

## 5.2 Human Performance Modeling Tools for Better System Design



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# Human Performance Modeling Tools for Better System Design

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## Agenda

- Why Human Performance Modeling (HPM)?
- Importance of HPM to System Design
- HPM Tools and Applications
  - CogTool
  - C3TRACE
  - IMPRINT
  - MIDS Plug-in
- Expansion of tools
- Summary

# Why Human Performance Modeling (HPM)?

Concept System

Many Variables

Field Study Not Feasible

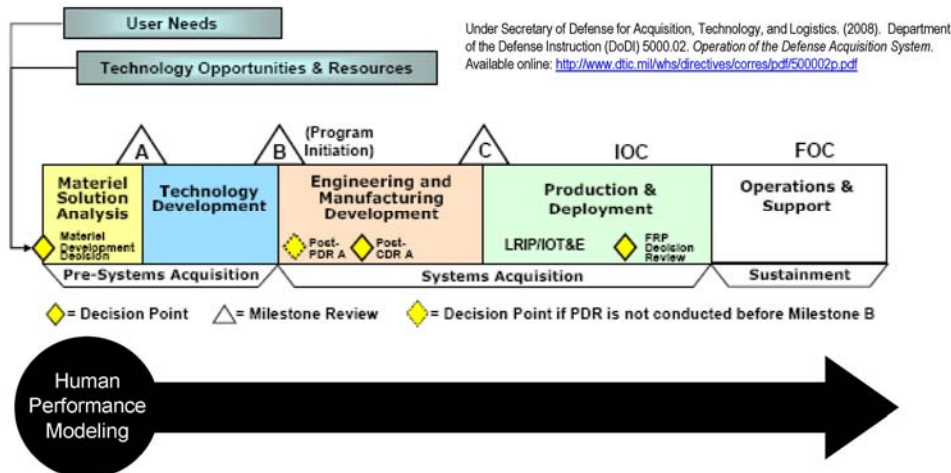
Too Dangerous

**Model – Test – Model**

**System Performance  $\cong f(\text{human performance})$**

3

## Importance of HPM to System Design



*Provide quantitative data to inform trade off decisions early in design process*



1. Set up a project to compare design alternatives on a suite of tasks
2. Lay out a storyboard of frames (what the user will see) and transitions between them (what the user will do)
3. Detail each frame with the interactive widgets available to the user
4. Demonstrate the tasks, CogTool creates a valid cognitive model of a skilled user.
5. Press "Compute" and CogTool creates ACT-R code, runs it and produces a prediction of skilled execution time
6. Examine what the ACT-R model did to produce the prediction in an interactive timeline visualization.

- General purpose UI prototyping tool
- Automatically evaluates design with predictive human performance model
- "cognitive crash dummy"

Bonnie E. John, Principle Investigator  
Human-Computer Interaction Institute  
School of Computer Science  
Carnegie Mellon University  
<http://cogtool.org>

John, B. E., (2010) CogTool: Predictive Human Performance Modeling by Demonstration. Proceedings of the 19th Annual Conference on Behavior Representation in Modeling and Simulation (BRIMS) (Charleston, SC, March 21-24, 2010).

## CogTool Application

- Compared time to complete programming tasks within two environments
  - 2002 – Unix command line and Vim editor
  - 2010 - Eclipse Parallel Tools Platform (PTP)

**Results**

Eclipse PTP interface will improve performance of skilled programmers over 2002 command line interface

Tasks	Command Line	PTP-Eclipse
▼ HelloWorld_mpi	Min: 114.405 s	Min: 40.090 s
HelloWorld_mpi with keyboard	161.111 s	
HelloWorld_mpi with mouse	114.405 s	40.090 s
▼ F1Help	Min: 30.726 s	Min: 10.462 s
F1 Help with keyboard	30.726 s	
F1 Help with mouse	31.247 s	10.462 s
▼ Code Folding	Min: 5.780 s	Min: 3.563 s
Code folding with keyboard	10.490 s	
Code folding with mouse	5.780 s	3.563 s
Barrier Analysis	40.149 s	11.833 s

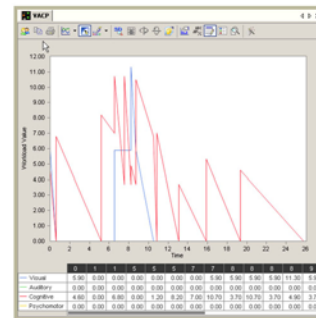
Richards, J., Bellamy, R., John, B., Swart, C. & Thomas, J. (2010) Using CogTool to Model Programming Tasks. Psychology of Programming Interest Group WIP (PPIGWIP) (Dundee 2010). [www.ppiq.org](http://www.ppiq.org).

# C3TRACE

## Command, Control, and Communications - Techniques for the Reliable Assessment of Concept Execution

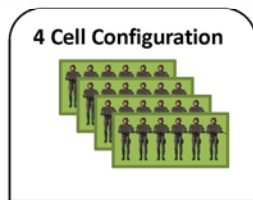
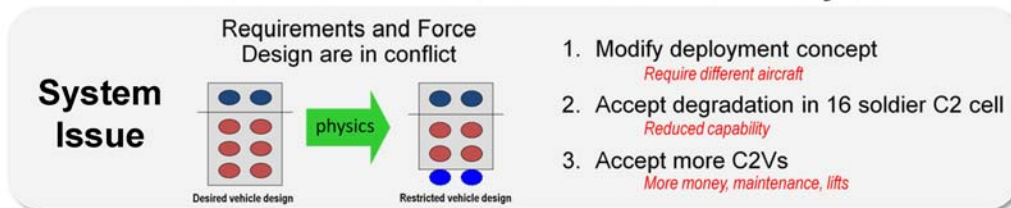
**Goal:** To conduct “what-if” analyses based on information flow and quality, to discover alternative organizational, personnel, and system configurations that increase performance

- Evaluate effects of different personnel architectures and information technology on system and human performance
- Investigate efficiency and effectiveness of message processing in Command & Control environments



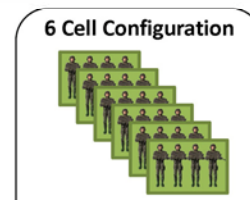
# C3TRACE Application

## Future Command and Control Cell Analysis



### Results

**Performance Measures**  
Utilization  
Probability of “good decision”  
Messages handling



- 19 of 24 - 100% utilization
- 6 of 24 – 25+% poor decision quality
- 18 of 24 - dropped 50+% of messages
- 13 of 24 - 100% utilization
- 5 of 24 – 25+% poor decision quality
- 8 of 24 – dropped 50+% of messages

Mitchell, D. K., Samms, C., Kozycki, R., Kilduff, P., Swoboda, J., & Animashaun, A. (2006) *Soldier Mental Workload, Space Claims, and Information Flow Analysis of the Combined Arms Battalion Headquarters Command and Control (C2) Cells* (ARL-TR-3861). Army Research Laboratory, APG, MD.

# Improved Performance Research Integration Tool

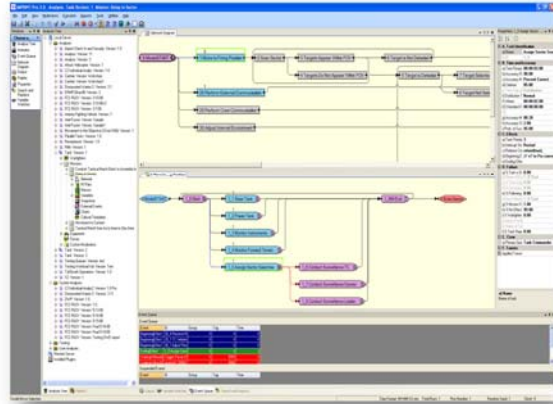


**IMPRINT**

Improved Performance Research Integration Tool



334 users supporting Army, Navy, Air Force,  
Marines, NASA, Department of Homeland  
Security (DHS), Department of Transportation  
(DoT), Joint and other organizations  
across the country



<http://www.arl.army.mil/IMPRINT>

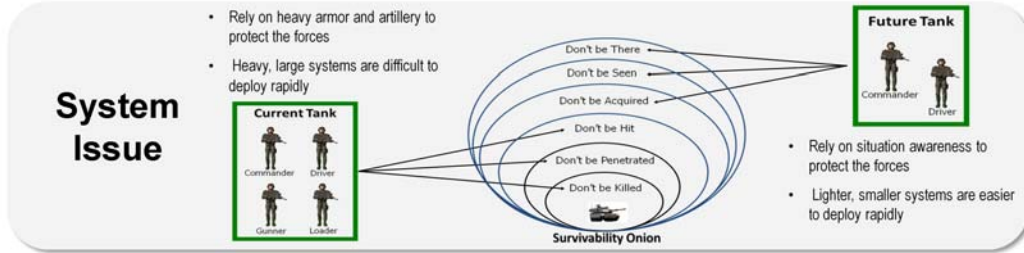
<https://km3.alionscience.com/sites/imprint>

## IMPRINT can be used to

- Set realistic system requirements
- Identify future manpower & personnel constraints
- Evaluate operator & crew workload
- Test alternate system-crew function allocations
- Assess required maintenance man-hours
- Assess performance during extreme conditions
- Examine performance as a function of personnel characteristics and training frequency & recency
- Identify areas to focus test and evaluation resources
- Quantify human system integration risks in mission performance terms to support milestone review
- Represent humans in federated simulations

**IMPRINT is a trade-off analysis tool**

# IMPRINT Application



## Methodology

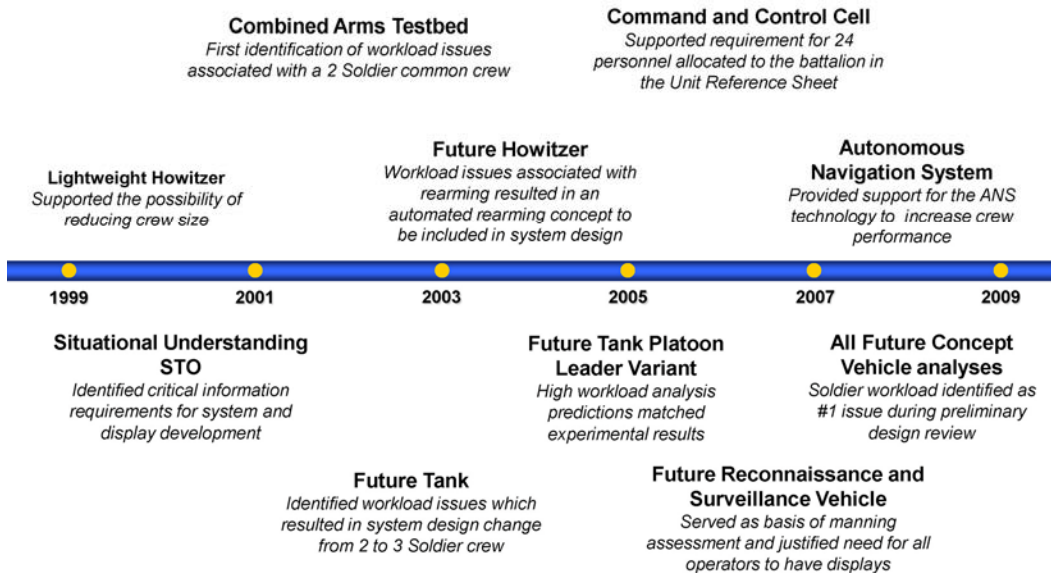
- Identified functions and tasks via knowledge elicitation
- Set up experimental conditions to model based on varying function allocations
- Built models
- Validated models by walking-through with Soldiers
- Completed runs and prepared results

## Results



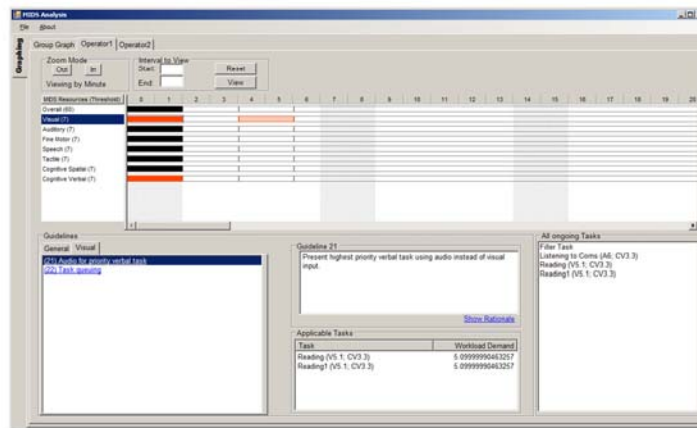
Mitchell, D. K., Samms, C. L., Henthorn, T., & Wojciechowski, J. Q. (2003). Trade study: A Two-versus three-Soldier crew for the Mounted Combat System (MCS) and other future combat system platforms (Technical report ARL-TR-3026). Aberdeen Proving Ground, MD, U.S. Army Research Laboratory.

# A Decade of Impact on Soldier-System Integration



## Multimodal Information Design Support (MIDS) Tool Plug-in

- Develop potential mitigation strategies from multimodal design guidelines matched to areas of high workload as identified in IMPRINT



## Expansion of Tools

- Develop smart “links” between tools
- Keep up with evolving analysis demands
- Specific Enhancements
  - CogTool
    - Additional measures
  - C3TRACE
    - Visualization of impacts to decision quality
  - IMPRINT
    - Connect to system engineering
  - MIDS Plug-in
    - Predict effect of incorporating mitigation strategies

## Summary

- Use of human performance modeling tools can
  - Provide quantitative data to inform trade off decisions early in design process
    - Cost savings
    - Better design
  - Focus test and evaluation resources
    - Model – Test – Model approach
- Expand tools to answer new analytic