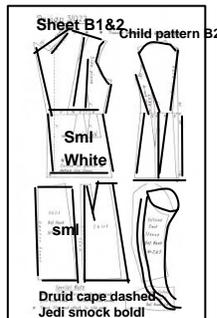
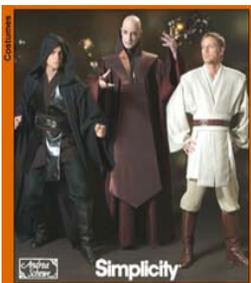
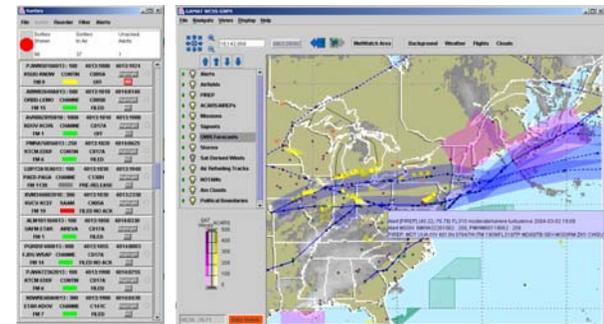
## Augmented MS Excel

Flight No	Flight Type	Man Number	Rank	Wk Pkg	AVC Type	Dep Airfield	Exc	Plan Dep	ETD	Dep Dev	OR	Air Airfield	Exc	Plan Ar	ETA	Ar De
999	CHANNE	ABB02F00043	Y		C009B	KDGV		0243/1030	0243/1030	-00:05	0243/1025	ETAR		0243/1025	0243/1025	00:00
999	SAAM	ALM70635043	Y		C017A	KDHS	Ve*	0243/2115	0243/2115	00:00		SKCG		0244/0000	0244/0000	00:00
999	SAAM	ALM70635043	Y		C017A	KDHS	Ve*	0243/2145	0243/2145	00:00		SKCG		0244/0000	0244/0000	00:00
999	TRANE	ALND07391243			C141B	KwRS		0243/1400	0243/1400	-00:06	0243/1354	KwRS	Cg	0243/1724	0243/1724	-00:06
999	TRANE	ALND07391243			C017A	KDHS	Ve*	0243/2100	0243/2100	00:00		KDHS	Cg*	0244/0220	0244/0220	00:00
999	TRANE	ALND07391243			C017A	KDHS	Ve*	0243/2115	0243/2115	00:00		KDHS	Cg*	0244/0215	0244/0215	00:00
999	CHANNE	J8AGF000041	Y	RQ	C005A	EGUN		0242/1200	0244/1845	+2:25		KDGV		0242/2035	0244/1900	+2:25
999	CHANNE	XLBRR000043	Y		C141C	ETAR		0243/1345	0243/1100	-02:26	0243/1119	ETAR	TRF*	0243/2330	0243/2100	-02:26



## Custom Design

- Reflects Cognitive Systems Engineering
- **Very Expensive**
- **Higher-Risk**
- **“Perfect Fit” to Work**



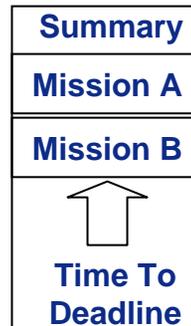
## Design Pattern

- Practical HCI design
- **Lower Expense than Custom**
- **Lower Risk than Custom**
- **Tailored Fit to Work**

## Original HCI



## Design Pattern



# Case Study: HCI Design Pattern Return On Investment



## Robert Dick & Alan Spiker, Anacapa Sciences Inc. (2006)

- ASW Human-Computer Interface developed using cognitive systems engineering methodology
- HCI Solution is “patternized” and reapplied in EW domain



	<u>ASW</u> “Original HCI”	<u>EW</u> HCI Reapplied
• Time to design:	72 month	6 months
• E6-E9 SMEs involved	44	1
• Payroll costs to Navy	75 man-days	0 man-days
• HCI man-years	11.0	0.5
• Cost to Program Office	>\$2,000K	\$70K

# HCI Design Patterns

## Addressing Human - IT Interoperability

### • Design Patterns

- Physical architecture (Alexander, 1977)
- Software coding (“Gang of Four”, 1994)

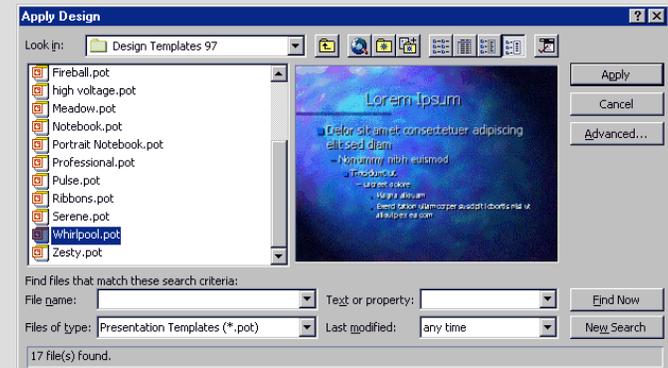
### • HCI Design Patterns

- “...a structured textual or graphical description of a proven solution to a recurring design problem” (Borchers, 2001)
- Several online pattern libraries  
[www.welie.com](http://www.welie.com)
- New book! Tidwell, J. (2006). **Designing Interfaces**
- Framed around common interactions with a general class of IT
- Applicable work domains are infinite

### Website / Navigation: “Double-Tab”



### Desktop App / File Selection: “Preview”



### Mobile Phone: “Selection”



# Two Varieties of HCI Design Patterns

## Work / Mission Domain



The Operator Accomplishes Mission-Relevant Goals within the Work Domain

- Human-Work Interoperability

*“Work-Centered Design Patterns”*

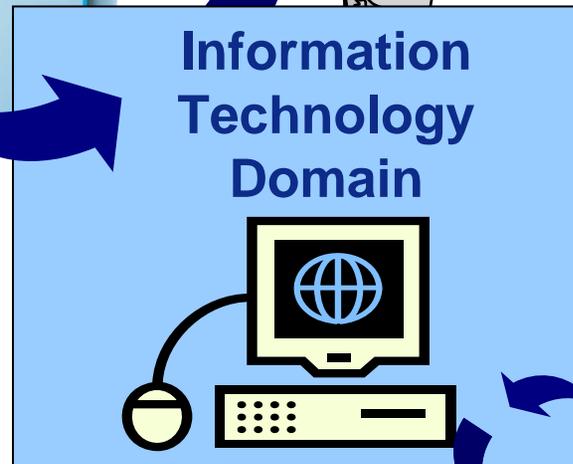
Need Set  
for C2

The Operator Acts within the IT Domain

- Human-IT Interoperability

*“IT-Centered Design Patterns”*

Existing  
HCI DP



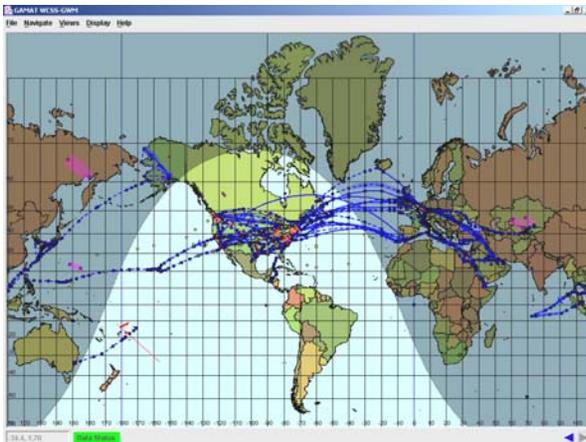
# Scientific Objective

## Identify HCI Design Patterns for C2

**Hypothesis: Similar environments benefit from similar HCIs**



Similar



Tailored

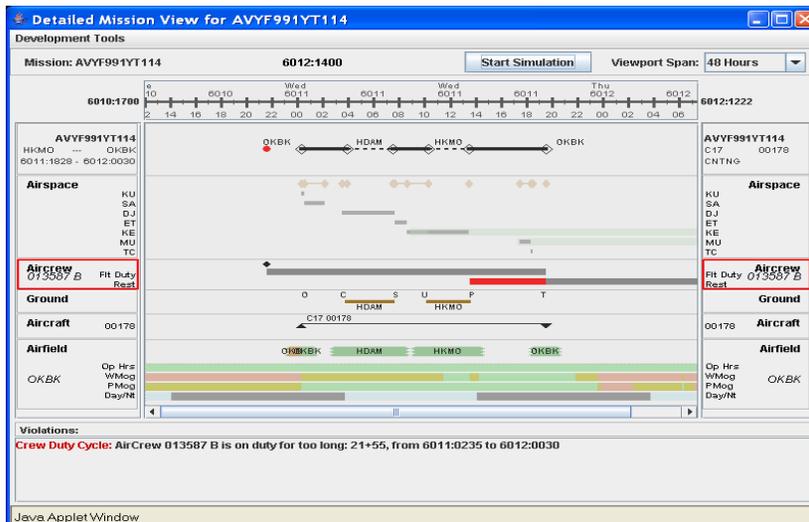


**Question: Where do we get the HCI design patterns to reuse?**

# Scientific Objective

## Identify HCI Design Patterns for C2

**Hypothesis: Existing “Work-Centered” HCI can be reverse-engineered to uncover HCI Design Patterns**



## Functional HCI Design

### 1. HCI Design Pattern Hierarchies

- a. Work-Centered DP
  - a. Work-Centered DP
  - b. IT-Centered DP

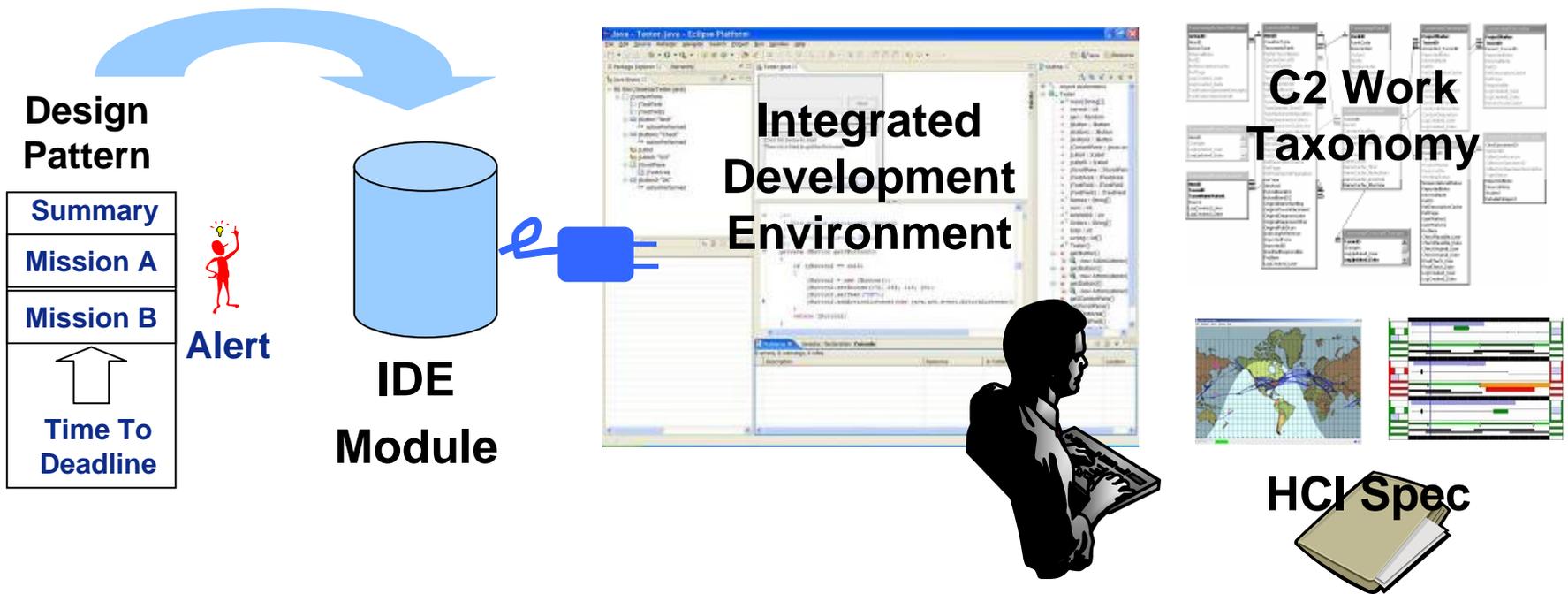
### 2. HCI Design Pattern Applications

- a. Work Field Representation DP
- b. Automation DP
- c. Interaction DP

**Question: What will we do with the HCI design patterns?**

## • HCI Builder within an Integrated Development Environment

- HCI Design Patterns embedded in software modules for IDE
- Software developer navigates C2 work function taxonomy
- Reviews potential, relevant HCI Design Patterns per work functions
- Selects, assembles, & populate HCI DP for specific project
- Output: Notional HCI Design, Skeletal HCI Specification

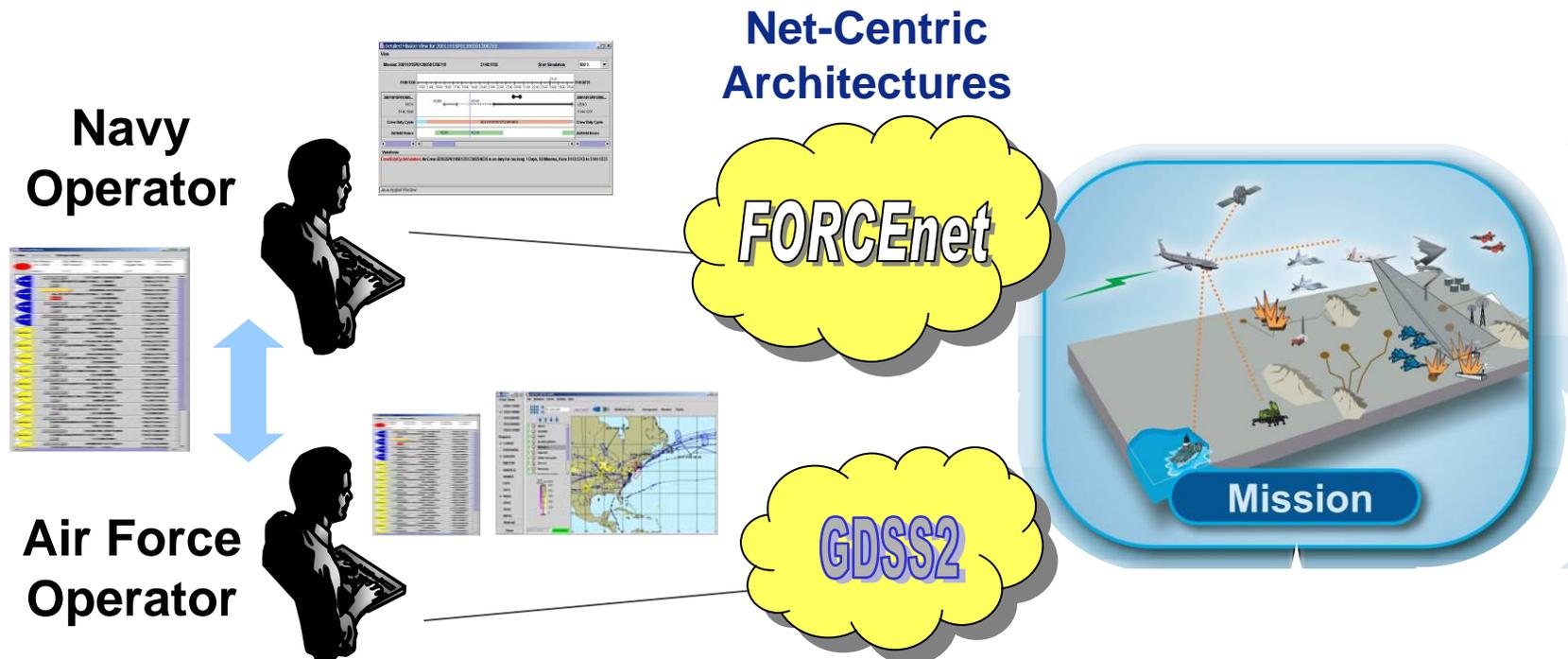


# Vision: Design Reference Library to Improve Joint Operations & Training



- DOD Design Reference Library based on HCI Design Patterns
  - “Flexible standardization” of HCI in C2 across armed services
  - “Human-Human Interoperability” across armed services
  - Facilitates C2 operator training

## *One Example: Joint AF-Navy Strike Operation*



# HCI Design Patterns for C2 Recap & Examples

*When Designers are faced with new problems...  
Patterns fill a significant gap in the design process...*

HCI Guidelines =  
*too generic...  
only GUI look & feel*

Completed HCI =  
too complex,  
difficult to abstract  
back into new task  
domains...

HCI Pattern =  
Usable for multiple task and  
mission domains

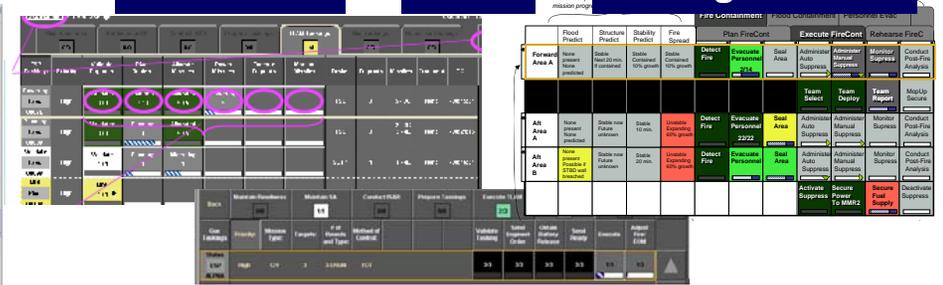
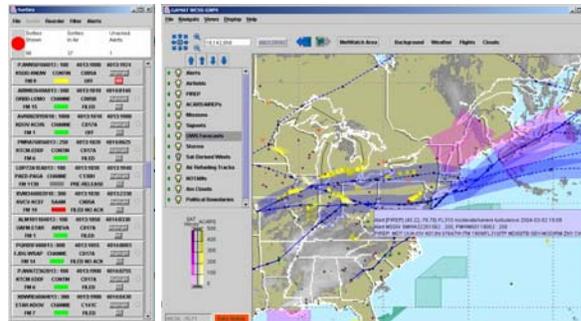


## Step-based Task Navigation Pattern

	Item Label	Item Label	Item Label	Plan Mission	Execute Mission	Rehearse Mission
2	Mission Thread One	Explanation Item 1 Explanation Item 2E	Explanation Item N	Exec Task Step 1 Label Task Step 2 3 lines Arial 10pt	Task Step 4 Task Step 5 Task Step 6 Task Step 7	Task Step 4 Task Step 5 Task Step 6 Task Step 7
	Mission Thread Two	Explanation Item 1 Explanation Item 2E	Explanation Item N	Exec Task Step 1 Label Task Step 2 3 lines Arial 10pt	Task Step 4 Task Step 5 Task Step 6 Task Step 7	Task Step 4 Task Step 5 Task Step 6 Task Step 7
	Mission Thread N	Explanation Item 1 Explanation Item 2E	Explanation Item N	Exec Task Step 1 Label Task Step 2 3 lines Arial 10pt	Task Step 4 Task Step 5 Task Step 6 Task Step 7	Task Step 4 Task Step 5 Task Step 6 Task Step 7

*Mission context application*

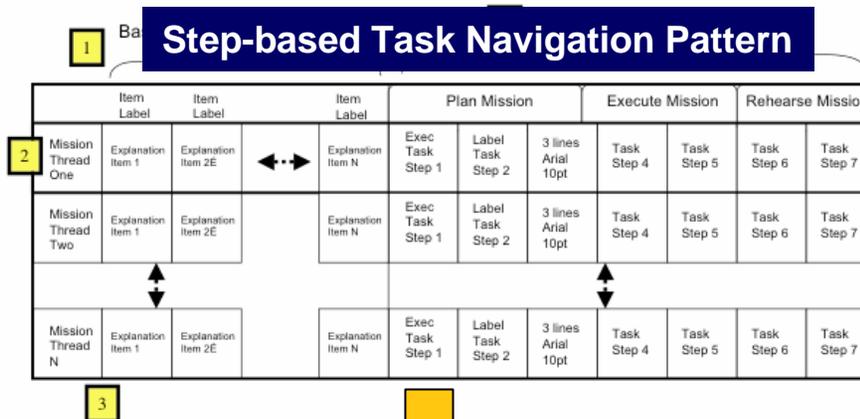
**Tomahawk**      **Guns**      **Damage Control**



# HCI Design Patterns for C2 Recap & Examples

*Patterns fill a significant gap in the design process...*

HCI Pattern = Usable for multiple task and mission domains



*Mission context application*

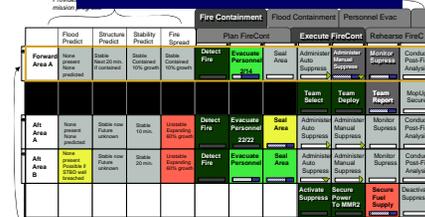
**Tomahawk**



**Guns**



**Damage Control**



# HCI Design Patterns for C2 Recap & Examples

## Work / Mission Domain



The Operator Accomplishes Mission-Relevant Goals within the Work Domain

- Human-Work Interoperability

*“Work-Centered Design Patterns”*

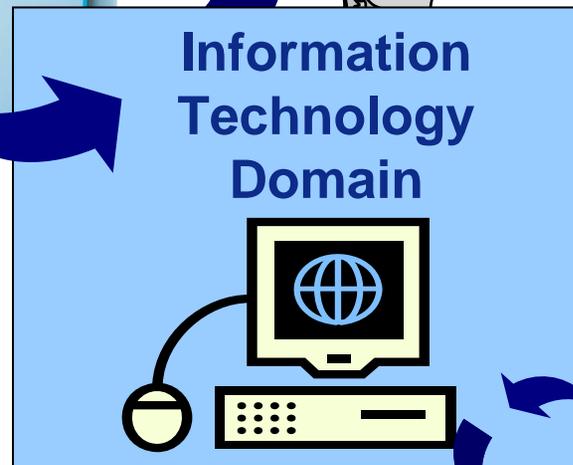
Need Set  
for C2

The Operator Acts within the IT Domain

- Human-IT Interoperability

*“IT-Centered Design Patterns”*

Existing  
HCI DP



# HCI Design Patterns for C2 Recap & Examples

## Tomahawk Launch Sequence Task Navigator

1. Initiation (triggering )
2. O
3. R
4. D

**Sequential Task Navigation Pattern**

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

ASCM

Prob of Success	Ownership Role	Space	Mission	Target	Munition	Range	Launch Area	Deconflict	Avoidance	Flight Corridors	TOL	
98%	Priority		2nd Howztl	IIC	153	Lima	02:45	MSL	1,200 ft	None	<10%	-0:09:07
91%	Priority		0013	IIC	99	Starboard	02:45	MSL	1,800 ft	None	<10%	-0:09:14
93%	Priority		16	IIC	99	Starboard	02:45	MSL	1,800 ft	None	<10%	-0:09:21

5. Confirmation

Send SCO

## AF Mission Monitoring Tool

Development Tools

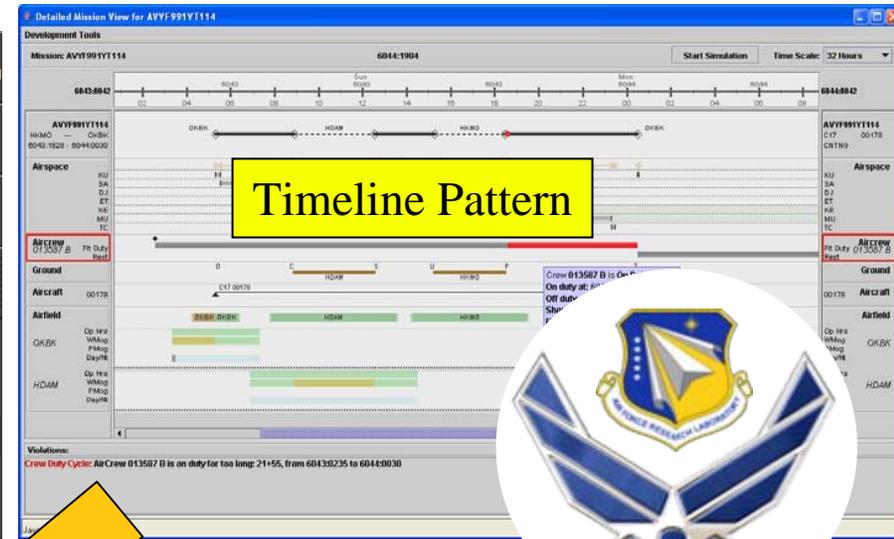
Mission: AVYF991Y1114

6044:1904

Start Simulation Time Scale: 32 Hours

6044:0042

Timeline Pattern



Violations:  
Crew Duty Cycle: AirCrew 013507 B is on duty for too long: 21:55, from 6043:0235 to 6044:0030



Time-Line Display for In-flight Missile Management

Sequence Display for Aircraft Maintenance Check

# HCI Design Patterns for C2 Recap & Examples

## Tomahawk Launch Sequence Task Navigator

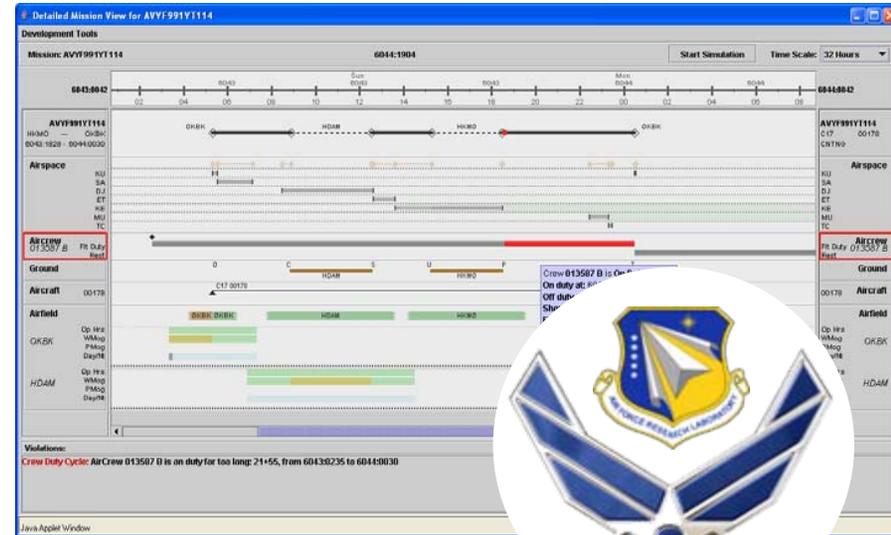
## AF Mission Monitoring Tool

1. Initiation (triggering )

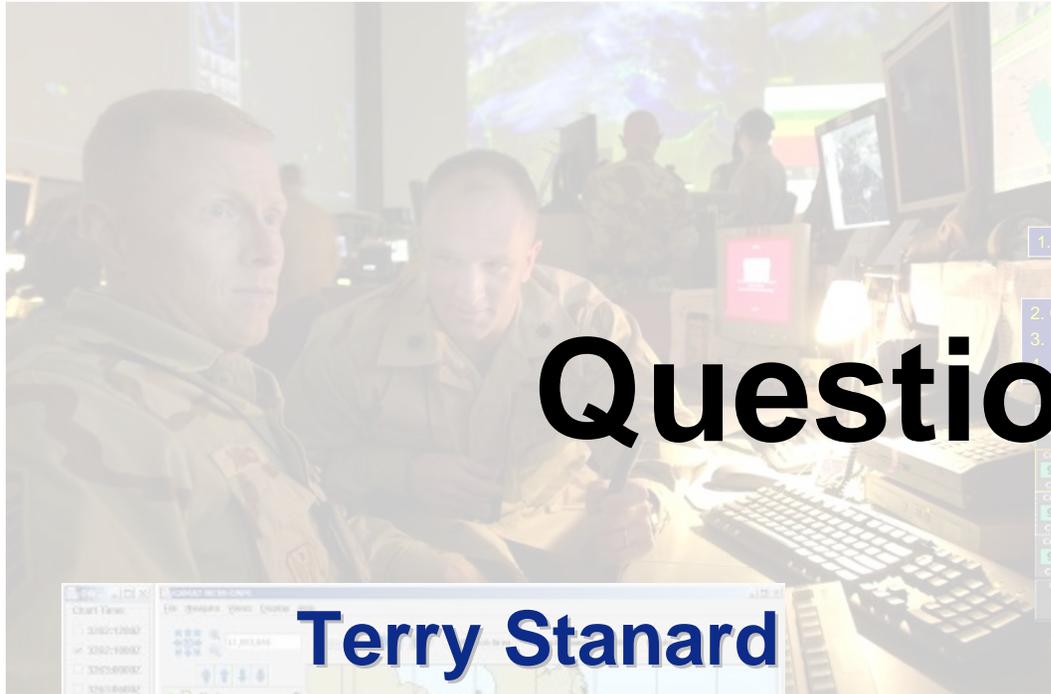
- 2. Orientation
- 3. Review
- 4. Decision & Action

		Execute TLAM		Execute Gun		Rehearse Taskings						
		1/5		2/2		0/0		M				
		Validate Tasking	Plan Routes	Allocate Missiles	Power Missiles	Execute Launch	Monitor					
		2/2	0/2	6. Transition		0/2	0/2					
		ASCM										
Prob of Success	Ownership Role	Sparr	Mission	Target	Munition	Range	Launch Area	Deconflict	Avoidance	Flight Corridors	TOL	
Comply	98%	Pri	2nd Howztr	IIC	1	153	Lima -02:45	MSL	1,200 ft	None	<10%	-0:09:07
Comply	91%		0013	IIC	1	160	Lima -02:45	MSL	1,800 ft	None	<10%	-0:09:14
Comply	93%		ack	IIC	3	183	Lima -02:45	MSL	1,900 ft	None	<10%	-0:09:24
Comply												

5. Confirmation



Detailed Examples in Conference Paper



# Questions?

1. Initiation (triggering)

2. Orientation

3. Review

4. Decision

5. 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
-0:00:00					
ASCM					

Compl	Priority	RS	Strategic	Mode	SACC	Pre Plan	Target	Maneuver	Range	Launch Area	Decoy	Avoidance	Flight	TOL
93%	Primary	RS	Strategic	None	SACC	Pre Plan	277941	Starboard	100	100	None	<10%	0:00:07	
91%	Primary	RS	Strategic	None	SACC	Pre Plan	277942	Starboard	100	100	None	<10%	0:00:14	
93%	Primary	RS	Strategic	None	SACC	Pre Plan	431023	Starboard	100	100	None	<10%	0:00:11	

5. Confirmation



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