



The Utilization of Synthetic Task Environments in Command and Control (C2) Domains

Scott Galster, W. Todd Nelson, Robert Bolia

AFRL/HECP



Who is HECP?





Network-Centric Warfare





Collaborative Tools for BMC2

Who are our Stakeholders?

- **Battle Managers**
 - E-3/AWACS
 - E-8/JSTARS
 - E-10A/MC2A
 - BCS-F/M
 - E2-C Hawkeye (USN)
 - Wedgetail (RAAF)
- **AWACS EPMR**
- **AWACS SPO**
- **AWS Nellis AFB**
- **BMC2 HMIWG (ACC/DRR/DOY)**
- **FORCEnet HSI Working Group (USN)**



Advanced Interfaces for BMC2

GOAL: Enhance performance efficiency, workload, and situation awareness of air battle managers through the use of advanced interface technologies

- increase operator workstation efficiency
- enhance data visualization
- increase shared battlespace awareness
- enhance decision speed and effectiveness
- reduce training requirements



AF Research Progression



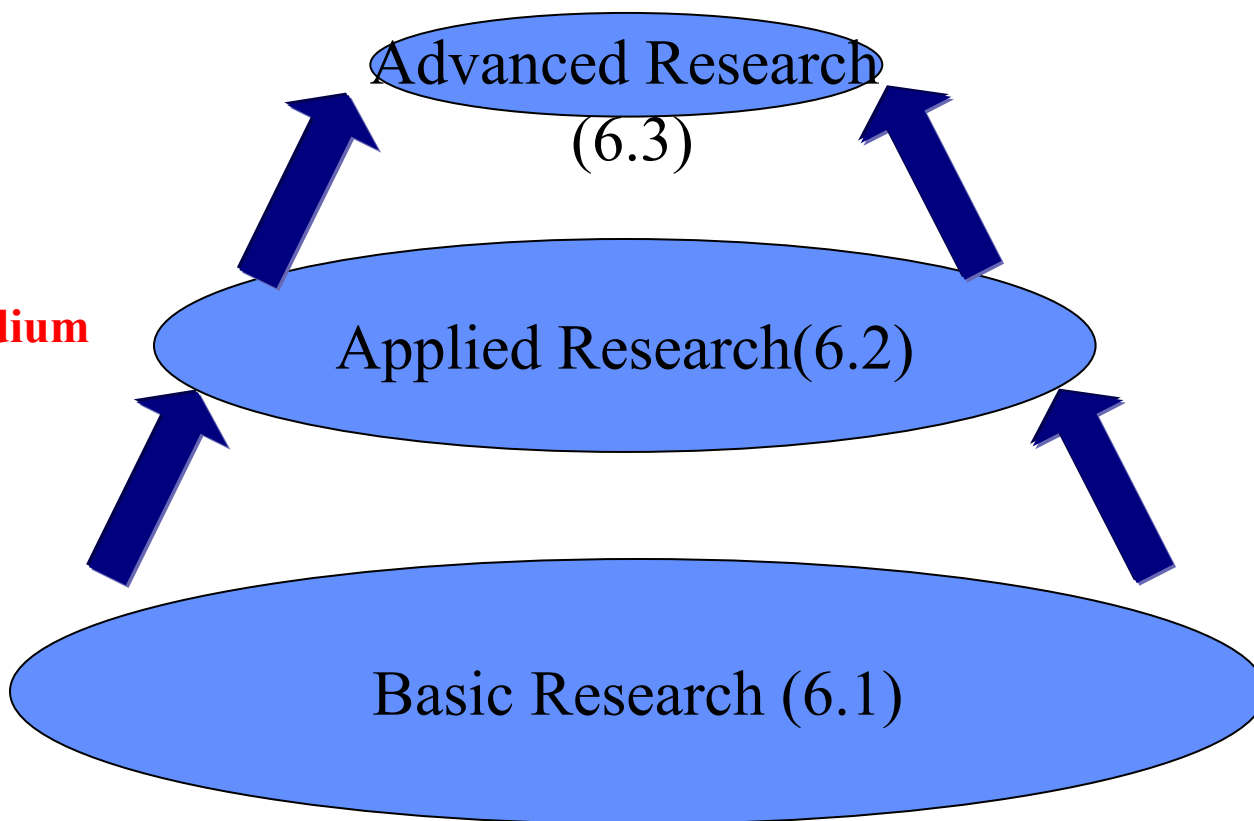
Fidelity

High



Low

Medium



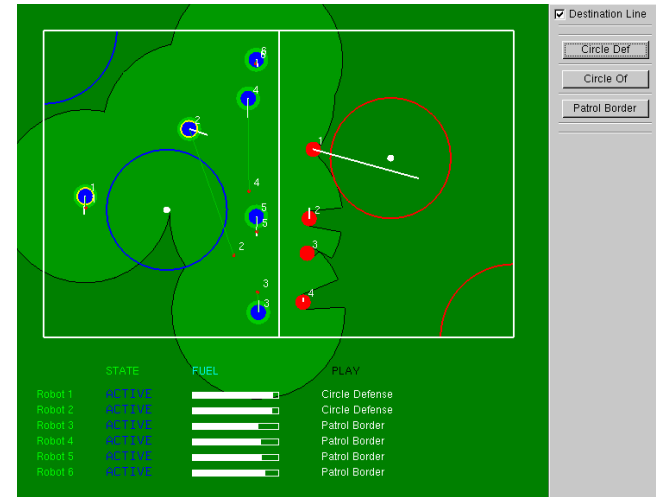


STEs for Basic Research

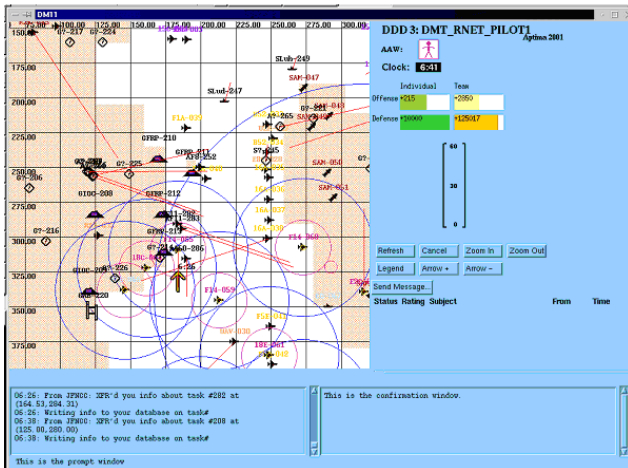
➤ MIIRO (Multi-Modal Immersive Intelligent Interface for Remote Operation)



➤ RoboFlag



➤ DDD (Dynamic Distributed Decision Making)



Research Thrust Areas

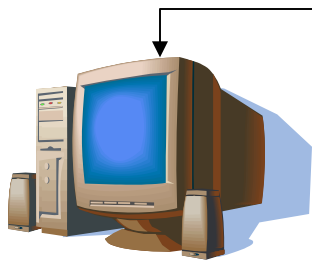
- Automation levels
- Adaptive automation
- Decision support aids
- Flexible, co-operative task delegation
- Distributive collaboration
- Multi-modal interface concepts



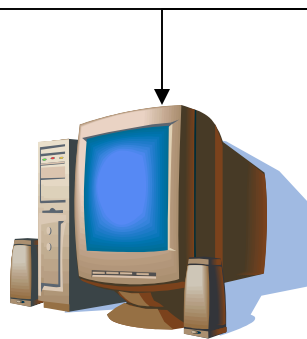
RoboFlag



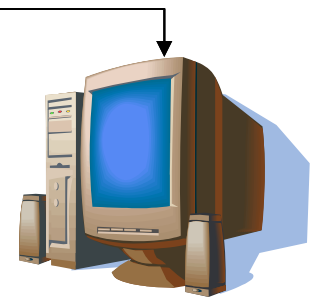
- Developed at Cornell University
- <http://roboflag.mae.cornell.edu/>



**Blue Team
(participant)**



**Red Team
(scripted)**



**Arbiter
(both teams,
Experimenter
Station)**



RoboFlag Blue Team GUI



The GUI displays a green field with a white boundary. Six robots are positioned on the field, each with a number (1-6) and a colored circle around it. Robot 1 is blue, Robot 2 is blue, Robot 3 is blue, Robot 4 is blue, Robot 5 is blue, and Robot 6 is blue. A red circle is centered on Robot 4. A yellow line connects Robot 1 to Robot 6. A red circle is centered on Robot 3. A red circle is centered on Robot 4. A red circle is centered on Robot 3. A red circle is centered on Robot 4. A red circle is centered on Robot 3. A red circle is centered on Robot 4.

Destination Line

Circle Def

Circle Of

Patrol Border

Robot	STATE	FUEL	PLAY
Robot 1	ACTIVE	<div style="width: 100%;"><div style="background-color: yellow; height: 10px;"></div></div>	Circle Defense
Robot 2	ACTIVE	<div style="width: 100%;"><div style="background-color: yellow; height: 10px;"></div></div>	Circle Defense
Robot 3	ACTIVE	<div style="width: 100%;"><div style="background-color: yellow; height: 10px;"></div></div>	Patrol Border
Robot 4	ACTIVE	<div style="width: 100%;"><div style="background-color: yellow; height: 10px;"></div></div>	Circle Offense
Robot 5	ACTIVE	<div style="width: 100%;"><div style="background-color: yellow; height: 10px;"></div></div>	Patrol Border
Robot 6	FLAGGED	<div style="width: 100%;"><div style="background-color: yellow; height: 10px;"></div></div>	Circle Offense



Typical UMV Problems



- **Managing Data and Information Fusion**
- **Coordination – Self-Synchronization**
- **Interface Design**
- **Level and Scope of Automation to Utilize**
- **Human Limitations – i.e. working memory, attention**
- **Information Overload, High Demands on Mental Workload**



RoboFlag



Used to evaluate:

- **Cooperative Estimation Algorithms (Cornell University, Cal Tech)**
- **Manual vs. Automated Control (AFRL, CUA, GMU)**
- **Automation Usage and Delegation Control Architectures (AFRL, SIFT, CUA, GMU)**
- **Interface Evaluations for increased Situation Awareness (SA) (Vanderbilt)**
- **Decision Effectiveness (AFRL)**
- **Team Decision Making and Shared SA (AFRL)**



Results:

- **Delegation-Type interfaces lead to increased mission success rates and reduced mission completion times.**
- **Increasing the flexibility of the delegation-type interfaces exacerbated the benefits**
- **Delegation-type interfaces were best when supervising four robots rather than eight.**
- **Task-network modeling produced similar results to those seen in empirical studies**



RoboFlag Version 2.0



Human-in-the-Loop Display

Field Conditions

- Night
- Grass
- Desert

Robot Ability Options

- Enable Destination Line
- Enable Vision Cones
- Enable Opponent Vision Cones

Play Options

- Resume Play

OverRide Play Options

- HITL Destination
- SuperChase Flagged
- Chase Flagged
- Low Fuel Go Home
- Enter Defense Zone

Select All Robots

Unselect All Robots

Stop

Go Home

Chaser

SuperChaser

Guard Position

Stop Or Guard

Circle Offense

Evade to Dest

Patrol

Decoy & Attack

Return Flag & Bkup

ROBOT ID	STATE	TYPE	PLAY	FUEL
Robot 1	ACTIVE	SAM_SIGHT	Destination	24.3
Robot 2	ACTIVE	SAM_SIGHT	Destination	17.7
Robot 3	ACTIVE	PLANE	Destination	29.5
Robot 4	ACTIVE	PLANE	Destination	12.7
Robot 5	ACTIVE	TANK	Destination	43.2
Robot 6	ACTIVE	TANK	Destination	41.0



MIIRO: Supervisory-Control Testbed

Developed by IA Tech, CA (www.ia-tech.com/)

- **Synthetic Task Environment which flexibly emulates envisioned single operator supervision of multiple UAVs**

- **Supports collaboration of UAV assets**

- **Designed to support human factors research on:**

- Automation levels

- Adaptive automation

- Decision support aids

- Flexible, co-operative task delegation

- Distributive collaboration

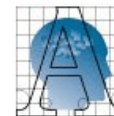
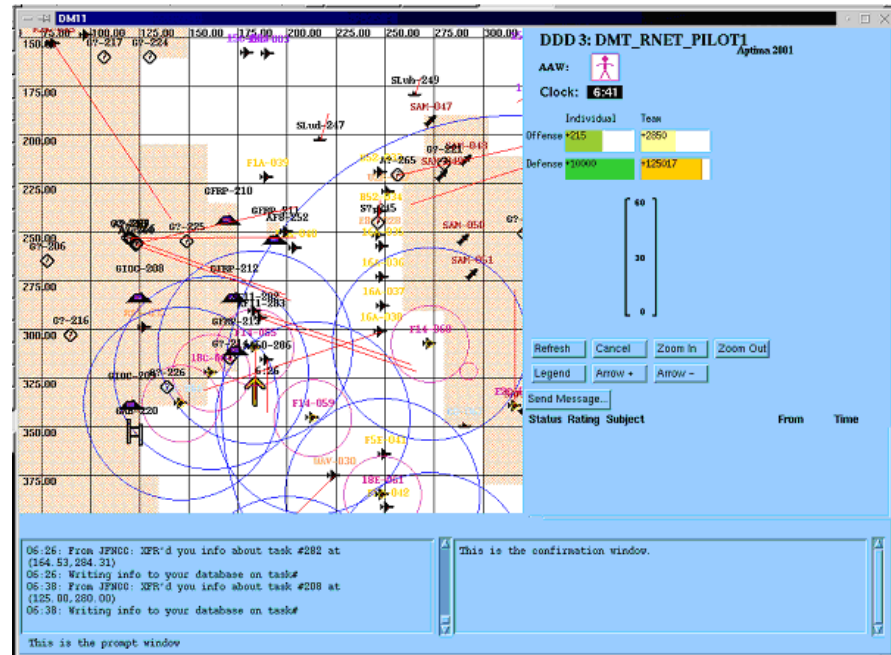
- Multi-modal interface concepts

- **“Researcher-friendly”**

- **Modularized architecture: easily reconfigured**



- DDD Background
- Previous Investigations
- DDD Issues
- Aptima/DDD SBIR
 - Phase I
 - Phase II
 - Current Status



Aptima[®]
Human - Centered Engineering



DDD Background

CTBMC2

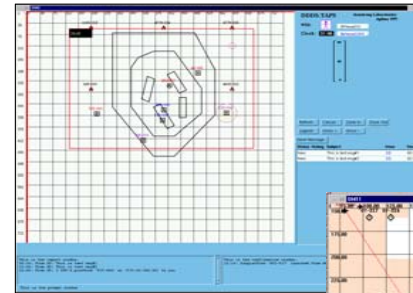
- **A distributed multi-person simulation and software tool for understanding decision-making in a dynamic team environment**
- **Team-in-the-loop testbed**
- **Developed at UConn in the early 1980's**
- **Numerous different generations have demonstrated its flexibility**
- **Allows for high degree of experimental control with low to moderate degree of realism**



Previous Investigations

CTBMC2

- Joint Task Force
- Naval Battle Group
- Army Urban Warfare/Special Ops
- Air Force AWACS
- Army Ground Maneuvers
- NASA Search and Rescue
- Joint Peacekeeping Operations



**AWACS
WD/AWOs**

**Air
Operations**



**Joint Task
Force**



**NASA Search
and Rescue**



**SASO
Peacekeeping**



Advanced Interfaces for BMC2

Key Research Areas



Spatial Audio Interfaces



Speech Recognition Interfaces



Visual Interface Technologies



Collaboration Technologies



BMC2 Research ROI

Technology	Operational Payoff	Value Proposition
Spatial Audio	speech intelligibility, comm effectiveness	training, operational safety
Speech Recognition	reduced workload, performance efficiency	manning, training
Head-Mounted Displays	performance efficiency, situation awareness	prosecution time, time critical opportunities
Net-Centric Collaboration Tools	decision effectiveness, shared battlespace awareness	speed of command, time critical opportunities



Clutter Problem

The screenshot illustrates a cluttered desktop environment with several overlapping windows. The windows include:

- MSN Data**: A File Explorer window showing the contents of the H:\MSN Data folder.
- Authentication Table**: A Microsoft Word document containing an authentication table.
- Audio Panel Suite**: A Control Panel window for configuring standard radios.
- SMSMainCommCard**: A Microsoft Word document containing a list of codes and names.
- Authentication Table**: A Microsoft Excel spreadsheet showing a table with columns for Page, Section, Line, and Column.
- MIM (Mobile Instant Messenger)**: A configuration window for mobile instant messaging.
- Tactical Display Framework**: The background application, partially obscured.

The **Authentication Table** (Word document) contains the following text:

Authentication Table

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	R	I	K	B	E	A	T	U	T	Z	V	T	G	O	N	Y	X	B	Q	Y	V	W	P	X	L	H
B	T	I	L	Z	T	Z	V	E	J	U	L	I	V	P	J	Y	R	V	B	V	O	L	N	O	T	N
C	J	X	P	R	P	S	K	R	L	H	G	G	S	K	M	I	F	O	Y	U	W	J	Q	Q	U	D
D	B	N	O	R	V	R	D	O	O	E	T	O	S	A	V	K	R	E	R	R	U	T	L	E	G	
E	X	A	W	K	O	J	I	G	L	S	H	O	O	C	S	F	S	M	O	N	M	V	K	F	Y	D
F	Q	H	M	P	R	P	A	O	G	H	H	L	E	A	Y	B	J	H	N	T	Y	F	O	Q	R	T
G	O	K	V	G	H	E	O	Z	Q	H	D	K	W	K	Q	G	E	N	X	O	O	E	Z	R	D	M
H	B	O	U	D	B	W	D	M	N	R	G	J	G	J	K	W	H	J	R	E	U	B	G	R	S	I
I	P	F	Z	M	I	P	B	T	M	G	R	Z	Z	C	D	G	Z	M	I	D	O	O	N	J	U	S
J	Q	Z	R	Z	O	W	R	F	I	X	E	C	S	E	E	P	H	K	V	M	X	V	M	B		
K	V	W	M	S	D	A	F	G	Z	O	B	V	G	B	K	T	I	S	W	P	V	C	V	F		

The **SMSMainCommCard** (Word document) contains the following text:

5455 1645 1700

9 400.025
10 400.025

CODEWORD

	MSG-25	COSTELLO
1	F-16 (5027)	ABBOTT
2	SAG	MIC
3	SAG	MIC
4	SAG	MIC
5	SAG	MIC
6	SAG	MIC
7	SAG	MIC
8	SAG	MIC
9	SAG	MIC
10	SAG	MIC
11	SAG	MIC
12	SAG	MIC
13	SAG	MIC
14	SAG	MIC
15	SAG	MIC
16	SAG	MIC
17	SAG	MIC
18	SAG	MIC
19	SAG	MIC
20	SAG	MIC

RESUME JAM SPOOFER
SPOOFER GHOST
BASE ALT TOR
BASE # 5

IDENTIFICATION MATRIX

	E	F	G	H	I	J	K
UL	17	16	15	14	13	12	11
NT	27	26	25	24	23	22	21
SP	37	36	35	34	33	32	31

Push 1800 Last Relex 1755
Val 18-1830

The **Authentication Table** (Excel spreadsheet) contains the following data:

Page	Sec	Ln	At	Ln	Col	REC	TRK	EXT	OWR
1	1	1	1	1	1				
1	1	2	1	2	1				
1	1	3	1	3	1				
1	1	4	1	4	1				
1	1	5	1	5	1				
1	1	6	1	6	1				
1	1	7	1	7	1				
1	1	8	1	8	1				
1	1	9	1	9	1				
1	1	10	1	10	1				
1	1	11	1	11	1				
1	1	12	1	12	1				
1	1	13	1	13	1				
1	1	14	1	14	1				
1	1	15	1	15	1				
1	1	16	1	16	1				
1	1	17	1	17	1				
1	1	18	1	18	1				
1	1	19	1	19	1				
1	1	20	1	20	1				

The **MIM (Mobile Instant Messenger)** configuration window shows the following settings:

MIM (Mobile Instant Messenger)
Configuration: Auto

- mobile-4.2 - Hi Ho
- mobile-4.2 - Hi Ho
- mobile-4.2 -
- mobile-4.2 - Authenticate L S
- mobile-4.2 - Can so so reful
- mobile-4.2 - Hi Ho
- mobile-4.2 - Test



Advanced Interfaces for BMC2

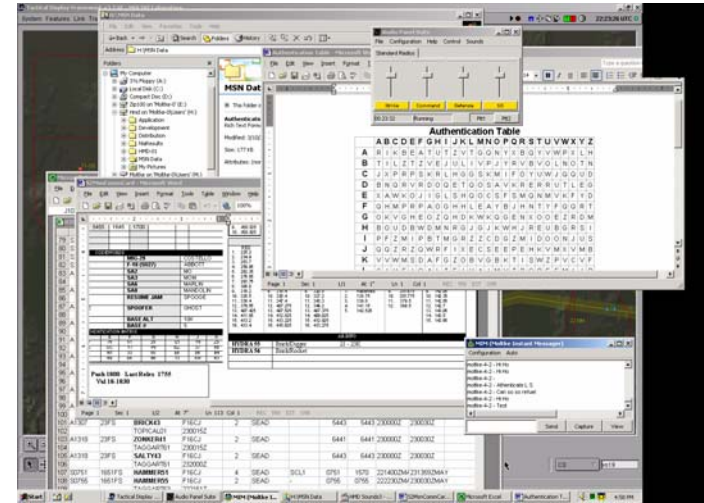
Rationale for Visual Interface Technologies

Problem – limited workstation and display real estate on BMC2 platforms, introduces high memory loads, increases need for paper documents and time away from the primary situation display

Objective – increase visual display real estate through the use of HMDs and multi-layer displays

Approach – identify high payoff display content, evaluate candidate technologies through user testing and simulation experiments

Benefits – increase operator efficiency and situation awareness through more effective display of critical visual information





Primary Display

Solipsys Corporation Tactical Display Framework v3.6.1

System Features Link Tracks View Help 02:54:46 UTC

PLAYING: TT2-02.02.dv

157.5 NM

CS: CYLON 03 ID: Friend Lat: 37:33:19 N Lon: 115:51:50 W Alt: 22,868 ft Alt: 129C / 229R Velocity: 014° M / 319 kt M2: 0042 M3: 0036 M4: No Response MC: 129	CS: CYLON 02 Alt: 133C / 258R Velocity: 326° M / 111 kt M2: 0042 M3: 0036 M4: No Response MC: 133	CS: CYLON 01 Alt: 131C / 253R Velocity: 330° M / 269 kt M2: 0042 M3: 0036 M4: No Response MC: 131	CS: CYLON 03 Alt: 129C / 229R Velocity: 014° M / 319 kt M2: 0042 M3: 0036 M4: No Response MC: 129
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------

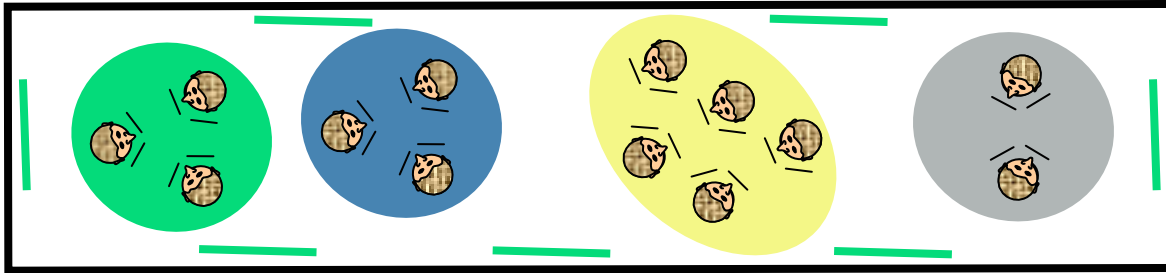
History Tags Beacon Radar IDENT Tracks IFF FND PND FND ASF NEU UNK SUS HOS

32.0 NM 37:28:46 N 115:49:26 W CEPN

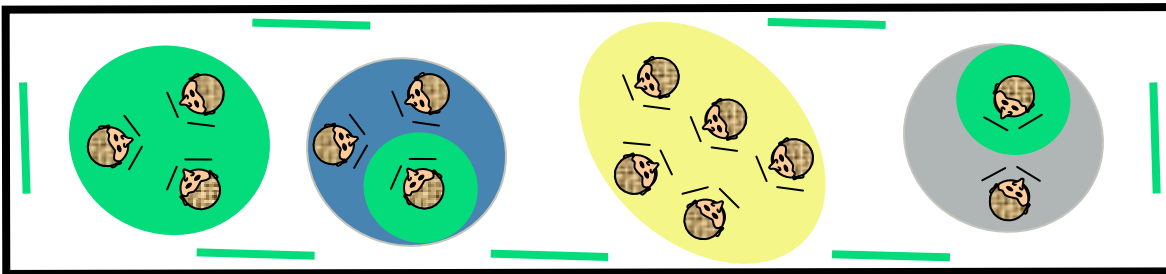


Advanced Interfaces for BMC2

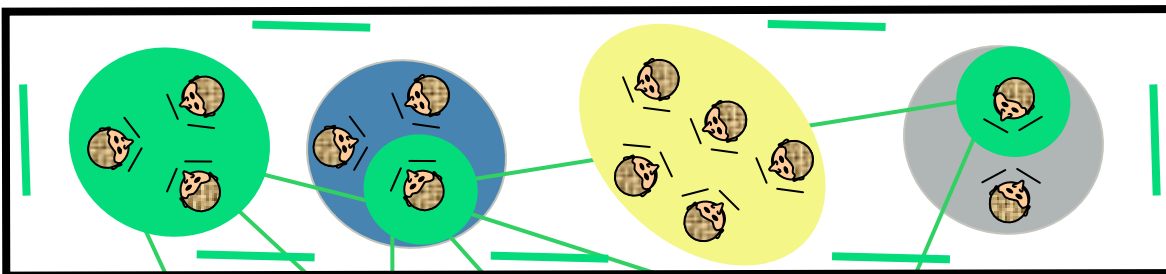
Rationale for Collaboration Technologies



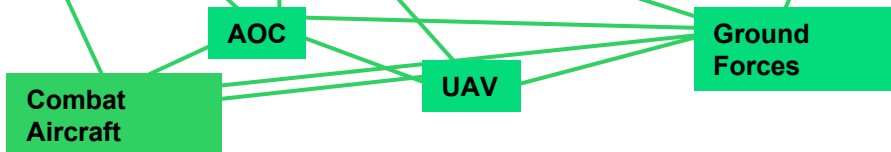
Face-to-Face



Local Remote



Distant Remote





Collaboration Technologies for BMC2

COTS Collaborative Interface Technology

- **Face-to-Face, Local Remote, and Distant Remote**
 - **Advanced Displays**
 - **Data Visualization Tools**
 - **Decision Support Tools**
 - **File and Application Transfer**
 - **Video Conferencing**
 - **Interactive Virtual Whiteboards**
 - **Chat and Discussion Groups**
 - **Broadcast and Alerts**
 - **Data Capture and Replay**
 - **Expertise and Knowledge Locators**
 - **Opinion and Polling Tools**
 - **Knowledge and Content Management Tools**
 - **Automated Workflow**
 - **Calendar and Timelines**



Taxonomy

- **Tractability**
 - Can the STE answer the research question?
 - Theoretical Continuum
- **Realism**
 - Functional relationship between STE and real-world systems
 - Levels of Abstraction
- **Experimental Control**
 - Allowance of Variability and resultant behaviors
 - Risk and applicability of the data



Questions?

Scott Galster, Ph.D.

scott.galster@wpafb.af.mil

(937) 255-8737