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MARITIME OPERATIONS CENTERS with INTEGRATED and ISOLATED PLANNING TEAMS

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Adaptive C2 Concepts for Maritime Operations Centers



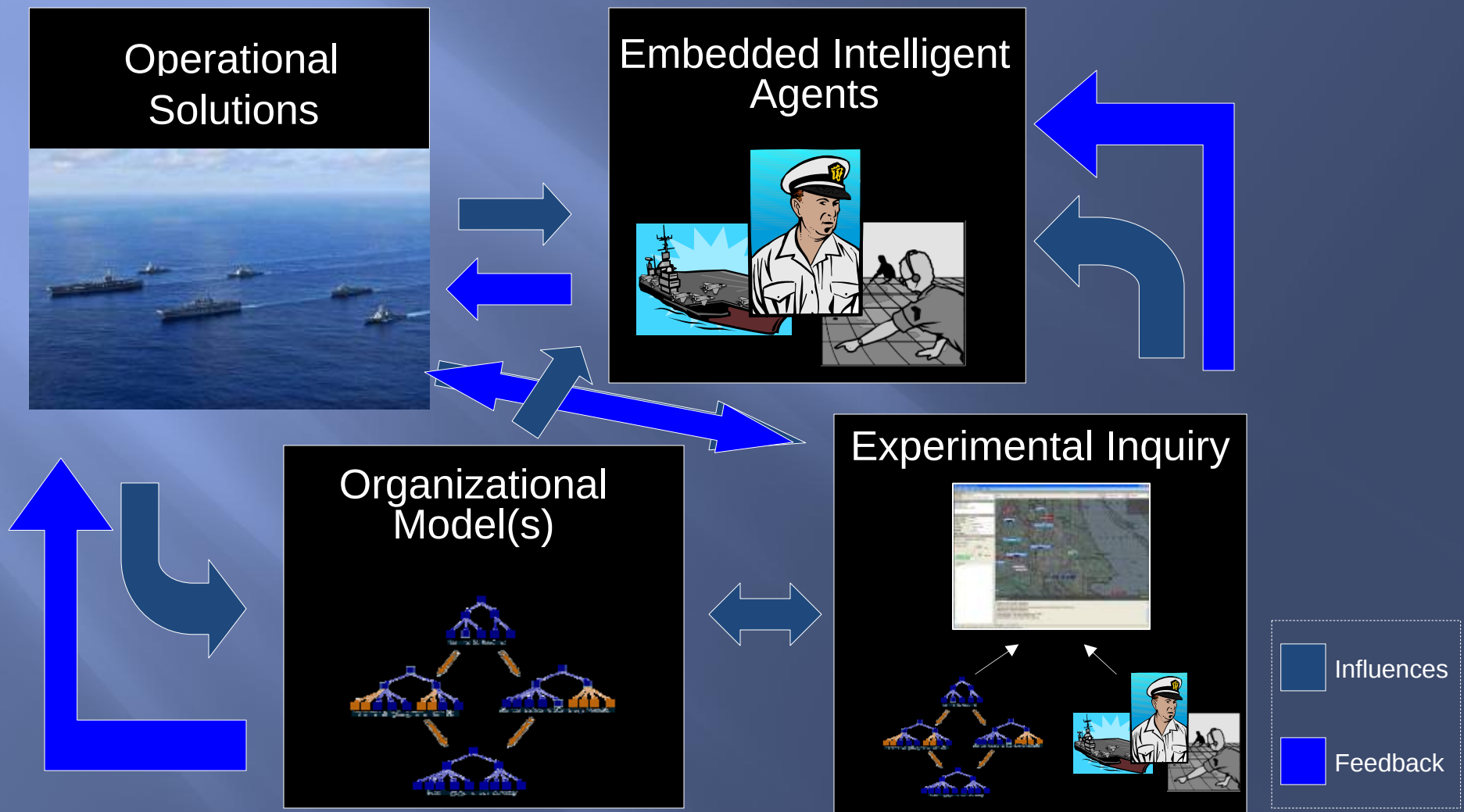
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- *MOC Empirical Research Campaign*
 - *Operational versus tactical*
 - *Planning versus execution*
- *MOC designed to integrate planning elements of FOPS to provide*
 - *More rapid and accurate resource allocations*
- *Staff simultaneously participate in planning effort, while executing the current mission*
- *Frequently, an operational planning team (OPT) – a task-organized team formed to conduct integrated planning – is formed by MOC*
 - *Offers advantage of focused group of SMEs approaching the problem in integrated manner*
 - *Performance problems may be realized with OPT being isolated in situations that require OPT to closely coordinate with the rest of the MOC*



Adaptive Architectures for C2



Purpose of the Study



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Research Question

- How are emergent events best handled when resources must be shared among separate planning teams?
 - *Example:* Operational Planning Teams

Current Study

- Examine efficiency and planning performance of two (2) alternative organizational structures:
 - Integrated: Planning teams with a real-time view of others' resource planning
 - Isolated: Planning teams operating in isolation, without ability to directly view others' resource planning

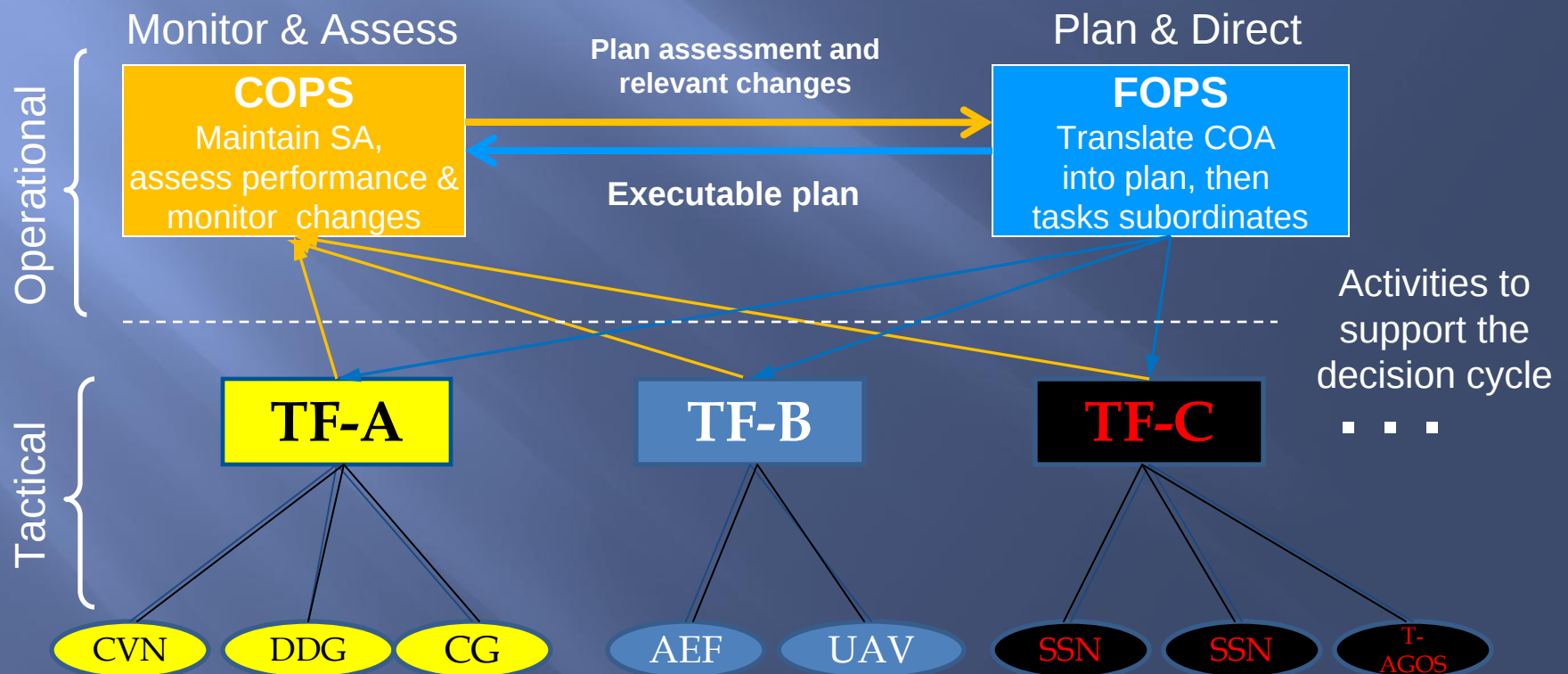
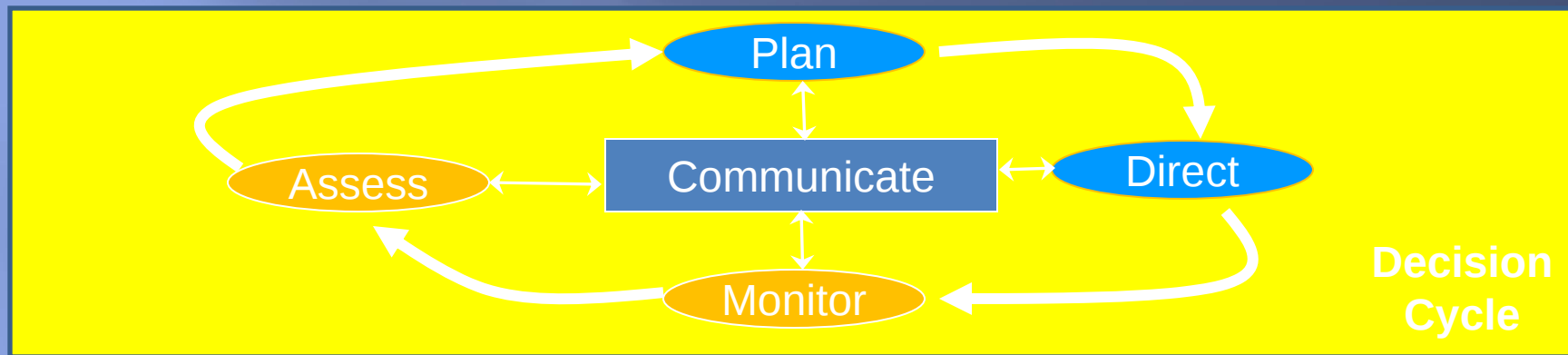
Experimental Hypotheses

1. “Integrated” teams create more effective plans than “isolated” teams
 - Real-time awareness of others’ planning status provides situation awareness that enhances the interdependent solution
2. “Isolated” team members experience higher levels of workload than “integrated” team members
 - Lack of real-time planning status requires more frequent status-related communication in addition to collaborative effort
3. “Isolated” team members communicate more frequently in response to emergent events
 - Isolated team members must communicate to learn how others alter plans in response to unexpected events

Measures

- Plan Quality (*Max score = 110*)
 - Percentage of resource demands met per task, weighted by both CDR's intent and task priority rating
 - Algorithm applied via system database query
- TLX Workload Measure (*Scale: 1 - 10*)
 - Avg. across 5 self-report dimensions (reported at end of each Day):
Mental, Time Pressure, Performance, Effort, Frustration
- Chat-based Communication (*coded chat logs*)
 - *Status-based*: one-way communication: update or request for status of resource(s) or task(s)
 - *Collaborative*: strategic coordination and negotiation of resources; articulating implications for multiple players

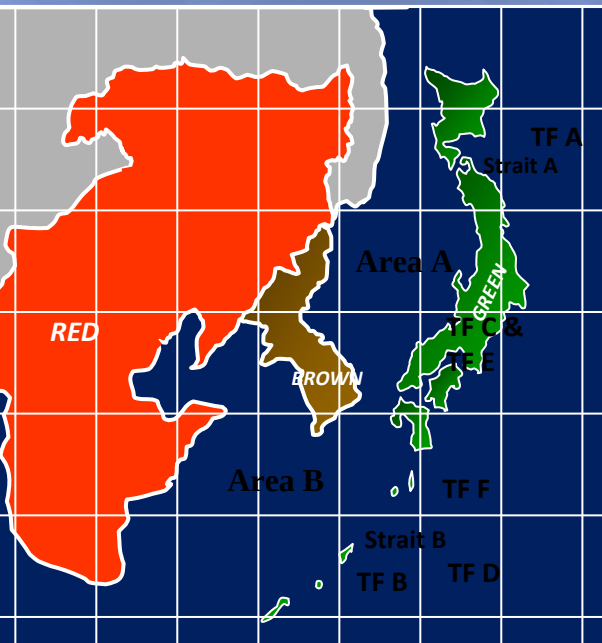
MOC PROCESSES and FOCUS



MODELING FORMALISM: TASKS

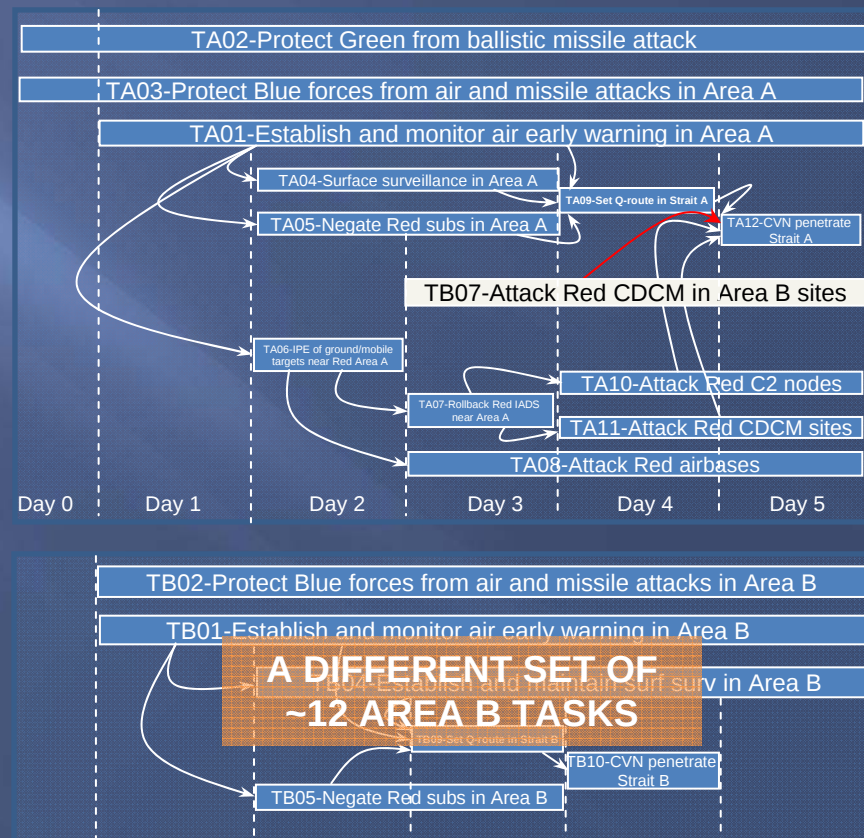
OPERATIONAL MISSION IS COMPOSED OF A SET OF HIGH-LEVEL TASKS

- Spread over several days, with precedence requirements → **TASK GRAPH**
- Represents a COA or “How to do the overall mission” → from a Future Plans Cell
- FOPS will **operationalize** this plan; COPS will **monitor** its execution

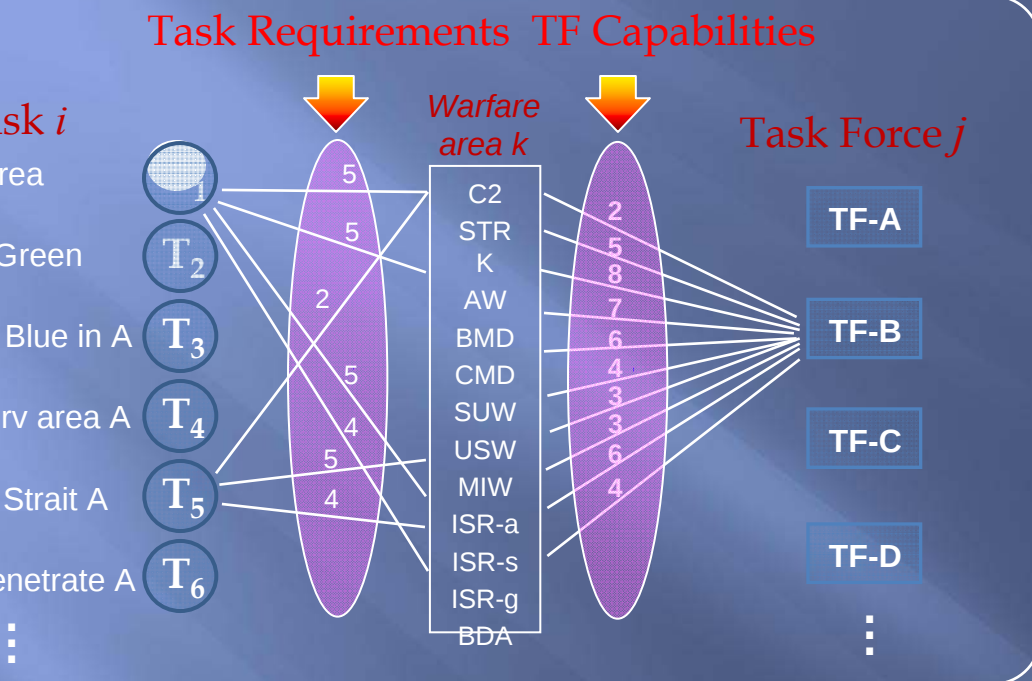


AREA A

AREA B



MODELING FORMALISM: MATCHING TASKS-to-ASSETS



TASKS AND ASSETS ARE REFERENCED TO THE **SAME** SET OF SELECTED WARFARE CATEGORIES

- R_{ik} : Requirement k of task i
- r_{jk} : Capability k of asset/TF j

Values (resource vectors) are readily obtained via discussions with SMEs or Fleet personnel

CAPABILITIES ARE DAY-by-DAY ROLL-UPS OF THE INDIVIDUAL ASSET CAPABILITIES

	C2	STRK	AW	BMD	CMD	SUW	USW	MIW	ISR_a	ISR_s	ISR_g	BDA
CVN-1	6	6	5		2	6	2	1	4	6	2	6
CG-1	3	4	8	7	6	4	4	3	6	5		
DDG-1	2	5	8	7	6	4	3	3	6	4		
DDG-2	2	5	8	7	6	4	3	3	6	4		
FFG-1	1	1	4		2	2	4	3	2	4		
Total TF-A	14	21	33	21	22	20	16	13	24	23	2	6

ASSIGNS EACH TASK TO A TF, with PERFORMANCE GOALS and PRIORITIES

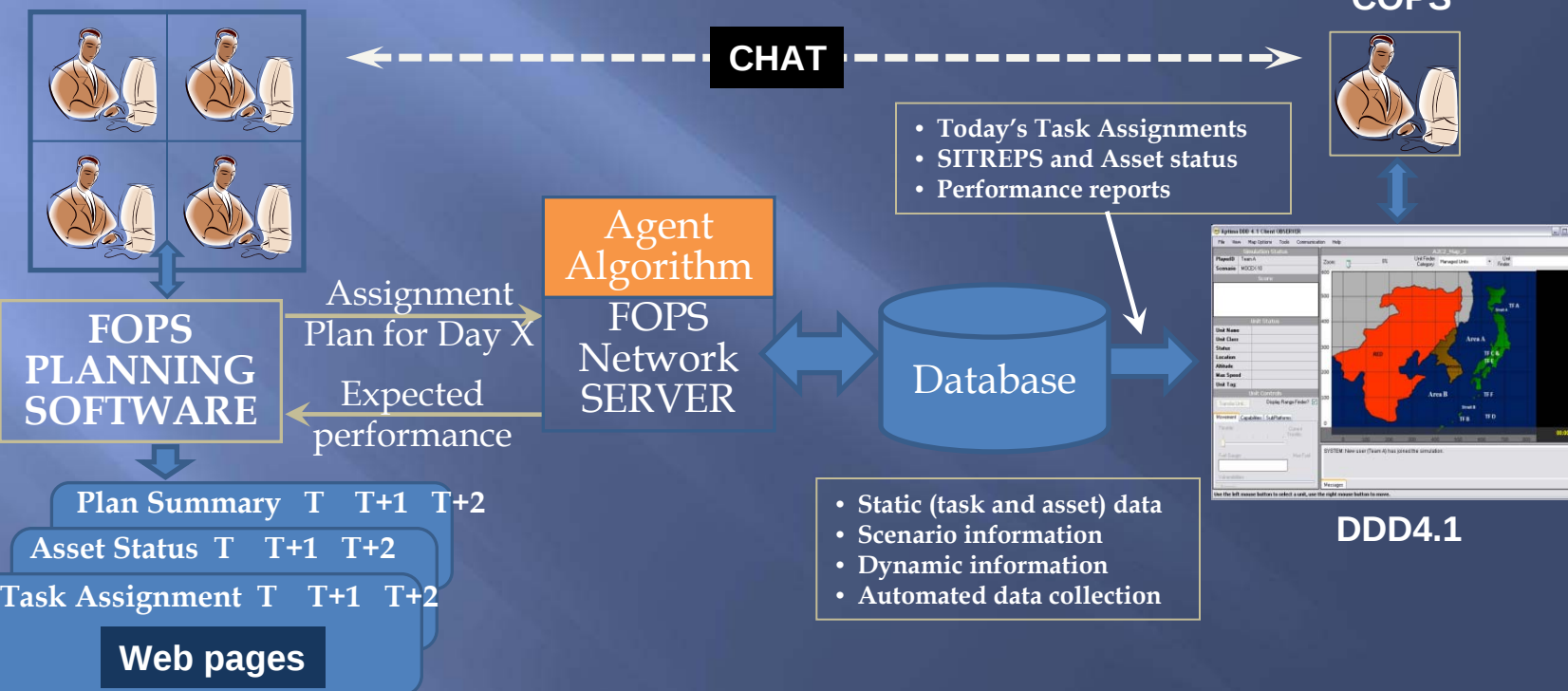
the **primary** TF, with others assigned as **supporting** in one or more warfare areas

the TFs determine how to best utilize their assets to meet performance goals

LABORATORY ENVIRONMENT

SOFTWARE REQUIREMENTS via NPS; IMPLEMENTATION via UCONN/APTIMA
 Layers produce a "plan": Assignment of all active tasks on day T+1 and T+2 to the TFs
 UConn **agent algorithms** allocate TF assets to best meet overall task performance goals

FOPS PLANNING TEAM



DIFFERENT FOPS PLANNERS HAVE RESPONSIBILITIES FOR DIFFERENT TASKS

FOPS1 and 3 plan area A tasks; FOPS2 and 4 plan area B tasks

FOPS PLANNING PROCESS and SOFTWARE

Current Time Period: 0

Task Status: DAY T + 1 DAY T + 2

Asset Status: TAMD GREEN (TA02)

Assignment: TASK PRIORITY: 3 RESPONSIBLE DM: Player_1

EXPECTED BY STFS: ?? TASK PREQ STATUS: This assignment has not been vetted

	C2	STRK	AW	BMD	CMD	SUV	USW	MIW	ISR (A)	ISR (S)	ISR (C)	BDA	Primary	Supp-1	Supp-2
Requirements	5	0	12	14	10	0	0	0	12	0	4	0			
TF-A													none	none	
Capabilities	14	21	33	21	22	20	16	13	24	23	2	6			
for this task	14	21	33	21	22	20	16	X	24	23	2	6			
ated by TFs	0	0	0	0	0	0	0	0	0	0	0	0			
TF-B													STRK	none	
Capabilities	10	0	6	0	0	0	0	0	9	3	1	0			
for this task	14	0	12	X	X	0	X	X	18	6	2	0			
ated by TFs	0	0	0	0	0	0	0	0	0	0	0	0			
TF-C													none	C2	
Capabilities	6	12	0	0	0	20	16	8	4	16	4	0			
for this task	6	15	X	X	X	25	32	11	X	24	5	X			
ated by TFs	0	0	0	0	0	0	0	0	0	0	0	0			
TF-D													none	none	
Capabilities	0	0	0	0	0	0	0	0	0	0	0	0			
for this task	0	0	0	0	0	0	0	0	X	0	0	0			

Task assignment page

Plan is submitted to "TFs" for review

- FOPS assesses expected performance
- Modifies assignments on those tasks not meeting desired criteria
- When satisfactory, the plan is "finalized"
 - T+2 plan => start for next T+1 plan
 - T+1 plan => EXORD for tomorrow

Rolling Horizon Planning

Each task, the responsible planner assigns:
 • primary TF
 • two supporting TFs
 • each in up to 2 warfare areas
 • desired perf level (accuracy, % complete)
 • Plan = aggregate of all assigned tasks for given day, is posted on the summary

MOC-Experiment

File Help Current Time Period: 0

Summary Task Status Asset Status Assignment

DAY T DAY T + 1 DAY T + 2

ID#	TASK	PRIORITY	DM	PRIMARY STF	SUPPORTING STF	CRITERIA	DESIRED	EXPECTED	ACTUAL
TA01	AEW AREA A	3	Player_1	??	??	Accuracy	??	??	N/A
TA02	TAMD GREEN	3	Player_1	??	??	Accuracy	??	??	N/A
TA03	TAMD BLUE in A	3	Player_1	??	??	Accuracy	??	??	N/A
TA04	SURF SURV Area A	3	Player_1	??	??	Accuracy	??	??	N/A
TA05	NEGATE RED SUBS in A	3	Player_1	??	??	Accuracy	??	??	N/A
TA06	IFE GROUND TGTS in A	3	Player_1	??	??	Accuracy	??	??	N/A
TA07	ROLLBACK IADS near A	3	Player_1	??	??	Accuracy	??	??	N/A
TA08	ATTN AIR BASES in A	3	Player_1	??	??	Accuracy	??	??	N/A
TA09	O-ROUTE in STRAIT A	3	Player_1	??	??	Accuracy	??	??	N/A
TA10	ATTACK C2 NODES in A	3	Player_1	??	??	Accuracy	??	??	N/A
TA11	ATTN CDM SITES in A	3	Player_1	??	??	Accuracy	??	??	N/A

Plan summary page

EXPERIMENT DESIGN and CONDUCT

MANIPULATION: Isolated vs Integrated team

Isolated: Area A and B planners see only their own task assignments on the summary page, and submissions for TF review are done asynchronously/independently by area

- Conflicts in TF assignments need be resolved via CHAT (e.g., FOPS1-FOPS3)

Integrated: Area A and Area B planners see the total assignments on the summary page, and submissions for TF review include the composite/integrated plan for both areas

- Conflicts in TF assignments are seen directly on the summary page

TEAMS of 4 PLAYERS (FOPS); SURROGATE OPS)

Participants were all NPS C4I student officers
3 teams in each condition

OUR 2-HOUR LABORATORY SESSIONS (“days”)

Training: Planning for area A tasks only, 6 TFs available
Sudden need to take on area B tasks => Spin-off sub-team

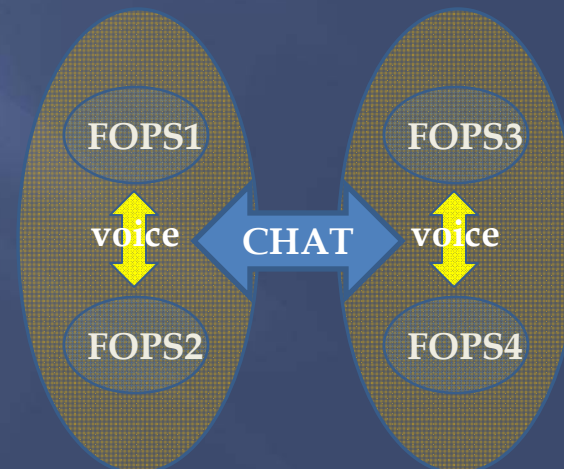
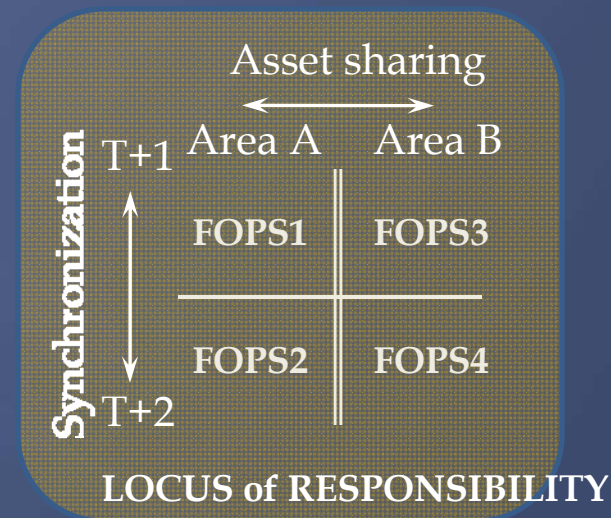
- No additional assets are available

Re/plan for loss of CVN-2 (due to weather) on day 4

Re/plan for additional asset reductions (SSN, Surtass, ..)

DATA COLLECTION

Task assignment history (via database), CHAT logs, voice comms coding, TLX workload, task performance scores, AAR,



COMMS STRUCTURE

EXPECTED FLOW OF FORCES (TPFDP)

Task Force A - all Day 0

CVN-1
CG-1
DDG-1
DDG-2
FFG-1

Task Force B

AEF
AWACS-1
AWACS-2
UAV-1
UAV-2

Task Force C

SSN-1
SSN-2
SSN-3
SSN-4
SSN-5
SSN-6
SURTASS-1
SURTASS-2

Arrival

2

0

1

2

2

Arrival

0

0

0

0

1

3

1

2

■ Today, Day 0

■ Day 1

■ Day 2

■ Beyond Day 2

Task Force D - all Day 1

• CVN-2
• CG-2
• DDG-3
• FFG-2
• FFG-3

Task Force E

• P-3C-1
• P-3C-2
• P-3C-3
• P-3C-4
• P-3C-5
• P-3C-6
• EP-3E
• RJ
• U-2
• LSRS
• JSTARS

Task Force F

• MCM
• MH-53
• DDG-4

Arrival

0

0

1

2

3

4

1

2

2

0

3

Arrival

0

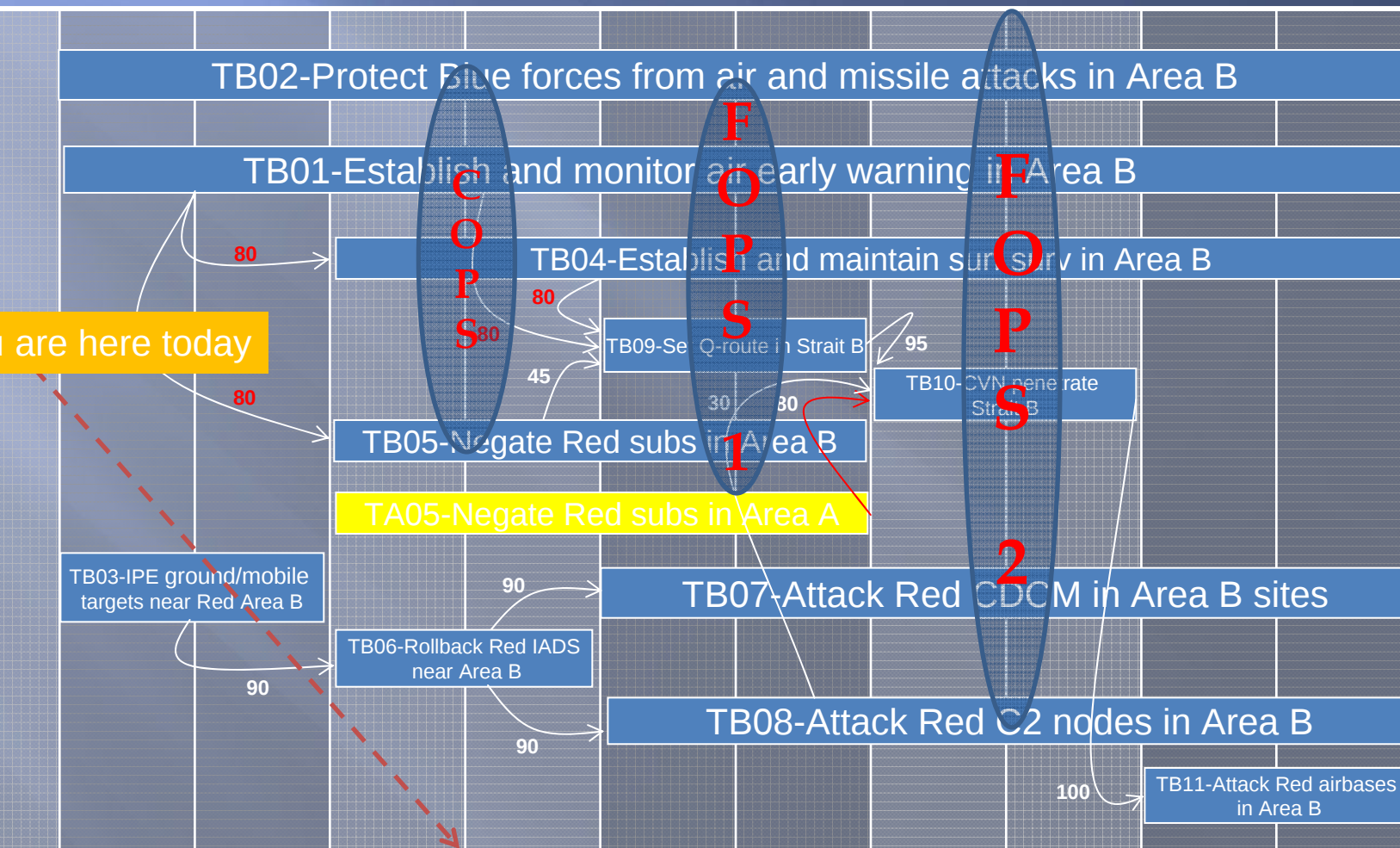
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2

FROM COMMANDER'S BRIEF: DAY 2, AREA B TASKS

COMMANDER BRIEF WAS GIVEN AT THE START OF EVERY PLAY SESSION

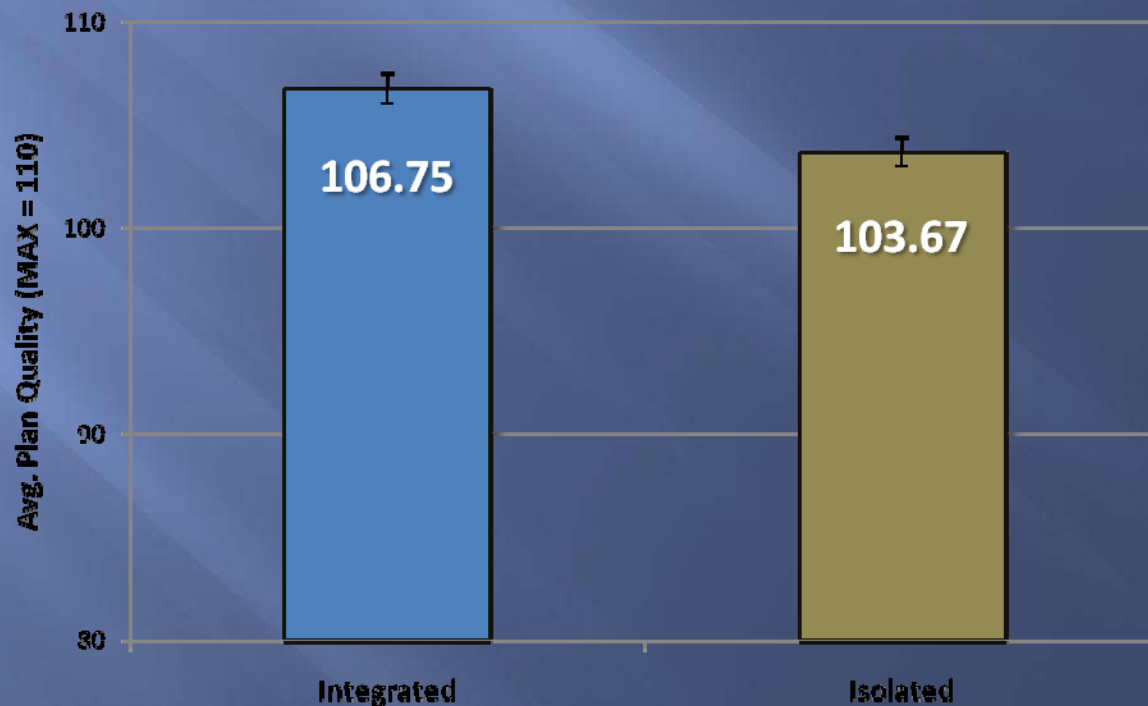
- Gave update on force flow, intel, CDR guidance/priorities



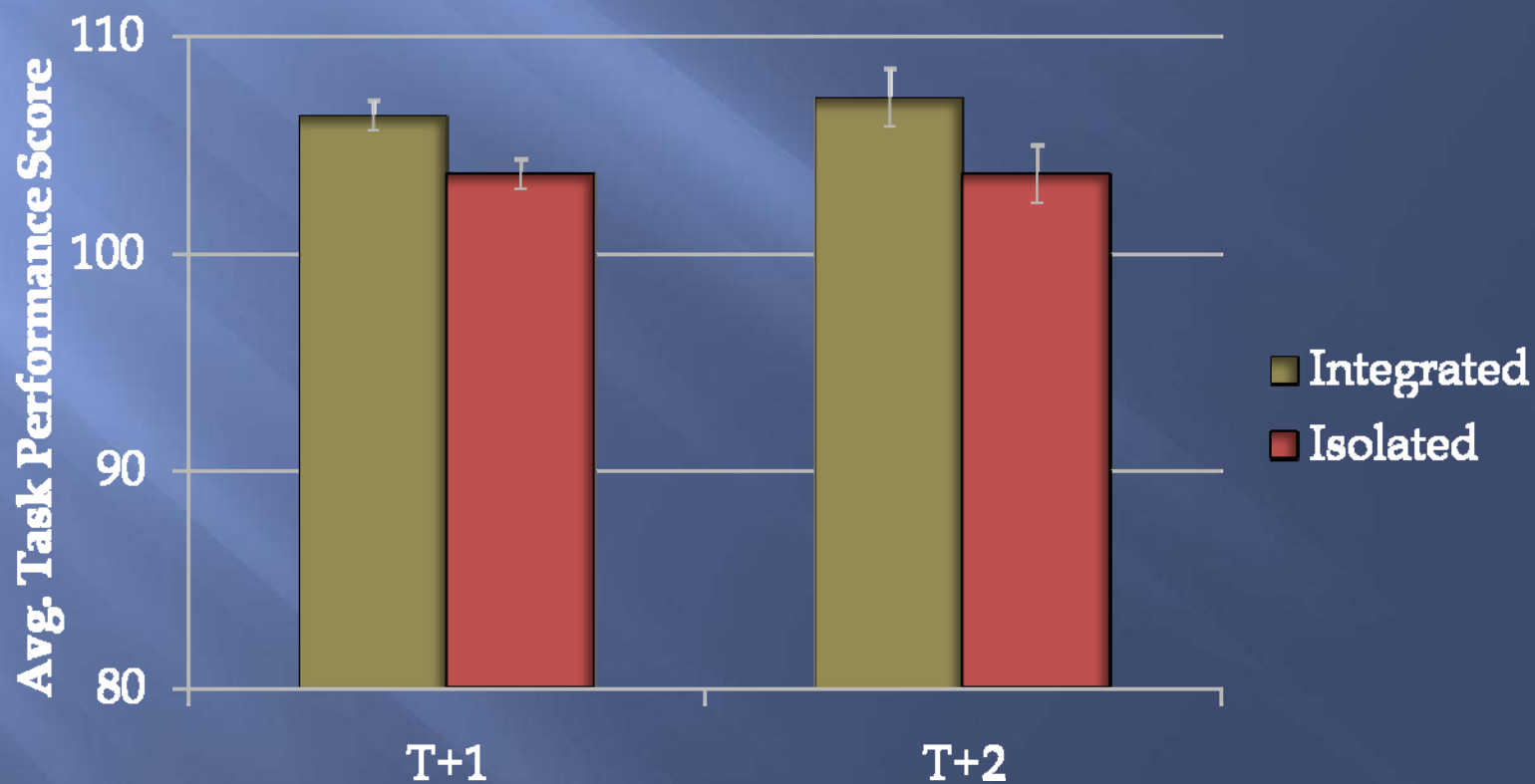
Integrated Teams Produce Better Plans (Hypothesis 1 supported)

Significantly higher-quality plans produced by Integrated teams than Isolated teams in final two performance periods

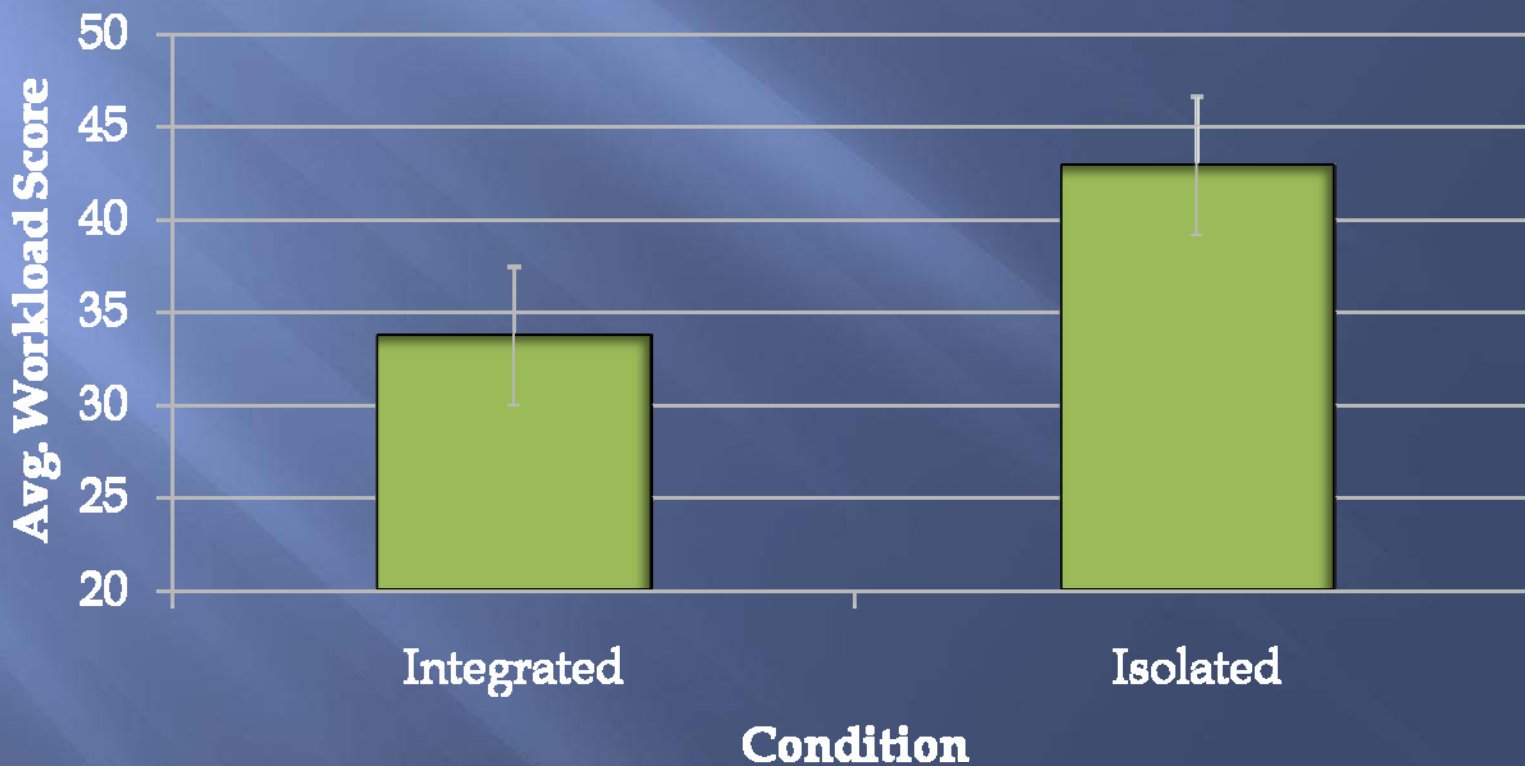
- $F(1, 22) = 8.91, p < .01$



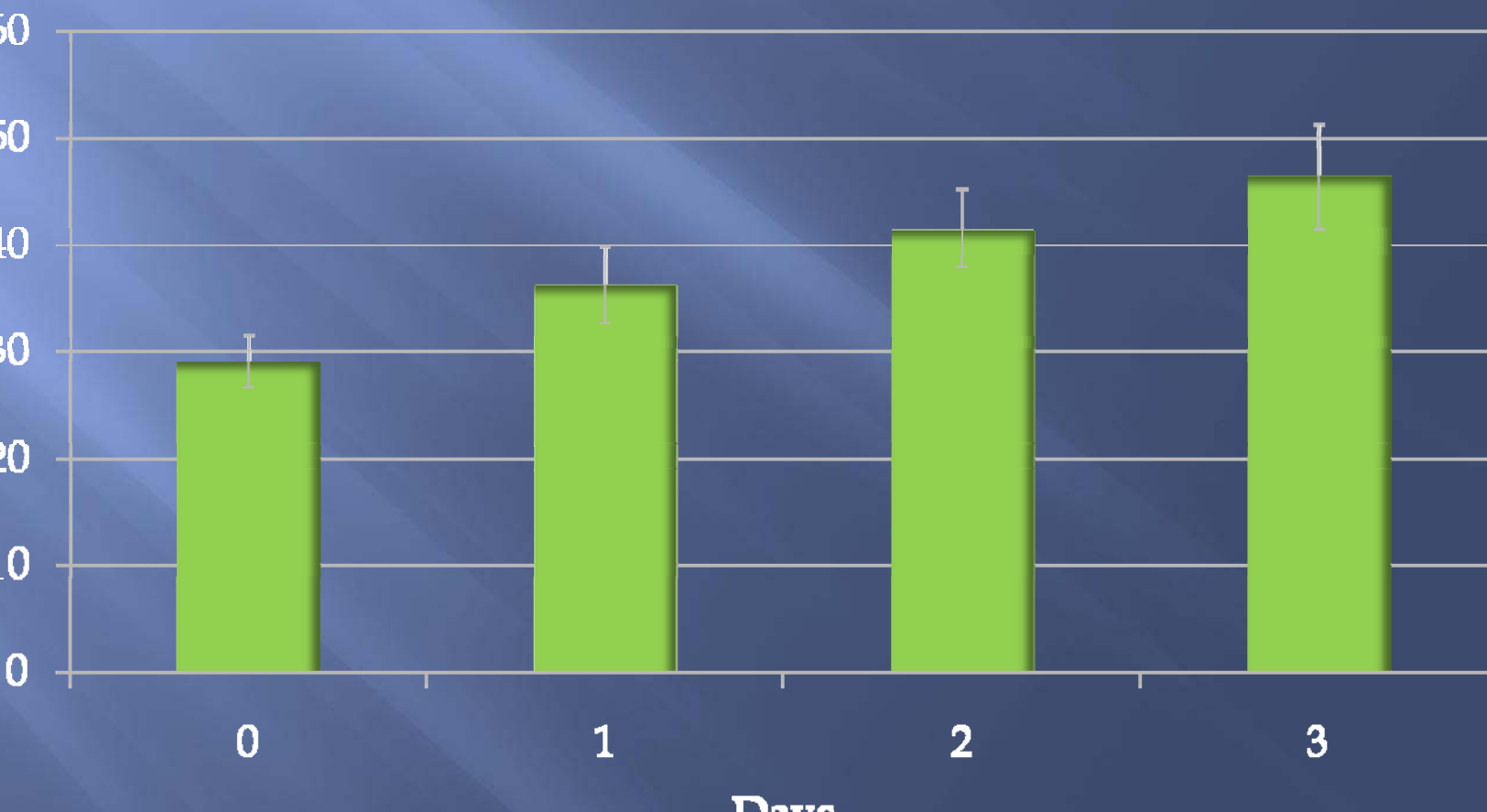
Average Performance between Conditions for T+1 and T+2 Planners



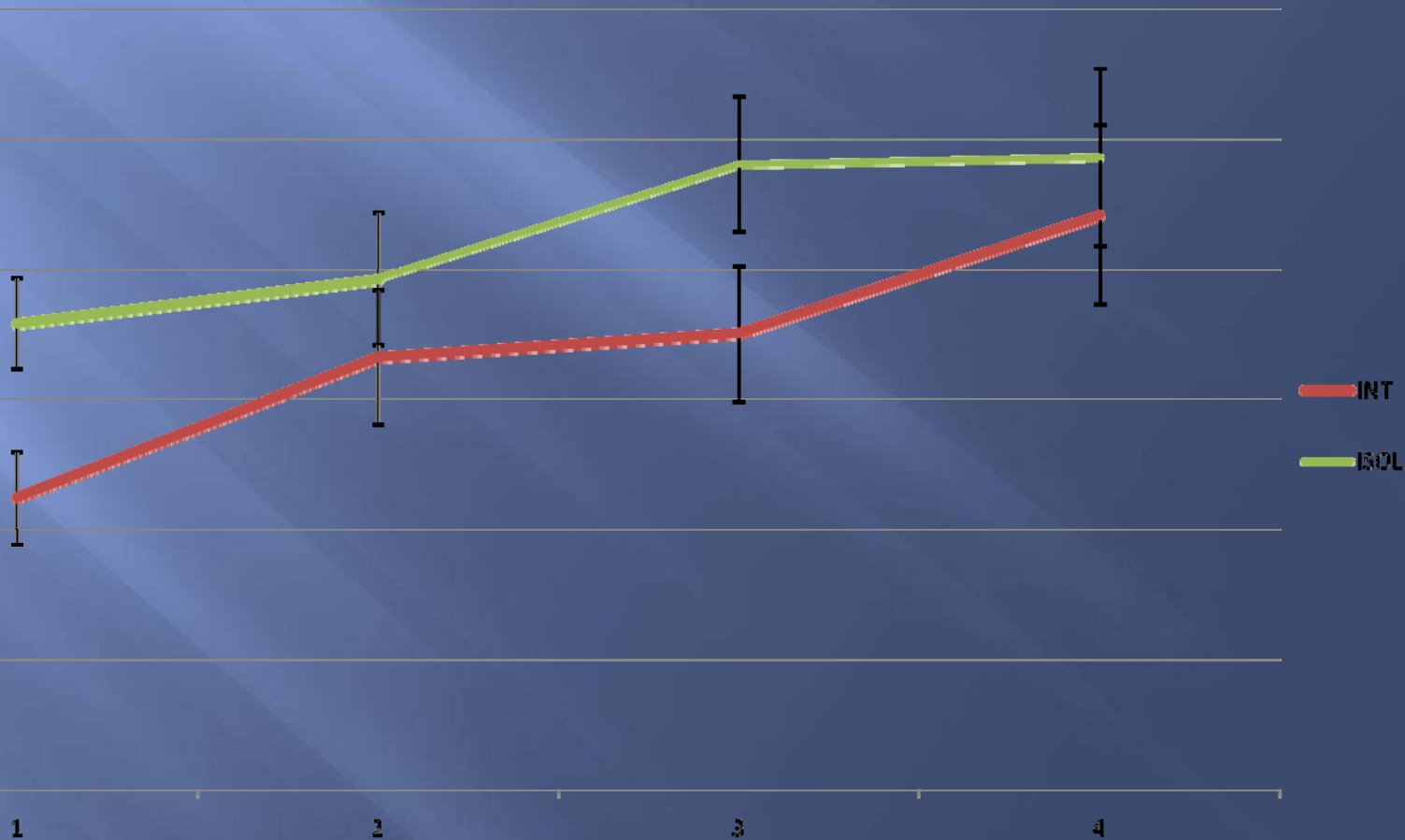
Average Workload Scores between Conditions across all Experimental Sessions



Linear Increase in Workload throughout Subsequent days of the Experiment



Greater Workload for Isolated vs. Integrated Team Members



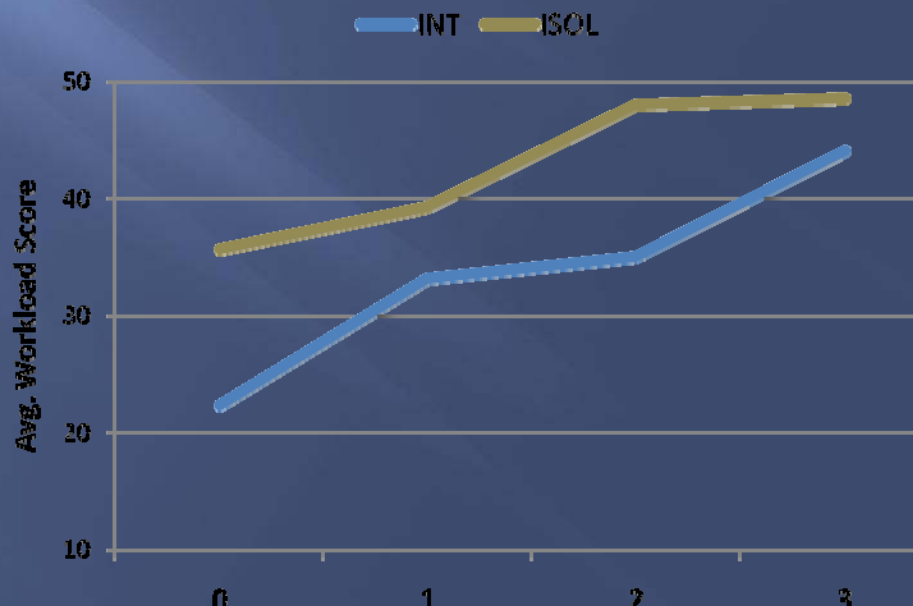
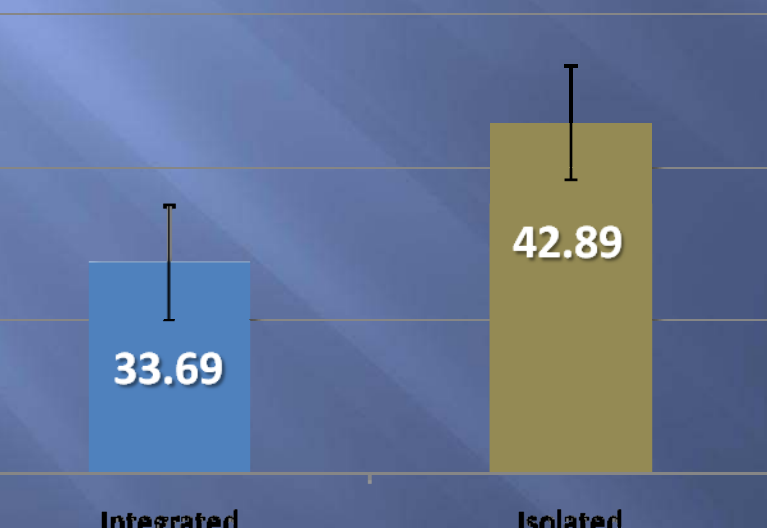
Isolated Teams Report More Workload (Hypothesis 2 supported)

significantly less workload reported by Integrated teams compared to isolated teams

$F(1, 22) = 3.01, p < .05$, one-tailed. High reliability ($\alpha = .87$)

- Workload consistently lower for Integrated teams; increased linearly during study

- $F(1, 22) = 8.50, p < .01$

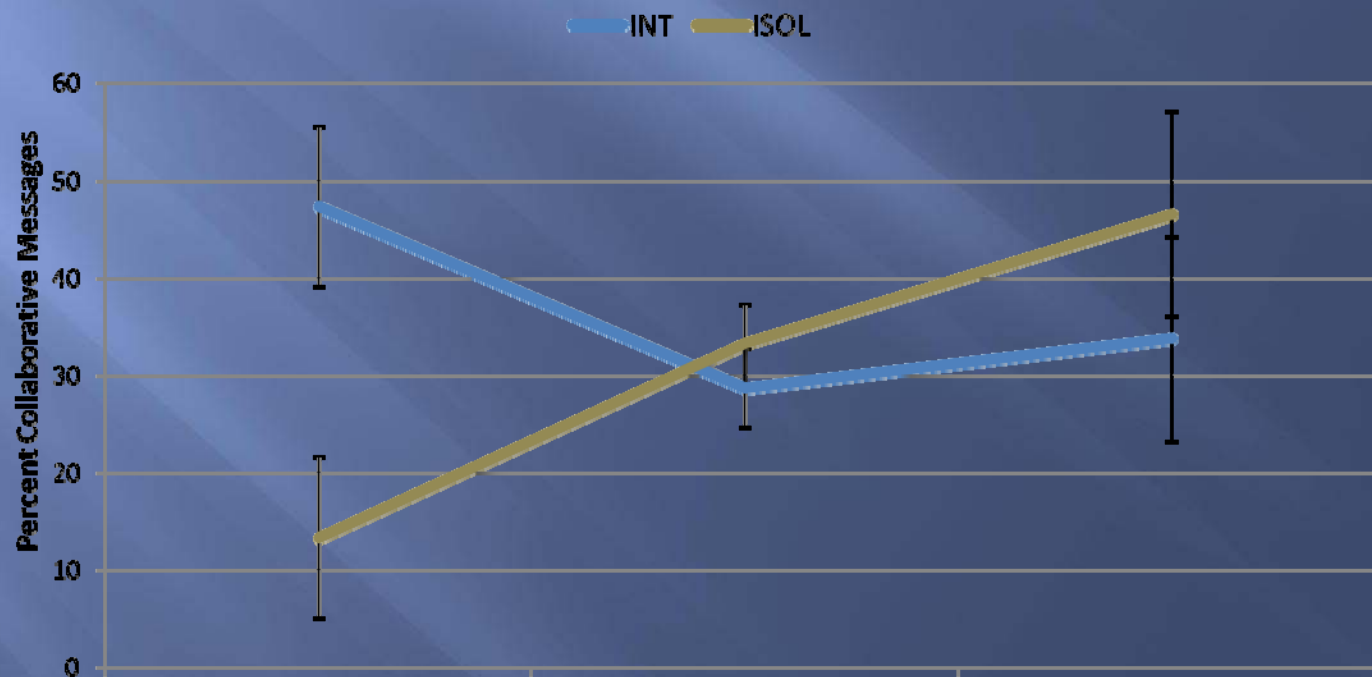


Collaborative Communication (Overall)

Isolated teams require consistently more collaborative communication as difficulty increases

Integrated teams require fewer collaborative comments over time

- Shared situation awareness leads to *team interaction mental models*, reducing need for explicit communication (Mathieu et al, 2000).

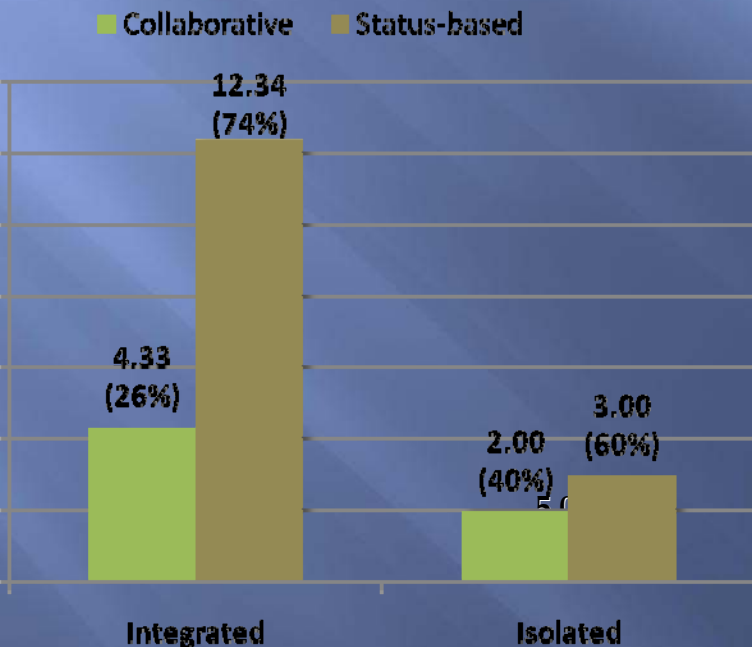


Communication After Emergent Events (Hypothesis 3 *not supported*)

Isolated teams communicated less frequently than Integrated teams following reduction in available resources

Explanation: Integrated teams can see how emergent events affect others' plans as well, prompting necessary communication

Day 2 - Statements within 30 minutes of inject



Day 3 - Statements within 30 minutes of inject

