



# Congruence of Human Organizations and Missions: Theory versus Data

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# Motivation: What Improves Performance?

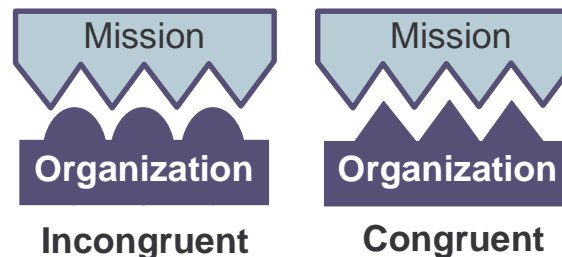
A2C2 - ONR

## ■ Performance

- ✚ **Optimality** is subjective: different performance factors can be deemed important
- ✚ Dynamic Measures: show local picture – allow to find **when** the performance decreases, but do not tell **why**, or **when** the adaptation is needed

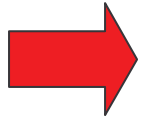
## ■ Mission-Organization

- ✚ What does the **match** between mission and organization mean?
- ✚ Can the **match** be measured, predicted?
- ✚ How do the structures of mission and organization **interplay**?
- ✚ How does the match relates to **performance**?

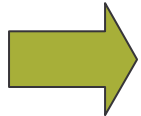


# Overview

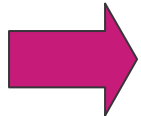
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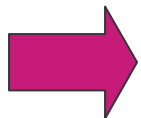
Motivation: Congruence Hypothesis & Experiment-8



Team Measures



Incongruence Types & Examples



Experiment-8: Pre- and Post-processing Results



# Motivation: How to Induce Incongruence

A2C2 - ONR

## ■ Hypotheses – the following factors increase incongruence:

- + High DM-DM coordination
- + Workload (task load) imbalance among DMs

Why?

They result in **DELAYS** in task processing  $\Rightarrow$  negative impact on *speed of command* (throughput) and *synchronicity of operations*

## ■ Delay Types

- + asset request, communication, synchronization, and task load

## ■ Theoretical Basis

- + Queuing networks: **balanced service rates**  $\Rightarrow$  maximum throughput
- + Manufacturing systems: **imbalance in workloads**  $\Rightarrow$  bottlenecks

## Model-based Mission Design

- Design organizations  $F$  and  $D$  – structurally different
- Synthesize  $f$  and  $d$  missions such that  $f \leftrightarrow F$  and  $d \leftrightarrow D$  are congruent while  $f \leftrightarrow D$  and  $d \leftrightarrow F$  are measurably incongruent with each other



What aspects of  $f$  and  $d$  induce the "greatest pain" in the mismatched cases?

## Model Predictions (Pre- and Post-Experiment)

- Team performance and process measures
- Process and structural congruence

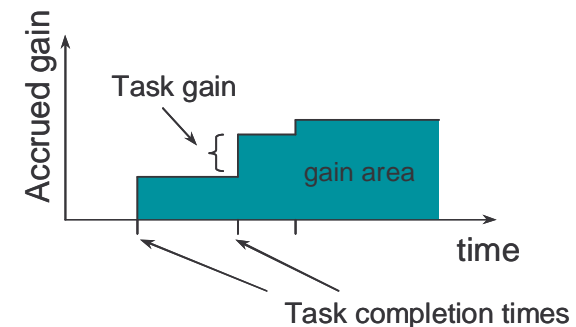
## Experiment Design and Implementation at NPS

(D. L. Kleinman)

## Performance Measures

- Accumulated task gain
  - provides a measure of team efficiency in processing tasks
  - tradeoff between accuracy and timeliness

$$\text{task gain} = (\text{value}) \bullet (\text{accuracy})$$



## Process Measures

- Workload
  - **internal coordination** – multi-asset operation and coordination
  - **external coordination** – multi-DM synchronization and task processing
  - **total workload** – weighted combination of internal and external coordination and its distribution among DMs
- Operational Tempo versus Resource Utilization
  - Efficiency of resource utilization and its effect on operational tempo
  - Task latency across different task classes

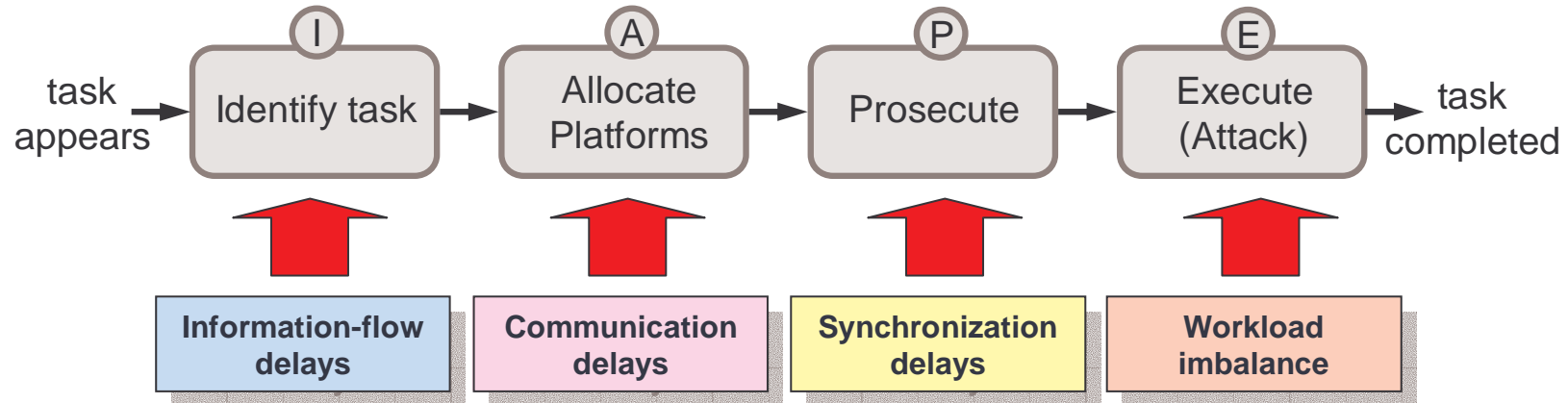
## Process and Structural Congruence Measures

- Workload balance as a **process congruence** metric
- Capability-Task match as a **structural congruence** metric



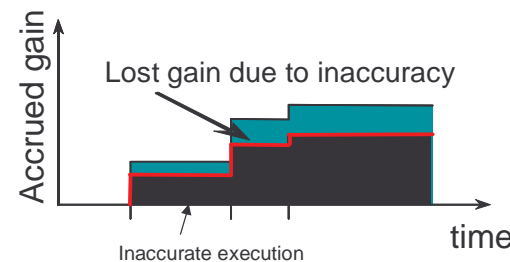
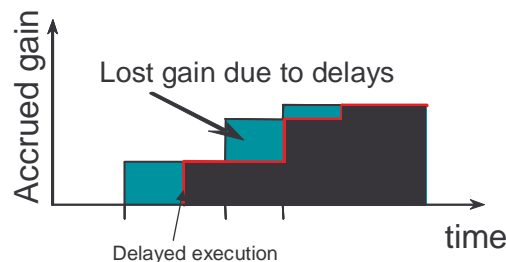
# Incongruence

## Task Processing Structure



- Task identification: delays occur when DMs need to receive information from other DMs
- Platform-task allocation: delays occur when multiple DMs need to coordinate to utilize their assets
- Task prosecution: delays occur when multiple DMs need to coordinate to synchronize their asset arrival to the task and targeting the task
- Task execution: imbalance of workload due to incongruent resource allocation creates bottlenecks

## Trading-off accuracy vs. timeliness in incongruent situations





# Example: Resource (In)congruence - communication

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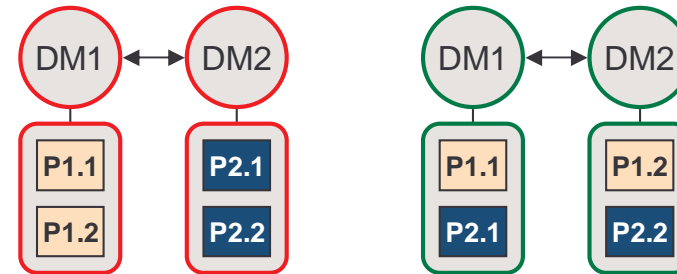
## Assets and Capabilities

Assets	Resource capabilities	Velocity	Locations	DM allocation	
				Organization A	Organization B
P1.1	[1,0]	1	(0,0)	1	1
P1.2	[1,0]	1	(1,1)	1	2
P2.1	[0,1]	1	(0,0)	2	1
P2.2	[0,1]	1	(1,1)	2	2

## Tasks with Resource Requirements of the same type

Tasks	Resource requirements	value	Locations
T1	[2,0]	1	(0,1)
T2	[0,2]	1	(1,0)

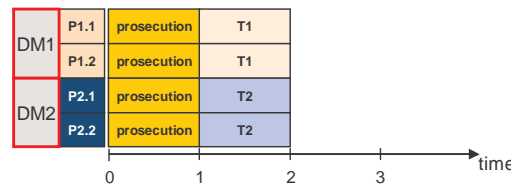
## Organizations



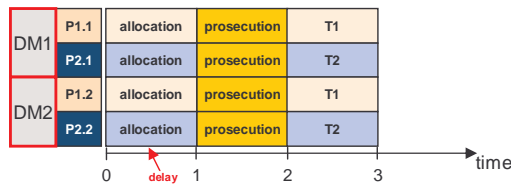
Organization A

Organization B

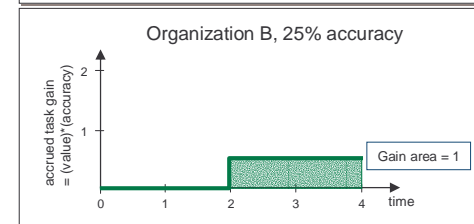
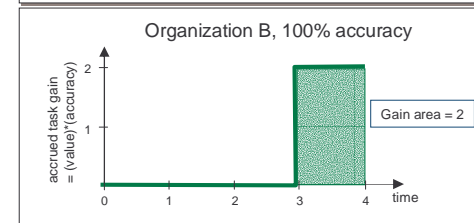
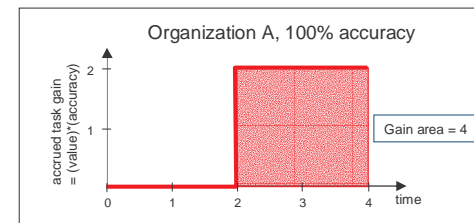
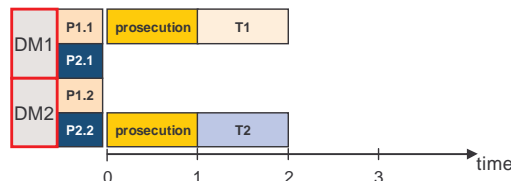
### Organization A



### Organization B, 100% accuracy



### Organization B, 25% accuracy







# Example: Resource (In)congruence – workload balance

## Tasks with Resource Requirements of the same type

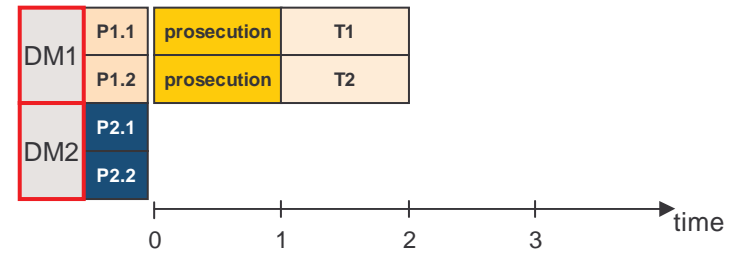
Tasks	Resource requirements	value	Locations
T1	[1,0]	1	(0,1)
T2	[1,0]	1	(1,0)

## Measures

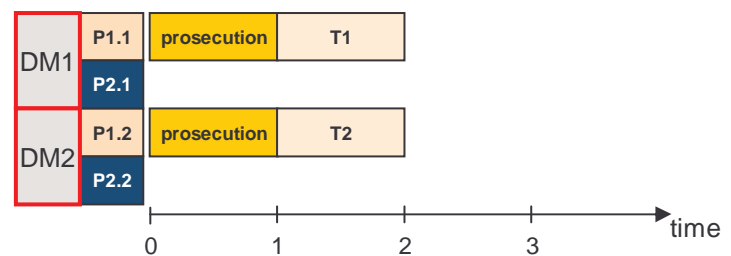
organization		I(m)	E(m)	CW(m)	⊕	gain area
A	DM1	2	0	2	1.41	2
	DM2	0	0	0		
B	DM1	1	0	1	1	2
	DM2	1	0	1		

## Gantt-Charts

### Organization A



### Organization B



Resource incongruence leads to

- reduced aggregated gain (slower operation tempo, slower speed of command)
- bottlenecks (due to workload imbalance)

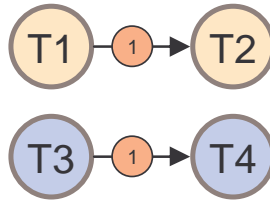




# Example: Resource (In)congruence – flow & interdependence

A2C2 - ONR

Task Network:

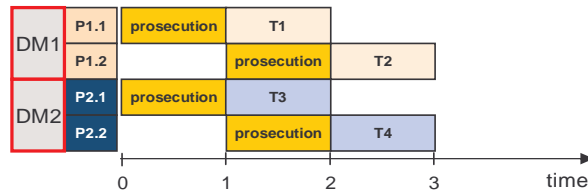


Task Parameters:

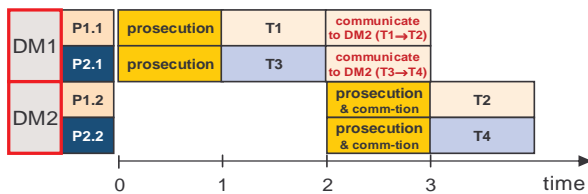
Tasks	Resource requirements	value	Locations
T1	[1,0]	1	(0,1)
T2	[1,0]	1	(1,0)
T3	[0,1]	1	(0,1)
T4	[0,1]	1	(1,0)

Schedule:

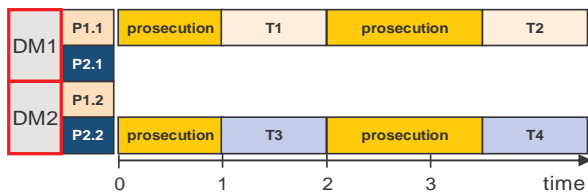
Organization A



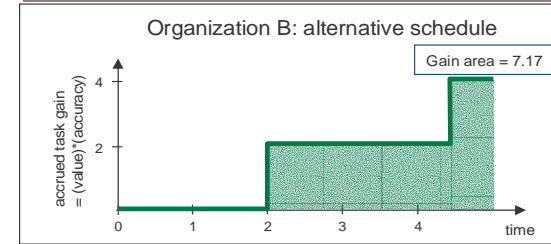
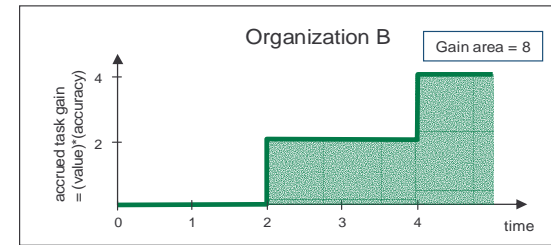
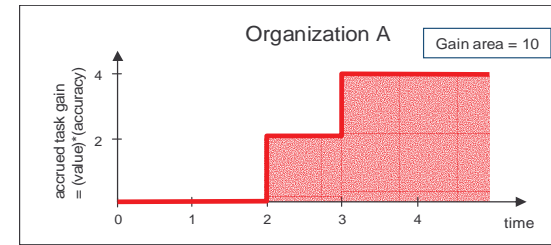
Organization B



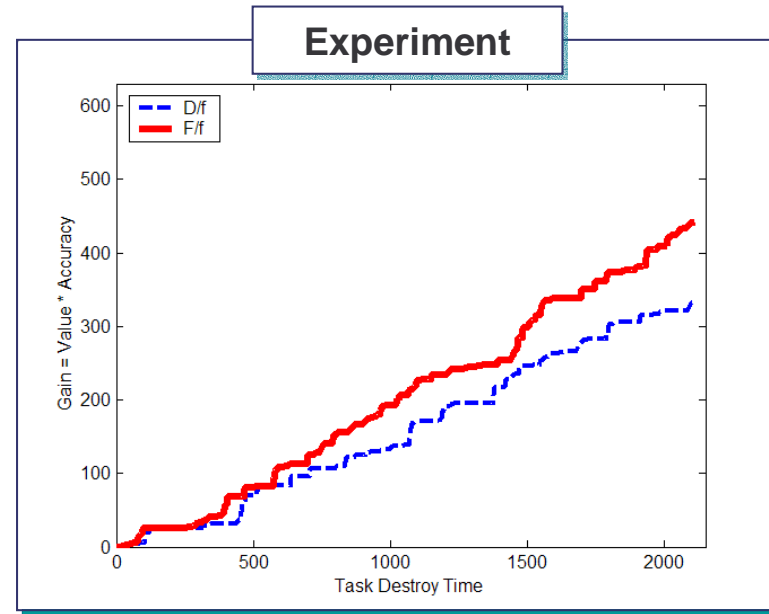
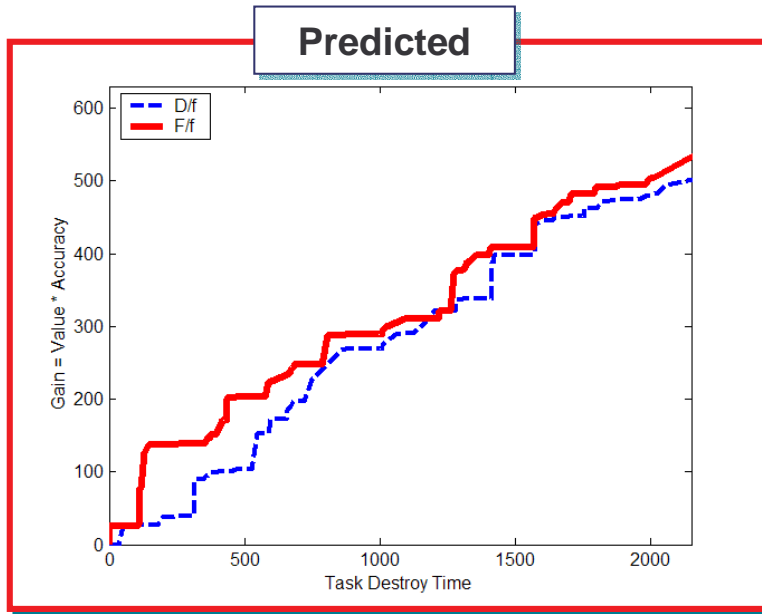
Organization B: alternative schedule



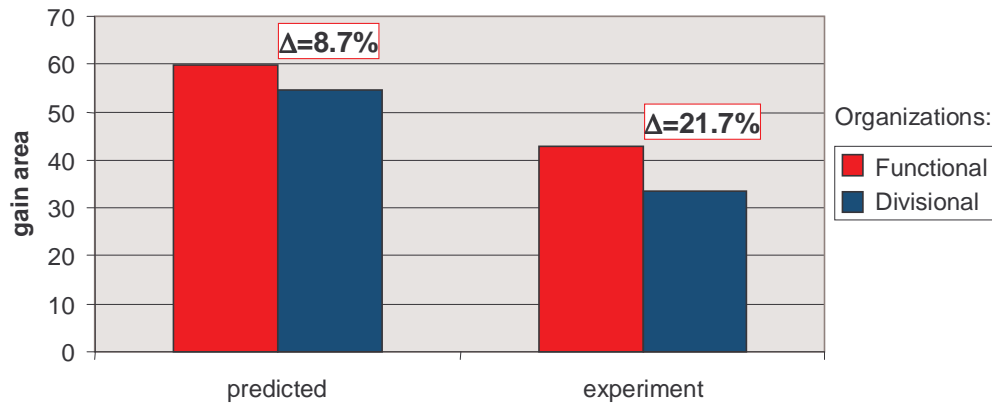
Gain:



# Experiment-8: Scenario f



**Gain Area**

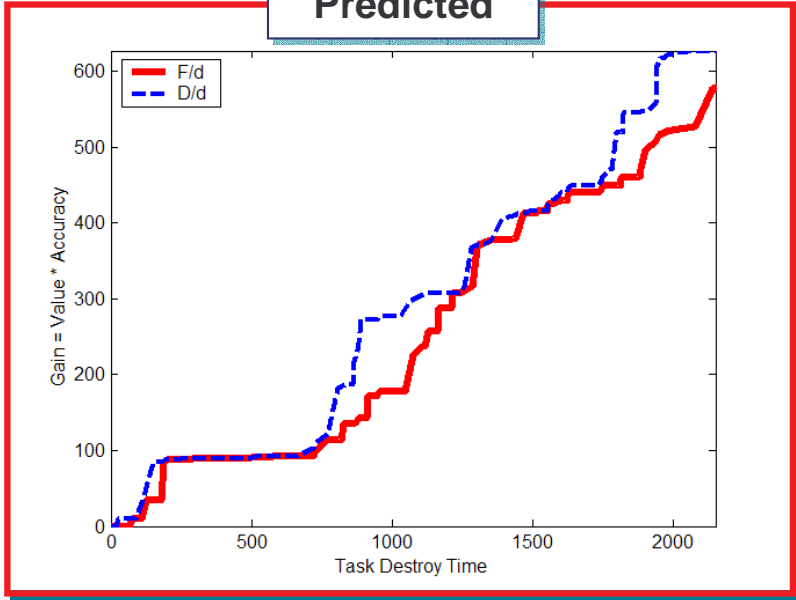


Congruent organization **F** executed time-critical tasks *faster* and with *better accuracy*, as predicted

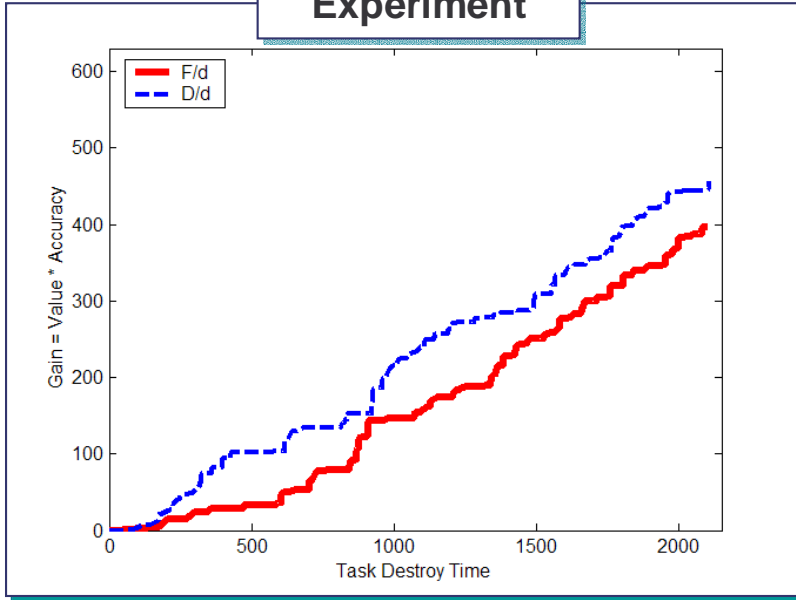


# Experiment-8: Scenario d

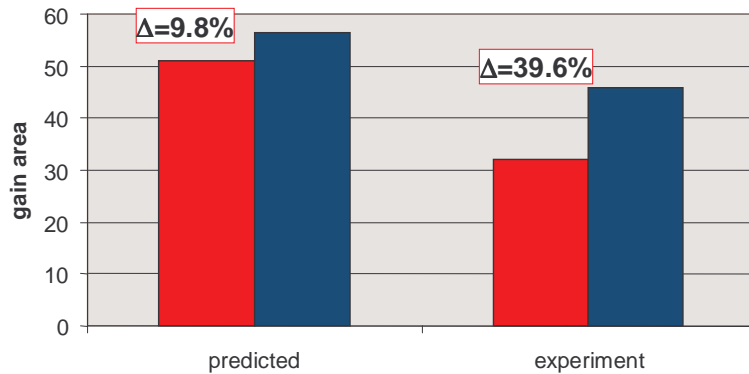
### Predicted



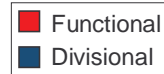
### Experiment



### Gain Area



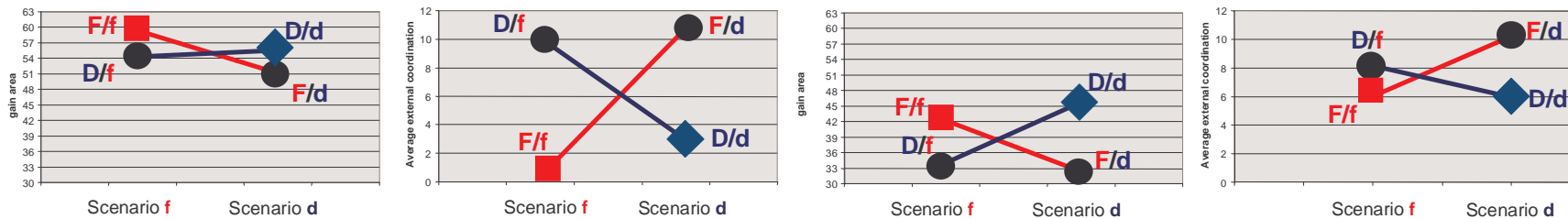
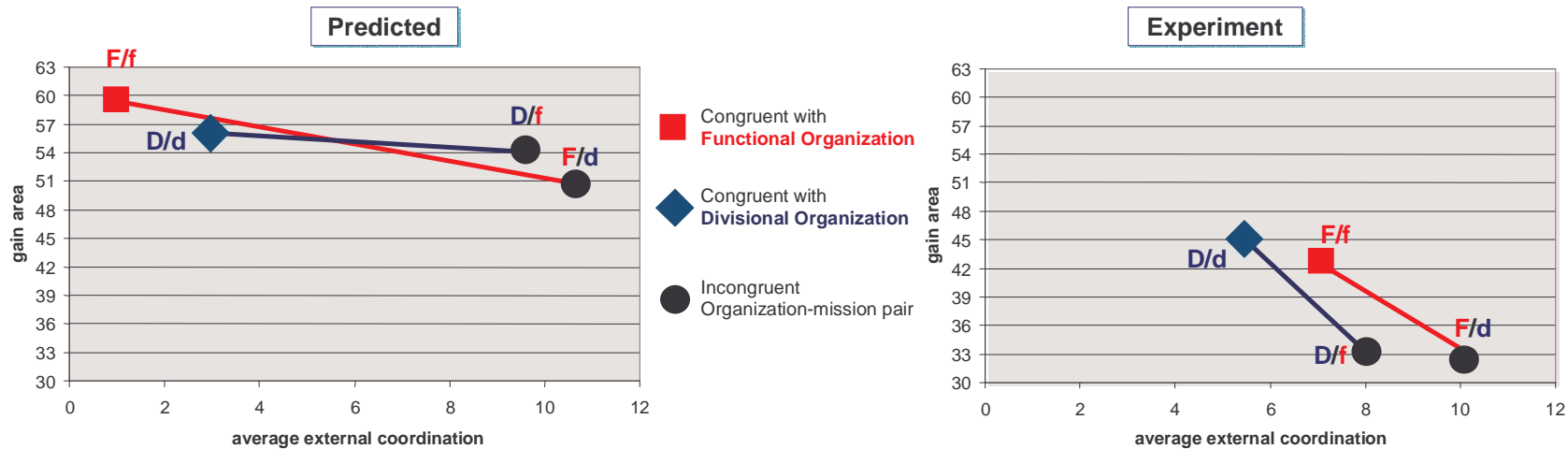
Organizations:



Congruent organization **D** executed time-critical tasks *faster* and with *better accuracy*, as predicted



# Experiment-8: Bases of Incongruence



- One of the major factors was **modeling resource requirements** of tasks: Incongruent organizations either had to resort to **multi-DM task processing** (which involved **communication delays**), or perform tasks with **lower accuracy**



## ■ Model Deficiencies

- ✚ **Load shedding:** not all tasks are done (especially mosquitoes)
- ✚ **Partial processing:** tasks are not all done with 100% accuracy
- ✚ **Task prioritization/importance:** not all tasks are created equal ~ task value
- ✚ **"Focus" of responsibility:** modify subjective weightings of tasks among DMs and even depending on the way team is organized
- ✚ Improve **workload submodel:** coordination delays
- ✚ **Stochastic choice model** to introduce randomness
- ✚ seek other dependent variables that can be compared to data

## ■ Extract Descriptive Factors of Human Decision Processes

- ✚ Limited look-ahead, stochastic choice, anchoring,...

# Conclusions

A2C2 - ONR

## ■ UConn's Role in Experiment 8

- ✚ Model-based mission design, pre-experimental model predictions

## ■ Team Measures

- ✚ Performance and process measures
- ✚ Process and Structural congruence measures

## ■ Model-data Comparisons

- ✚ Normative models predict the trend, but
- ✚ Overestimate performance & underestimates effects of incongruency

## ■ Next Steps in Model Development

- ✚ Load shedding, partial task processing, task priorities,...