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Issues in User Acceptance and Human + Machine Performance:

Lessons learned from fielding Intelligent, Adaptive Information Systems

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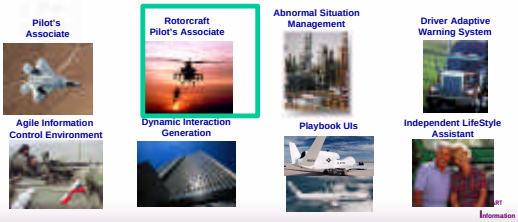
My Background

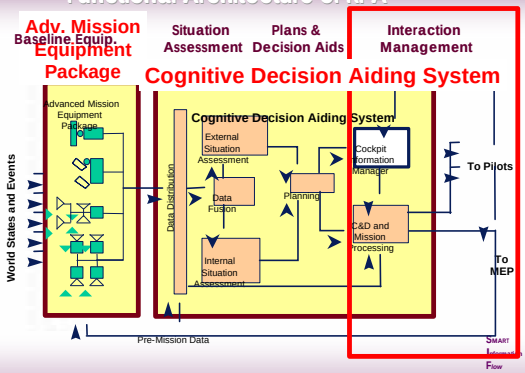
- **12 years experience in building autonomous, adaptive interfaces for high criticality (= "complex real world") systems**
  - "Agent" controls displays and sometimes controls
  - Task-, situation-, device- and/or user-sensitive
  - Varying degrees of autonomy, it must always follow the human operator's intent . . .



Rotorcraft Pilot's Associate

- **Goal: Provide Adaptive Information and Automation management for advanced Rotorcraft with effectiveness and workload payoffs**
- **5 year, $80M U.S. Army program**
  - 1994-1999
  - Flight tested in 1999
- **Honeywell team responsible for Cockpit Information Manager design**

Functional Architecture of RPA



The Big Tradeoff

Every-thing is done the way I like it

1. Pilot in charge of tasks
2. All needed tasks accomplished
3. Pilot in charge of information presented
4. All needed information provided
5. Stable task allocation
6. Only needed information provided
7. Tasks allocated as expected
8. Information presented as expected
9. Stable information configuration
10. Tasks allocated comprehensibly
11. Only needed tasks active

Every-thing gets done (well)

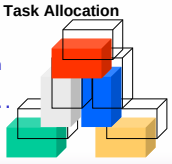
Operators want to remain in 'charge', even when they can't be fully in control

Cockpit Information Manager Behaviors

CIM Accomplishes its goals of context sensitive task and information management through five observable behaviors:

1. **Page or Format selection**
2. **Symbol selection/ declutter**
3. **Window placement**
4. **Automated Pan and Zoom**
5. **Task Allocation**

They combine in multiple variations . . .

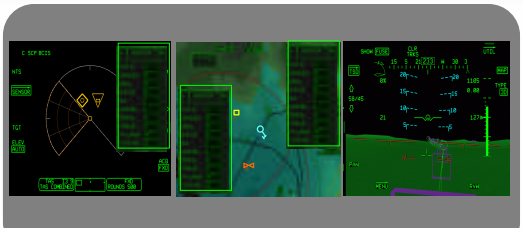


to provide intelligent cockpit information management. . .

The behaviors are building blocks.

in multiple contexts.

RPA Window Placement Example

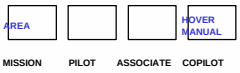


Default/Preferred Window Placement

Alternate, Scripted Window Placement

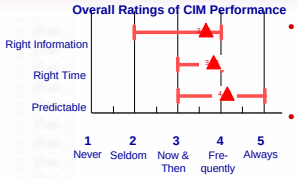
Window Placement for Actions on Contact given Threat Positions

Crew Coordination & Task Awareness Display



- Four buttons to convey major, associate-inferred task contexts
- Single press overrides = "No, you're wrong. That's not what we're doing"
  - Associate 'gets out of the way'
- Press and Hold scrolls through tasks at same level of hierarchy
  - E.g., Area Recon, Zone Recon, Attack in Force, Hasty Attack, Delay, Evade, Ingress, Egress, etc.

Overall CIM/CDAS Performance



- CIM 'Frequently' provided the right information at the right time
- CIM was seen as very predictable

- Perceived effectiveness was better with CDAS for all 4 mission types
- Averaged .5 points higher with CDAS (12.5% of scale length).

Perceived Effectiveness x Mission Task

Average Rating	AMEP	CDAS
Zone Reconnaissance	3.75	3.88
Area Reconnaissance	3.75	4.25
Deliberate Attack	4.13	4.75
Change to Attack	3.63	4.63

3='Fair'; 4='Good'; 5='Excellent'

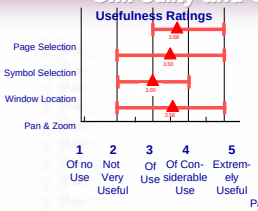
Subjective Workload (TLX) Ratings

TLX subscale	AMEP mean	CDAS mean	F-Value (df: 1,6)
Mental Demand	61.77	46.25	10.487*
Physical Demand	54.48	40.31	12.042*
Temporal Demand	62.08	45.73	14.061**
Perceived Performance	35.00	42.08	2.429
Effort	62.60	48.54	20.470**
Frustration	52.81	45.63	4.961

*p<.05 ** p<.01

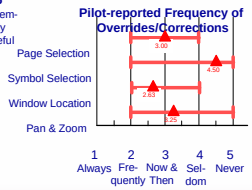
- Workload levels consistently higher for AMEP than for CDAS
- Significant differences for 4 of 6 TLX subscales (and close for the 5th)
- No effect on Perceived Performance-- perhaps pilots factor technology effects into their expectations?

CIM Utility and Overrides



Most crews said CIM Behaviors were 'Of Use' or "Of Considerable Use'

Crews 'Seldom' overrode CIM's symbol selections, but 'Now & Then' overrode other behaviors



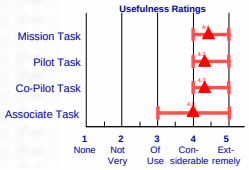
CIM was seen as useful and provided perceived performance and workload advantages

in spite of

'Now and Then' or 'Frequently' providing the wrong information.

Why?

Crew Coordination & Task Awareness Display



- Perceived accuracy of LED Task displays was very high
- Comments (and other ratings) indicated these were very useful to pilots

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Conclusions

- **The four CIM behaviors, as implemented:**
  - generally met mission expectations
  - contributed to perceived pilot effectiveness
  - reduced workload
  - are gaining pilot acceptance
- **Perfection in behaviors is <u>not</u> a prerequisite to this level of acceptance**
  - Crews 'Now and Then' overrode CIM behaviors
  - Perceived frequency of overrides uncorrelated with perceived usefulness
- **Strong contributors to CIM acceptance seem to be:**
  - High degree of predictability
  - Simple Crew Coordination display
  - Easy override of CIM behaviors

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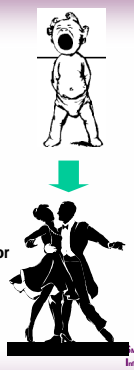
Etiquette(s) of HCI

- **Etiquette rules are generally NOT created from scratch**
  - based on observed good practice
  - extended into novel domains
  - made explicit for those who don't get it naturally
- **Etiquette rules for AUIs should be the same**
  - observe good human/human practice
  - extend and generalize to AUIs
- **Etiquette violations can be powerful**
- **Etiquette isn't the same for all situations**
- **Etiquette rules don't have to be achievable for AUIs . . . right now.**

Dear Miss Manners,
Are there any rules of etiquette yet governing use of voicemail systems?



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Lessons Learned

- **'Associates':**
  - Don't have to be perfect
  - Do have to communicate
    - Tasking Interactions
    - Etiquette
  - Do have to be subordinate
    - Be able to take instruction
    - Be able to act intelligently on it
    - Be able to avoid making the same mistake over and over again
  - Should be predictable
    - (at least in high criticality domains)

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