

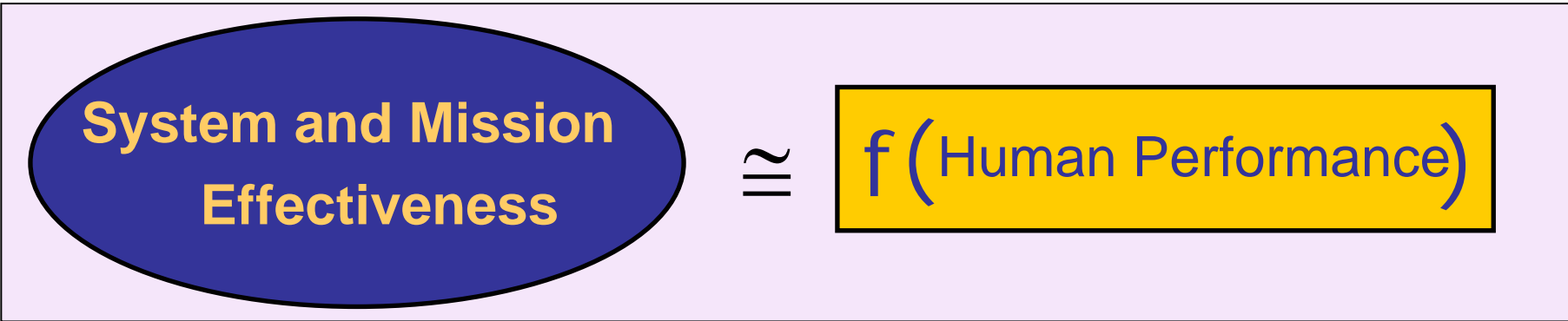


TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Using IMPRINT to Translate Human Performance into System and Mission Effectiveness

Diane Kuhl Mitchell and Charneta Samms

March 3, 2009



The Defense Acquisition Management Framework *

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Human performance is challenging to predict

Many Variables

Concept System

Too Dangerous

Field Study Not Feasible

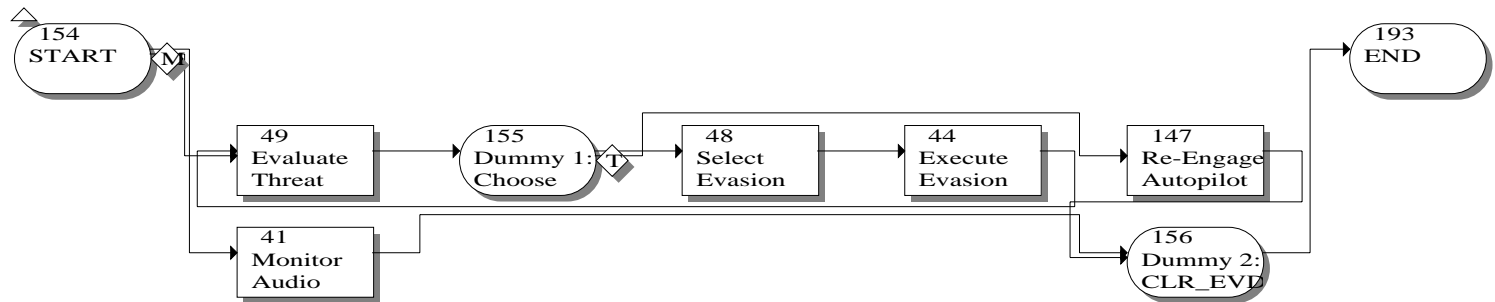
System Performance $\cong f(\text{human performance})$

INPUTS

- Time and accuracy of each task
- Consequences of "poor" performance

Gathered from such sources as existing data, algorithms, and estimates from SMEs

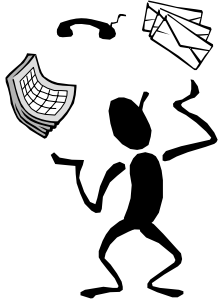
MODEL



OUTPUTS

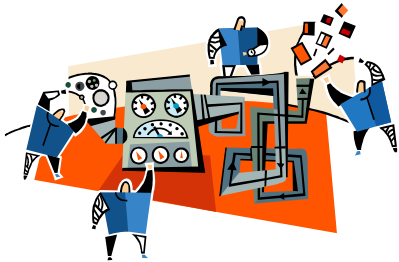
Measures of effectiveness

Not descriptive models, but predictive models



Is the human overloaded with tasks?

Will training improve human and system performance?

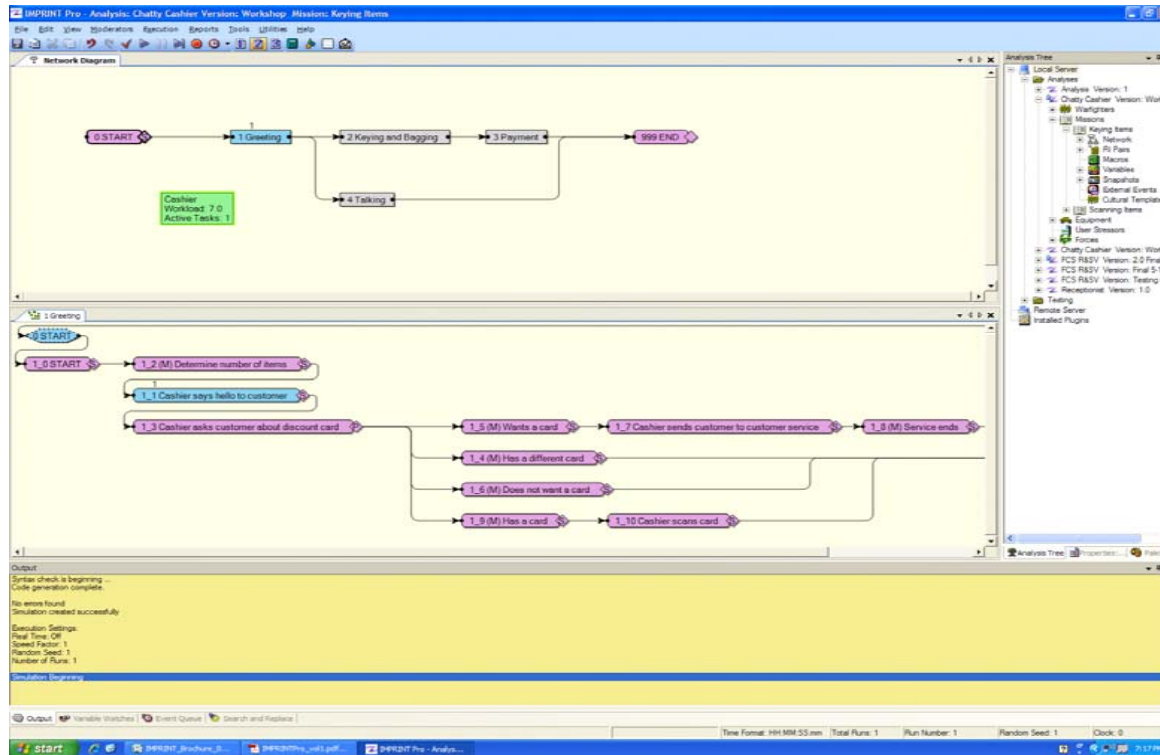


How to allocate tasks between human(s) and automation?

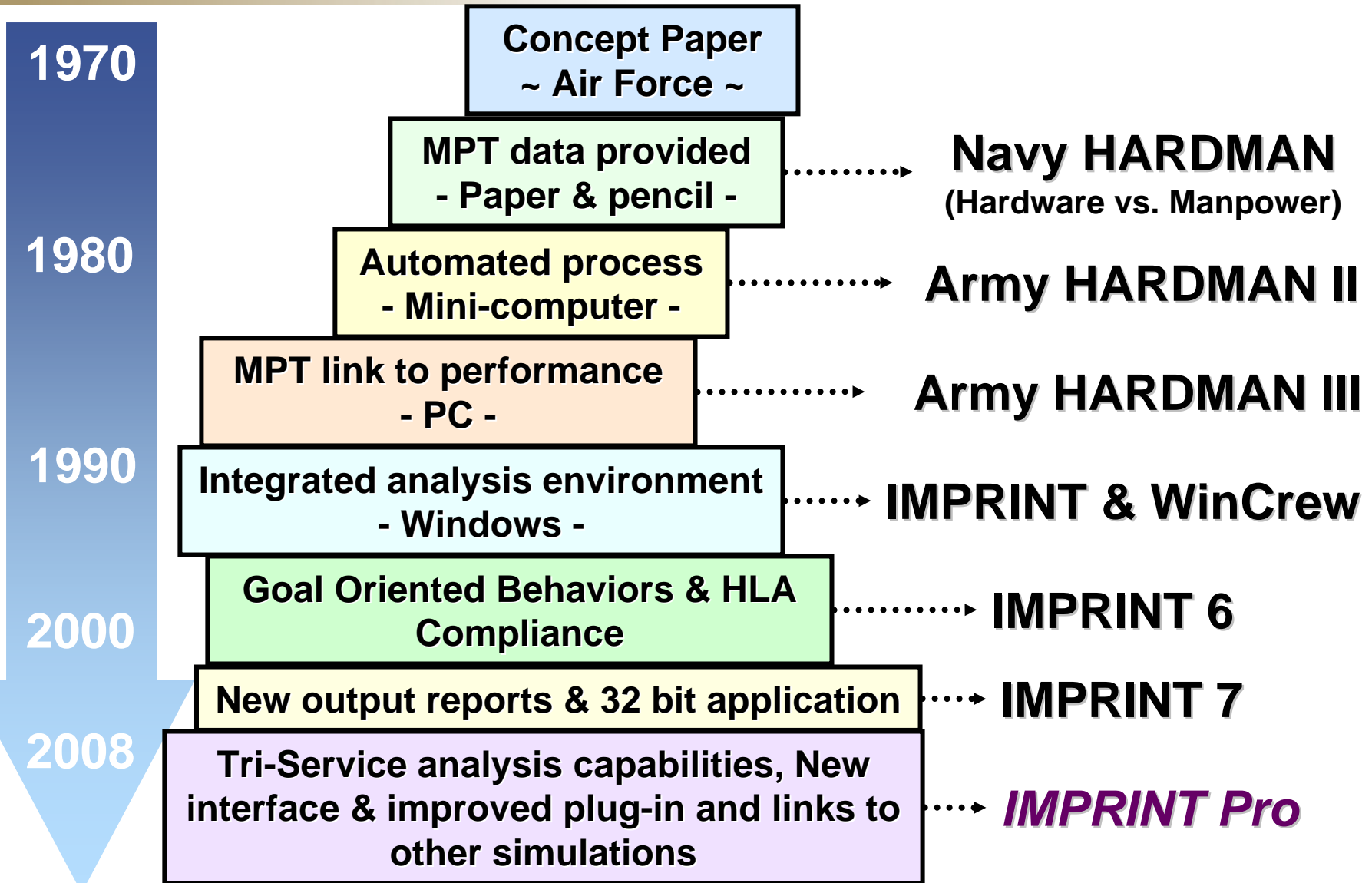
What are the performance tradeoffs with different system designs or levels of operator experience?

IMPRINT is...

- a Human System Integration tool
- a dynamic, stochastic discrete event network modeling tool

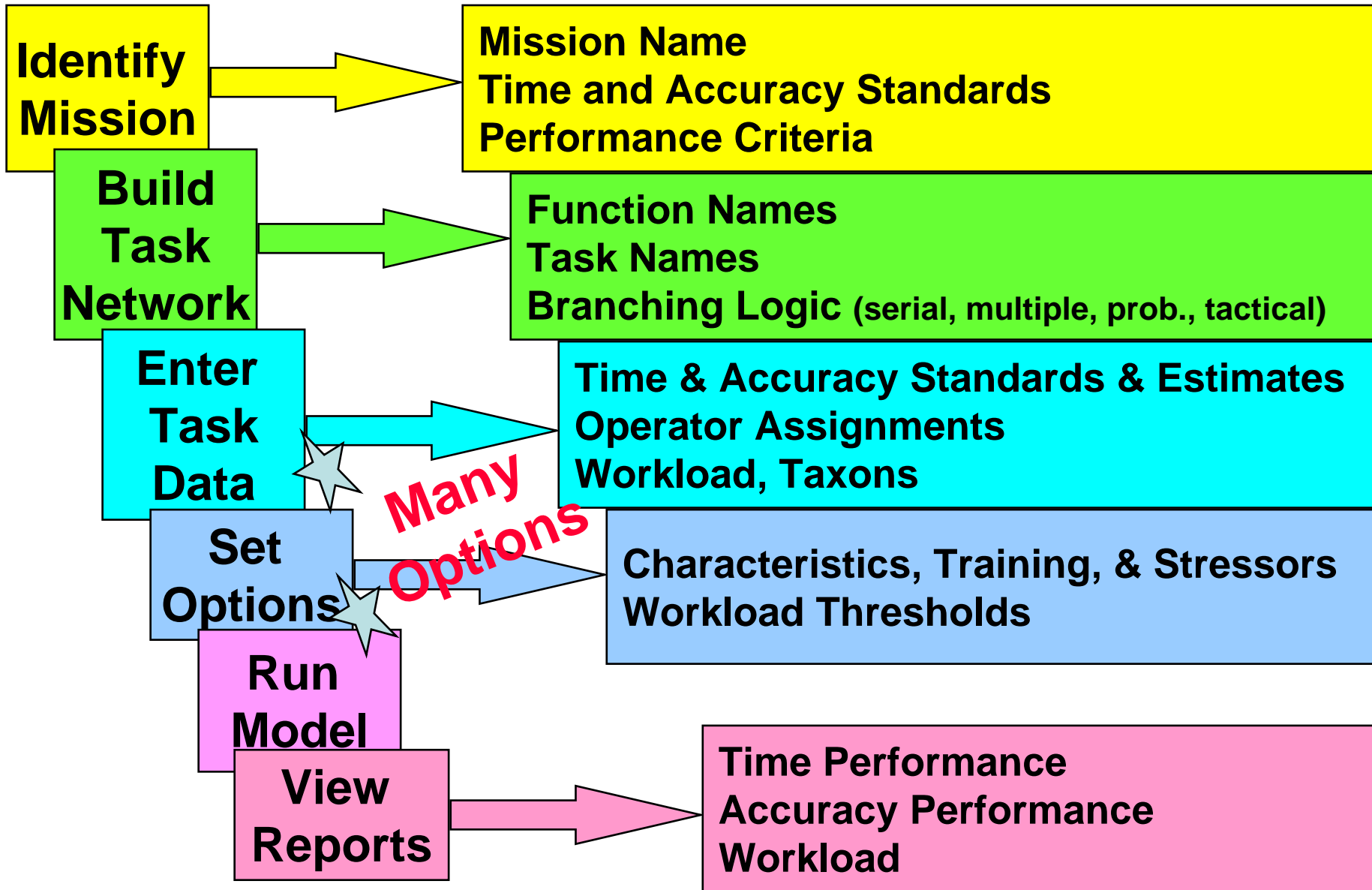


<http://www.arl.army.mil/IMPRINT>

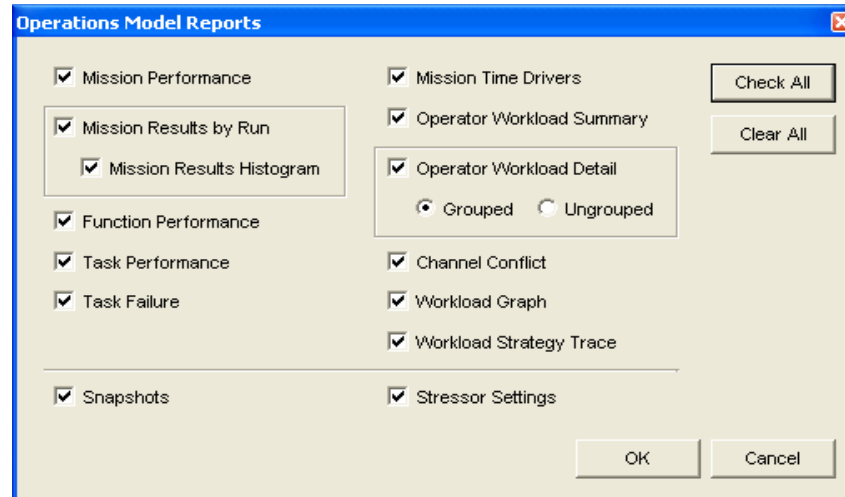


- Set realistic system requirements
- Identify future manpower & personnel constraints
- Evaluate operator & crew workload
- Test alternate system-crew function allocations
- Assess required maintenance manhours
- Assess performance during extreme conditions
- Examine performance as a function of personnel 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



- Mission Performance
 - Predicted time & success rate of mission
- Function Performance
 - Predicted time & success rate of individual functions



ID	Function	Times Performed	Standard	Minimum	Maximum	Mean	Std. Dev.	Met
117	(P3) Maintain local SA and scan for enemy	1	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	0.00
103	(C3) Conceal vehicle	3	00:00:00	00:10:00	00:10:00	00:10:00	00:00:00	0.00
106	(D3) Conduct Area Reconnaissance	1	00:00:00	00:17:39.66	00:17:39.66	00:17:39.66	00:00:00	0.00
118	(V3) Maintain local SA and scan for enemy	1	00:00:00	00:00:45.00	00:00:45.00	00:00:45.00	00:00:00	0.00
105	(D3) Get reconnaissance pictures or video	2	00:00:00	00:00:02.87	00:00:09.87	00:00:06.37	00:00:04.96	0.00
108	(U3) Maintain local SA and scan for enemy	1	00:00:00	00:00:45.00	00:00:45.00	00:00:45.00	00:00:00	0.00
167	(S3) Miss while dismounted	5	00:00:00	00:21:30.00	02:40:00.00	01:12:06.00	01:02:59.30	0.00
107	(U3) Control Mount Mounted Sensor	2	00:00:00	00:04:20.00	00:20:52.00	00:12:36.00	00:11:44.45	0.00
108	(U3) Conduct Area Reconnaissance	3	00:00:00	00:02:26.68	00:18:11.61	00:07:48.10	00:08:59.89	0.00
108_8	(U3) Get reconnaissance pictures or video	13	00:00:00	00:00:01.87	00:01:12.74	00:00:34.23	00:00:23.74	0.00
11	(G3) Move Tactically/Defeatly	5	00:00:00	00:29:00.00	02:00:00.00	00:47:12.00	00:40:41.79	0.00
166	Occupancy DP 1	1	00:00:00	00:40:00.00	00:40:00.00	00:40:00.00	00:00:00.00	0.00
13	(U3) Engage Threat	0	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	0.00
154_3	Actions on Contact_BTR60 - Part 2	1	00:00:00	00:30:00.00	00:30:00.00	00:30:00.00	00:00:00.00	0.00
114	(P3) Control Movement of Platoon	1	00:00:00	00:00:54.00	00:00:54.00	00:00:54.00	00:00:00.00	0.00
119	(S3) Maintain local SA and scan for enemy	1	00:00:00	00:45:00.00	00:45:00.00	00:45:00.00	00:00:00.00	0.00
168	(S4) Miss while dismounted	5	00:00:00	00:21:30.00	02:40:00.00	01:12:06.00	01:02:59.30	0.00
169	(P3) Mission Communication	0	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	0.00
169	Occupancy DP 2 and Set Screens	1	00:00:00	01:00:00.00	01:00:00.00	01:00:00.00	00:00:00.00	0.00
172	(P3) Miss while dismounted	1	00:00:00	01:14:00.00	01:14:00.00	01:14:00.00	00:00:00.00	0.00
173	(P3) Mount Up	2	00:00:00	00:01:00.00	00:01:00.00	00:01:00.00	00:00:00.00	0.00
174	(P3) Mount Up	1	00:00:00	00:12:00.00	00:12:00.00	00:12:00.00	00:00:00.00	0.00
130	(V3) Observe OBJ using observation plan	4	00:00:00	00:30:00.00	00:42:49.99	00:33:50.00	00:06:15.56	0.00
122	(S3) Dismount and conceal vehicle	5	00:00:00	00:11:00.00	02:02:30.00	00:33:18.00	00:49:51.86	0.00
123	(S3) Mount Up	5	00:00:00	00:01:00.00	00:01:00.00	00:01:00.00	00:00:00.00	0.00
124	(S3) Observe OBJ using observation plan	4	00:00:00	00:30:00.00	00:42:49.99	00:33:50.00	00:06:15.56	0.00
125	(S4) Maintain local SA and scan for enemy	1	00:00:00	00:00:45.00	00:00:45.00	00:00:45.00	00:00:00.00	0.00
126	(S4) Dismount and conceal vehicle	5	00:00:00	00:11:00.00	02:02:30.00	00:33:18.00	00:49:51.86	0.00
127	(S4) Mount Up	5	00:00:00	00:01:00.00	00:01:00.00	00:01:00.00	00:00:00.00	0.00
175	Enemy Contact - Technical Providing Reinforcements	1	00:00:00	00:48:00.00	00:48:00.00	00:48:00.00	00:00:00.00	0.00
128	(S4) Observe OBJ using observation plan	4	00:00:00	00:30:00.00	00:42:49.99	00:33:50.00	00:06:15.56	0.00
162	First Mounted OP	1	00:00:00	00:41:00.00	00:41:00.00	00:41:00.00	00:00:00.00	0.00
163	Second Mounted OP	1	00:00:00	00:20:00.00	01:20:00.00	01:20:00.00	00:00:00.00	0.00
154	Actions on Contact_BTR60	1	00:00:00	01:26:30.00	01:26:30.00	01:26:30.00	00:00:00.00	0.00
155	(V3) Observe OBJ using observation plan	1	00:00:00	00:17:06.90	00:17:06.90	00:17:06.90	00:00:00.00	0.00
156	(V3) Get reconnaissance pictures or video	1	00:00:00	00:03:02.87	00:01:17.81	00:02:07.97	00:00:01.15	0.00
156	(P3) Conduct Area Reconnaissance	2	00:00:00	00:17:19.06	00:06:55.40	00:13:46.30	04:09:06.97	0.00
156_11	(P3) Get reconnaissance pictures or video	3	00:00:00	00:00:02.87	00:00:04.47	00:00:22.89	00:00:19.27	0.00
157	(S3) Conduct Area Reconnaissance	1	00:00:00	00:19:47.14	00:19:47.14	00:19:47.14	00:00:00.00	0.00
157_11	(S3) Get reconnaissance pictures or video	4	00:00:00	00:00:10.87	00:00:02.47	00:00:29.49	00:00:19.14	0.00
158	(S4) Conduct Area Reconnaissance	1	00:00:00	00:17:46.63	00:17:46.63	00:17:46.63	00:00:00.00	0.00
158_3	(S4) Get reconnaissance pictures or video	0	00:00:00	00:00:00	00:00:00	00:00:00	00:00:00	0.00
177	(U3) Engage Threat	1	00:00:10	00:16:57	00:16:57	00:16:57	00:00:00.00	0.00
157	(P3) Mount UGV/UAV/IED	3	00:00:00	00:24:87	00:08:42	00:38:39	00:09:32	0.00
89	Internal Control (all)	1	00:00:00	00:02:21	00:02:21	00:02:21	00:00:00	0.00
74	(D3) Maintain local SA and scan for enemy	1	00:00:00	00:45:00.00	00:45:00.00	00:45:00.00	00:00:00.00	0.00
17	(G3) Move Tactically/Defeatly	5	00:00:00	00:29:00.00	02:00:00.00	00:47:12.00	00:40:41.79	0.00

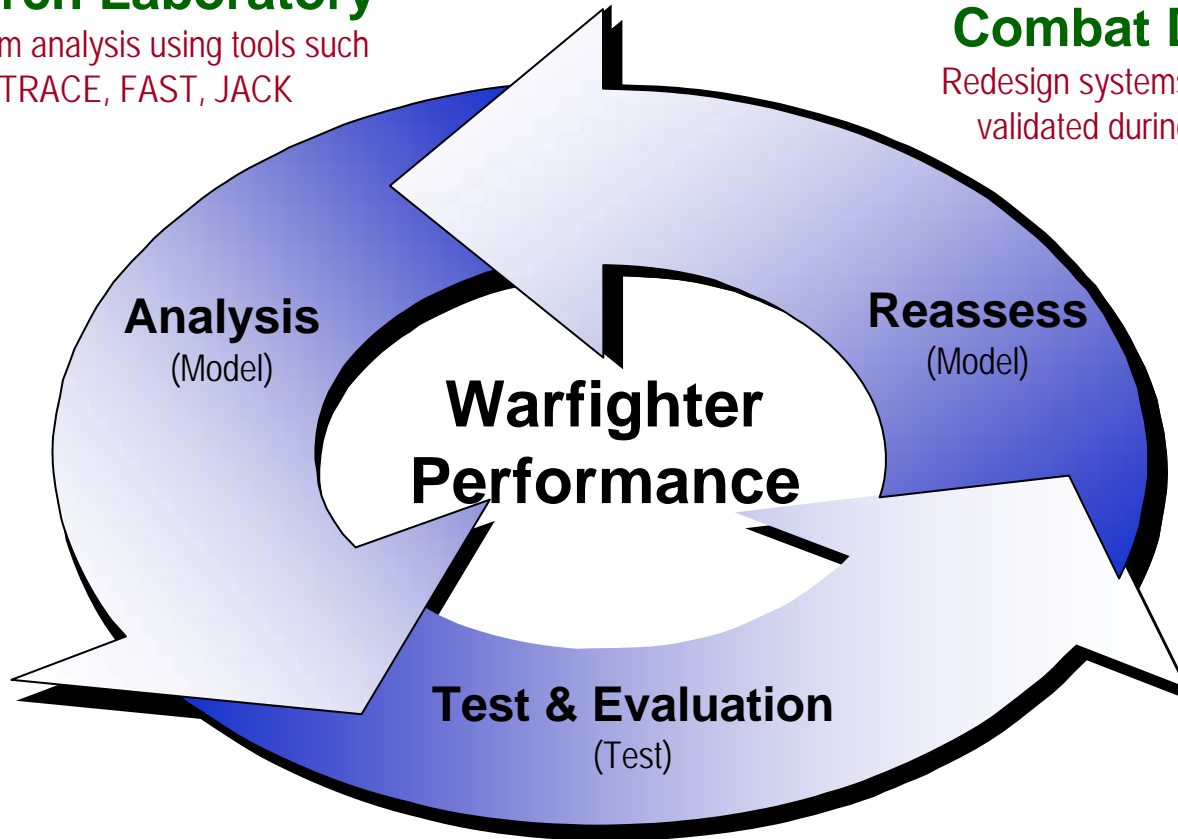
- Task Performance
 - Predicted time & success rate of individual tasks
- Operator Workload
 - Workload over time for each operator
 - Tasks performed over time and associated workload

Army Research Laboratory

Conduct human system analysis using tools such as IMPRINT, C3TRACE, FAST, JACK

Program Managers, Combat Developers

Redesign systems to overcome issues validated during test & evaluation

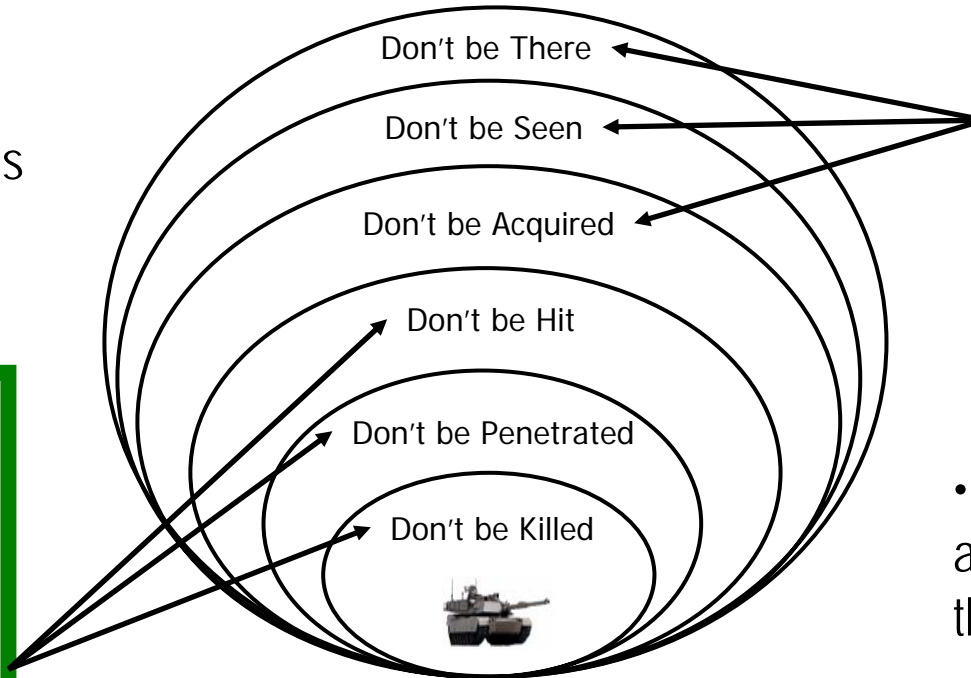


Army Test and Evaluation Center, Army Research Laboratory

Implement issues found during analysis into test plans

- Rely on heavy armor and artillery to protect the forces
- Heavy, large systems are difficult to deploy rapidly

Survivability Onion



NEED TO REDUCE CREW SIZE TO SUPPORT SMALLER, LIGHTER VEHICLE

- Rely on situation awareness to protect the forces
- Lighter, smaller systems are easier to deploy rapidly

- Identified functions to be completed - 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

Four Conditions

- **Gunner-Driver and Commander**
- **Commander-Driver and Gunner**
- **Commander-Gunner and Driver**
- **Commander, Driver and Gunner**

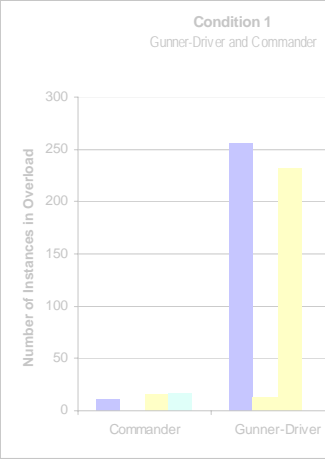
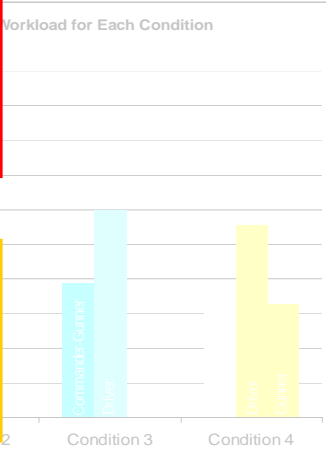
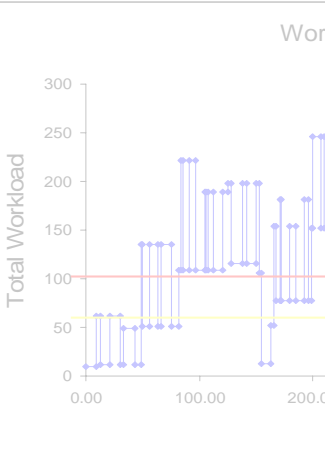
Function Name	Condition 1 GD and C	Condition 2 CD and G	Condition 3 CG and D	Condition 4 C and G and D
	<i>Function allocation</i>	<i>Function allocation</i>	<i>Function allocation</i>	<i>Function allocation</i>
Drive	GD	CD	D	D
Hindrance	GD	CD	D	D
Remediate	GD	CD	D	D
Engage	GD ^(C)	G ^(CD)	CG	G ^(C)
Local Security	C	G	CG	C and G
External Com	C	CD	CG	C
Crew Commo	GD & C	CD & G	CG & D	C & G & D

Commander - Driver and Gunner
Highest workload of all conditions

Gunner - Driver and Commander
No shooting on the move

Commander - Gunner and Driver
Best two crewmember function allocation; single vehicle commander

Commander, Driver and Gunner
Two crewmembers scanning; allows hunter-killer philosophy



Condition	Function allocation
Condition 1	D
Condition 2	D
Condition 3	D
Condition 4	G
	C and G
	C
	C & G & D

**2 Soldier crew
considered HIGH RISK**

- Changed the crewmember requirement for Operational and Organizational (O&O) Concept Document and the Operational Requirements Document (ORD)
- Role of third crewmember changed to gunner in prime contractor design concept.

3



PL/VC
O2
19A



Crew Chief
E5
19K20



DR
E4
19K10



ARV-Assault (L)
M240 7.62MM
Javelin (2)

XM36 120MM
M2 50 CAL
GMR
WiN-T
CC

3



PSG/VC
E7
19K40



Crew Chief
E5
19K20



DR
E4
19K10



CL I UAV Ch
CL 1 UAS LCU C

XM36 120MM
M2 50 CAL
GMR 8
CC

3



VC
E6
19K30



Crew Chief
E5
19K20



DR
E4
19K10

XM36 120MM
MK 19 40MM
GMR 8
CC

Original analysis

Provides BLOS support to Infantry Platoons

Response	Visual	Auditory	Manual	Verbal
Visual	HIGH CONFLICT (.7-.9) Directly competing resources (e.g. two search functions; less if functions adjacent or on same display areas)			
Auditory	LOW CONFLICT (.2-.4) Noncompeting resources (e.g., search and listening).	HIGH CONFLICT (.7-.9) Highly competitive resources; some time-sharing if discriminability between inputs is high		
Manual	LOW CONFLICT (.1-.3) Noncompeting resources.	LOW CONFLICT (.1-.3) Noncompeting resources.	HIGH CONFLICT (.7-.9) Competing resources such as two tracking functions or discrete choice functions have shown high-dual decrements.	
Verbal	LOW CONFLICT (.1-.3) Noncompeting resources.	MEDIUM CONFLICT (.4-.6) More interference if task requires voiced output.	LOW CONFLICT (.2-.4) Noncompeting resources (e.g., tracking and voice input).	HIGH CONFLICT (1.0) Requires complete serial output; e.g. giving two messages or voice commands.

* North, R. A., and Riley, V. (1989). "W/INDEX: A Predictive Model of Operator Workload." Applications of Human Performance Models to System Design, G. McMillan et al., eds. (Plenum Press, New York, NY).

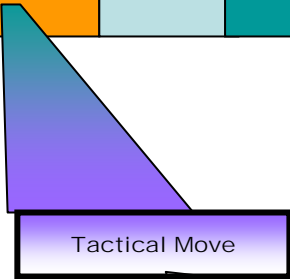
		Continuous Functions									Discrete Functions							
Vehicle	Position	Driving	Monitor Driver	Local Security	Battle Tracking	Monitor Vehicle Intercom	Monitor UAV	Monitor ARV	Monitor Platoon TacNet	Monitor Company TacNet	Communicate on Vehicle Intercom	Communicate on Platoon TacNet	Communicate on Company TacNet	LOS Engagement Threat Detected	BDA	Provide BLOS Capability	Intervene ARV	Intervene with UAV
PL MCS	PL		P		P	P			P	P	70%		70%		10%	10%		
	Crew Chief			P				P				70%		10%			100%	
	Driver	P																
PSG MCS	PSGT		P		P	P			P		70%	70%			10%	10%		
	Crew Chief			P				P						10%				100%
	Driver	P																
MCS	VC		P		P	P					70%				100%	100%		
	Crew Chief			P										100%				
	Driver	P																



- Crew chief (Gunner) has two primary functions
 - Local Security
 - ARV monitoring
- Both visual search tasks
 - 90% penalty in accuracy on one of the two concurrent functions
 - If local security than 9 out 10 targets might be missed
 - 9 out of 10 times MCS potentially hit and destroyed
- HRED experiment* looking at concurrent performance of a gunner's and robotic operator's tasks in a simulated MCS environment supports that local security will be the function degraded.

* Chen, J. Y. C., & Terrence, P. I. (2007). Effects of Tactile Alerts on Concurrent Performance of the Gunner's and Robotic Operator's Tasks in a Simulated Mounted Environment (Tech. Rep. ARL-TR-4227). APG, MD: U.S. Army Research Laboratory.

Mounted Supported by Dismount			Urban/Mout			Defensive Operations		
Tactical Move	Attack	Hasty Defense	Tactical Move	Attack	Hasty Defense	Tactical Move	Defend	Counterattack



Platforms Library of blocks

MCS PLT

ICV PLT

Co HQ

ICV PLT

- Three tanks in future concept platoon
 - 2 of the 3 vehicles have gunners monitoring robotic systems
 - 2 of the 3 vehicles have gunners potentially missing 9 out of 10 threats
 - 10% survivability
- Tank platoon mission is to provide fires for an infantry platoon
- Infantry platoon has reduced protection
- All vehicles may not arrive at attack start point
- Company mission may be degraded

- **IMPRINT Tool**
 - No cost to government employees and government contractors.
 - Email IMPRINT-INFO@arl.army.mil

- **Analytical support**
 - Assistance with structuring analysis.
 - Analyses completed for customers.
 - Email diane.k.mitchell@us.army.mil

**THANK
YOU**