Real-time Agent-based Decision Support System for the DDD Environment

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1

Outline

◆ **Agent-based Decision Support System**
  - ⊕ Overview
  - ⊕ Web-based User Interface

◆ **Contingency-based Mission Monitoring to Facilitate Organizational Adaptation**
  - ⊕ The contingency concept
  - ⊕ Real-time monitoring

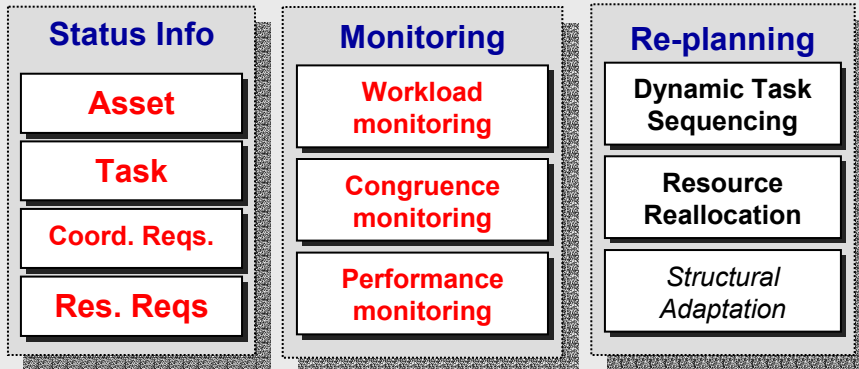◆ **Congruence Assessment: Effects of Resource Allocation Differences**
  - ⊕ Case 1: Coordination Delays are Small
  - ⊕ Case 2: Coordination Delays are Large
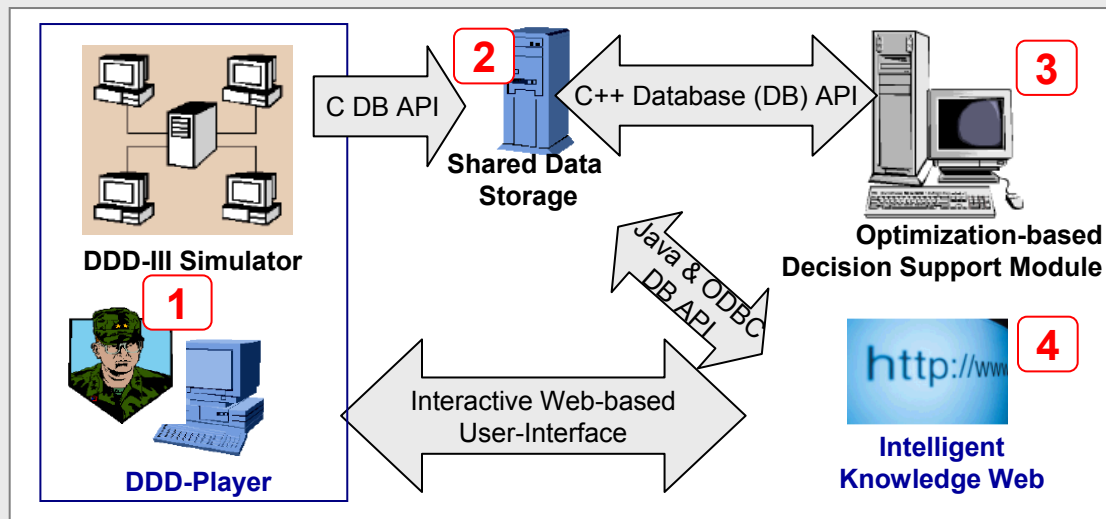
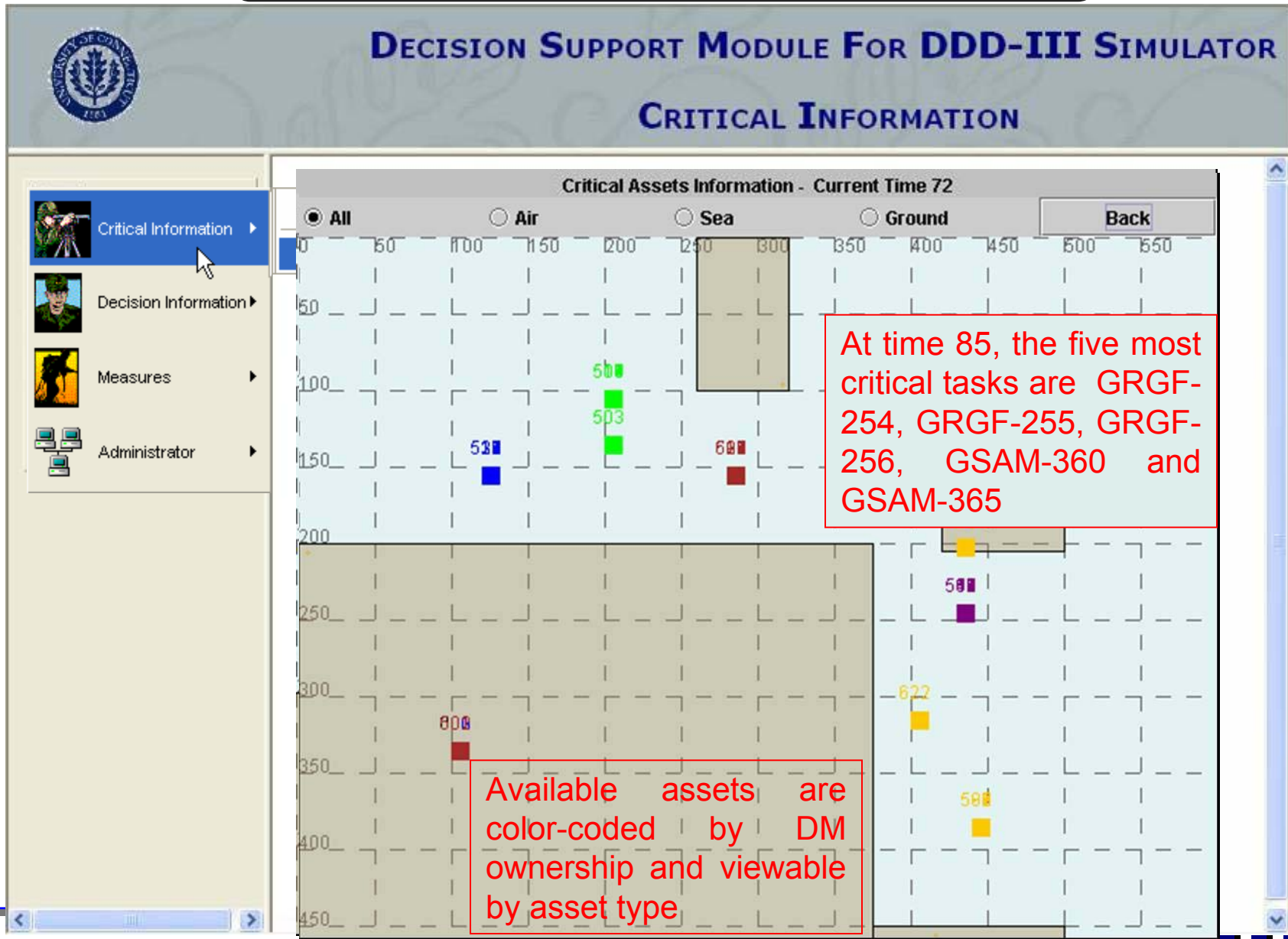◆ **Summary**

Objective:

Meth

System Components:
1. DDD-III simulator
2. Shared data storage
3. Optimization-based decision support module
4. Intelligent Knowledge Web (IK-Web): Web-based Knowledge Publisher and Tactical Display and Visualization (TDV)
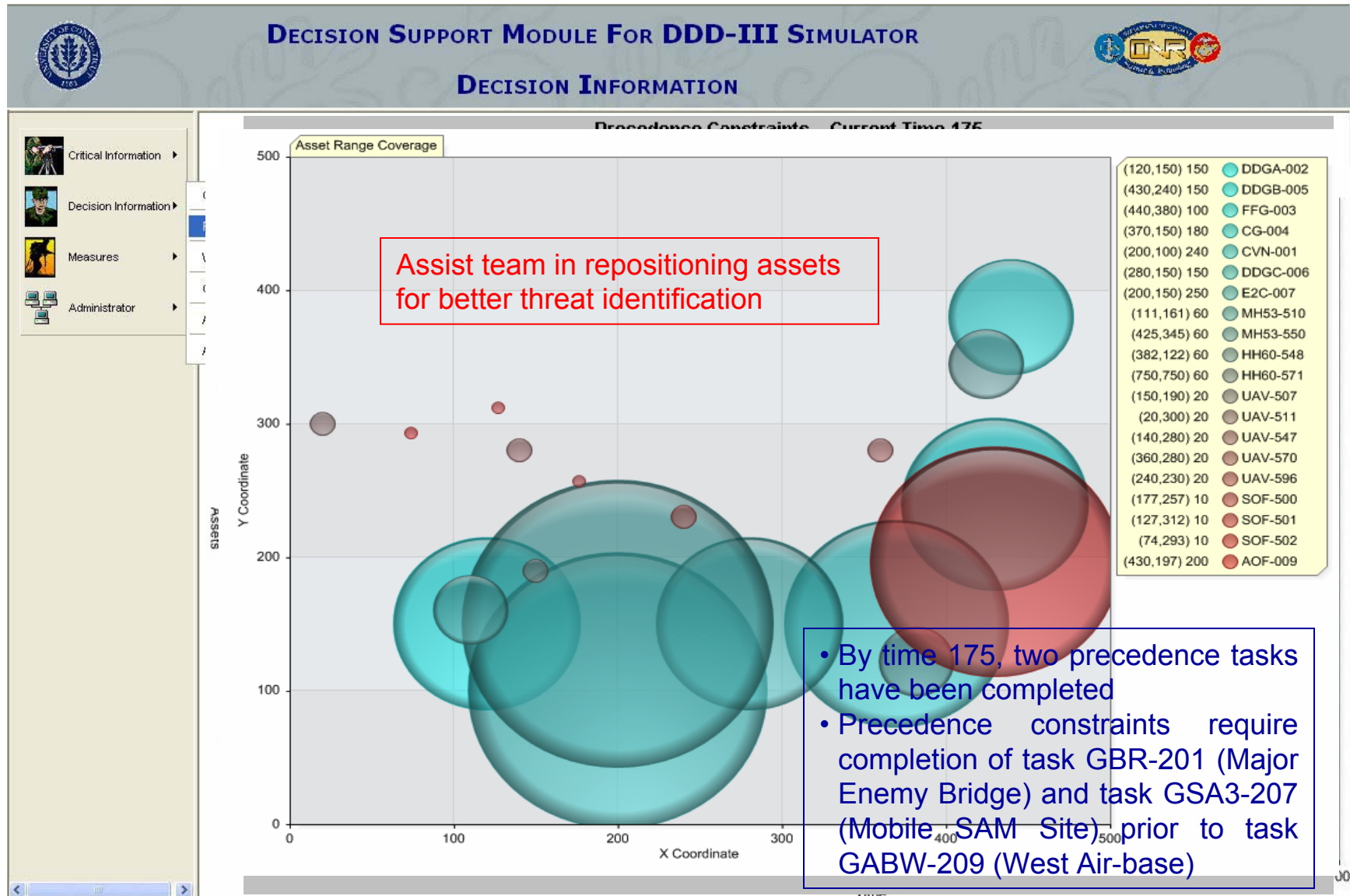
Status Info	Monitoring	Re-planning
Asset	Workload monitoring	Dynamic Task Sequencing
Task	Congruence monitoring	Resource Reallocation
Coord. Reqs.	Performance monitoring	*Structural Adaptation*
Res. Reqs		

DDD-III Simulator

1

DDD-Player

C DB API

2

Shared Data Storage

C++ Database (DB) API

3

Optimization-based Decision Support Module

Java & ODBC DB API

Interactive Web-based User-Interface

http://www

4

Intelligent Knowledge Web

3

Web-based Information Sharing

DECISION SUPPORT MODULE FOR DDD-III SIMULATOR

DECISION INFORMATION

Assist team in repositioning assets for better threat identification

- By time 175, two precedence tasks have been completed
- Precedence constraints require completion of task GBR-201 (Major Enemy Bridge) and task GSA3-207 (Mobile SAM Site) prior to task GABW-209 (West Air-base)

6

Performance and Congruence Assessments to Facilitate Adaptation Processes

Contingency-based Measures - Concept

Org. Process Attributes:
1. Task Prioritization
2. DM-Task Allocation
3. Task-resource Assignment

Organizational Structures:

Environmental Attributes:
1. Complexity
   - Task-resource requirements
   - Temporal loading of tasks
   - Spatial loading of tasks
   - Precedence requirements

Premise:

 ♦ Organizations whose internal features best match the demands of the environment achieve the best performance

Objective:

 ♦ Identify incongruence conditions that produce significant degradation in organizational performance

 ♦ Utilize performance and congruence assessment to guide when and how to adapt to regain congruence $\rightarrow$ improve organizational performance

Congruence Assessment

Structure-Environment Congruence (C^{SE}):
1. Congruence between DM-resource allocation and Task-resource requirements
2. C^{SE} in terms of external coordination workload

Process-Environment Congruence (C^{PE}):
1. Temporal C^{PE} in terms of task latency
2. Spatial C^{PE} in terms of average asset-travel distance

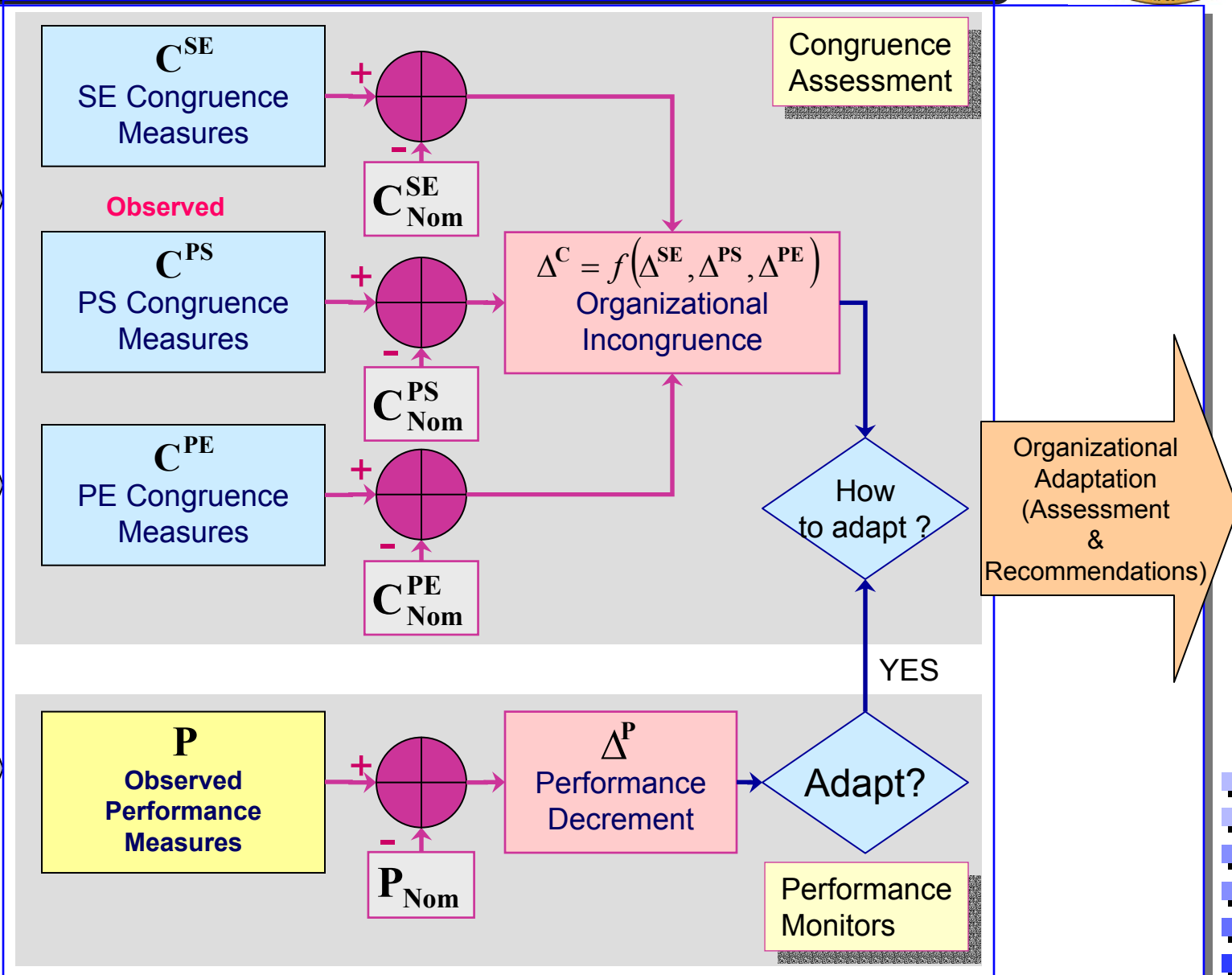**Process-Structure Congruence** (C^{PS}):
1. Congruence between DM-resource allocation and DM-resource utilization
2. C^{PS} in terms of internal coordination workload

$$\Delta^{C} = f\left(\Delta^{SE}, \Delta^{PS}, \Delta^{PE}\right)$$

Organizational Incongruence

SE Congruence Measures — C^{SE}

PS Congruence Measures — C^{PS}

PE Congruence Measures — C^{PE}

C^{SE}_{Nom}

C^{PS}_{Nom}

C^{PE}_{Nom}

Observed

Congruence Assessment

Structural Attributes

Process Attributes

Environmental Attributes

P Observed Performance Measures

P_{Nom}

Δ^{P} Performance Decrement

Adapt?

How to adapt ?

YES

Performance Monitors

Organizational Adaptation (Assessment & Recommendations)

$C^{XY}_{Nom}, P_{Nom} \equiv$ **congruence or performance measure of baseline organization, e.g., computational agent**
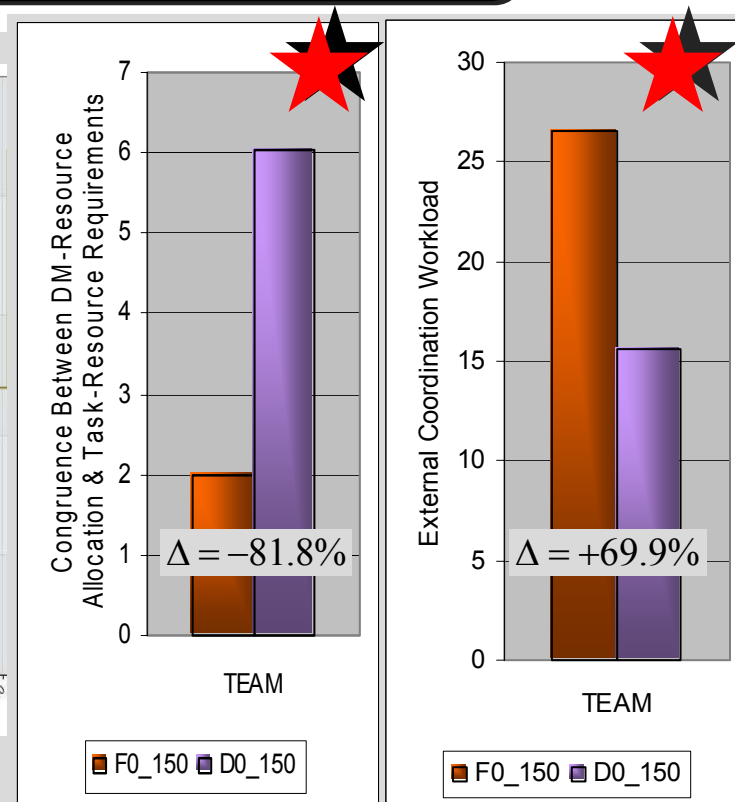
9

Congruence Assessment
Effects of Resource Allocation Differences

Structure-Environment Congruence (C^{SE})

Degree of Congruence between DM-Resource Allocation &
Task-Resource Requirements

Degree of Structural Differences between Dd and Fd

$\Delta = -81.7\%$

$\Delta = +68.6\%$

$\Delta = -81.8\%$

$\Delta = +69.9\%$
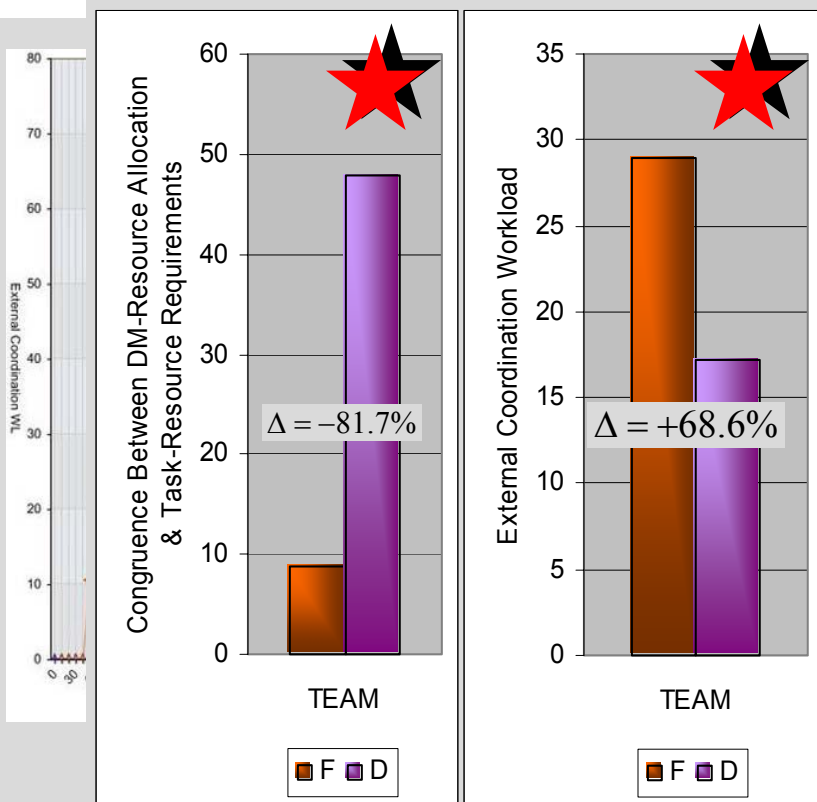
Case 1: Coordination Delays are Small

Case 2: Coordination Delays are Large

- There exists high external coordination workload when comparing the **Fd** pair
- The incongruity is mitigated as the structurally congruent **Dd** pair

The multi-resource team **D** fares better than the nearly-single resource team **F** in scenario **d**

↓

Need to structurally adapt?

Dd
Fd
A2C2 Exp. 8

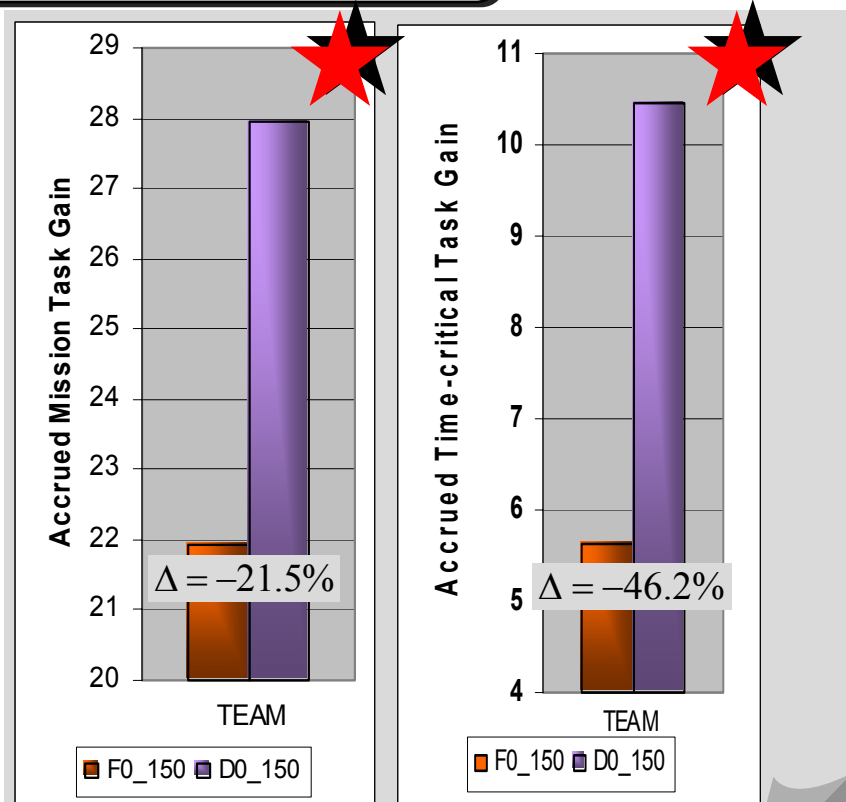Case 1: Coordination Delays are Small
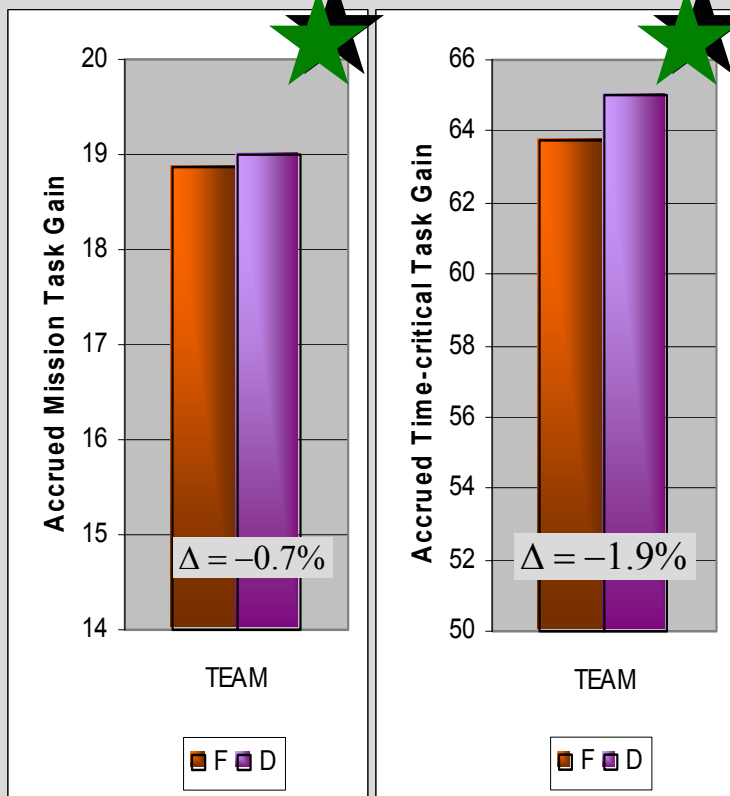
Case 2: Coordination Delays are Large

BUT…

Low coordination delays → Reduced Resource Allocation Effects → Team **F** suffers only a small performance degradation when compared to team **D** in scenario **d**

↓

Structural incongruence produces no significant performance degradation when coordination delays are low → Structural adaptation is unnecessary when congruent strategy is utilized
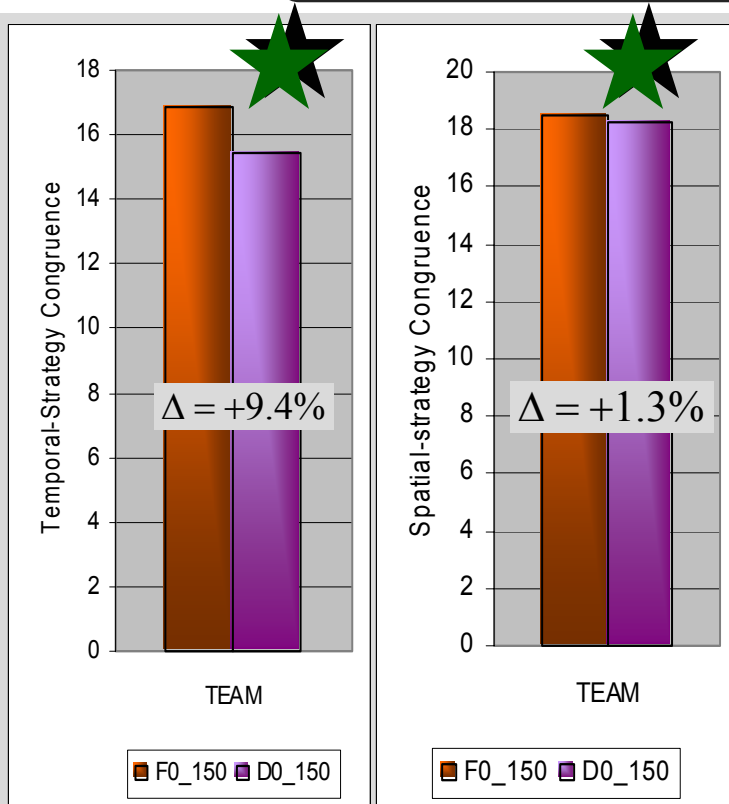
High external coordination delays → Significant resource-allocation effects → Team **F** suffers significant performance degradation when compared to team **D** in **d**
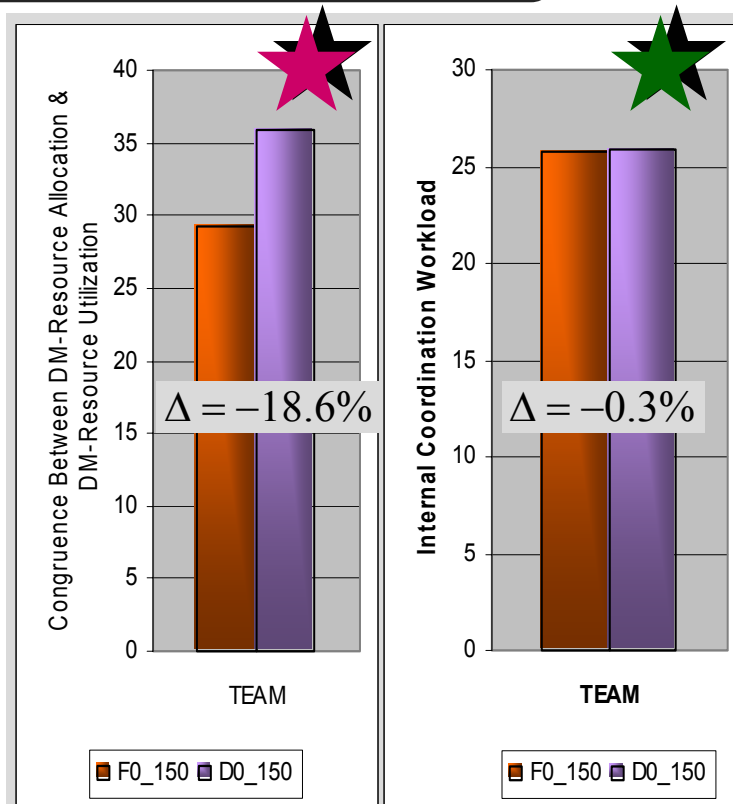
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Organizational adaptation is necessary → How to adapt? Structural adaptation only? or Strategy and structural adaptation?

Process-Structure Congruence (C^{PS}) & Structure-Environment Congruence (C^{SE})

Case 2: Coordination Delays are Large

$\Delta = +9.4\%$ (Temporal-Strategy Congruence)

$\Delta = +1.3\%$ (Spatial-strategy Congruence)

- No significant strategy-environment incongruence in **Fd** pair when compared to the **Dd** pair
  ↓
- Strategy adaptation is unnecessary

Case 2: Coordination Delays are Large

$\Delta = -18.6\%$ (Congruence Between DM-Resource Allocation & DM-Resource Utilization)

$\Delta = -0.3\%$ (Internal Coordination Workload)

- Team F has significantly less resource reserves when compared to team D in scenario d
  ↓
- Requires resource re-allocation to cope with the demands of the mission → structural adaptation is necessary

13

◆ Implemented an agent-based DSS as a means to augment the organizational cognitive capacity and to facilitate the processes of adaptation

◆ Implemented web-based information sharing to facilitate effective knowledge management:
- ⊕ Critical Information
- ⊕ Decision Information
- ⊕ Measures: Performance and Process Measures and Congruence Assessment

◆ Introduced *quantitative* measures to suggest when and how to adapt in fast-paced organizations facing highly dynamic mission environments

◆ Demonstrated the integrated multi-dimensional concept of organizational congruence, which incorporates:
- ⊕ Structure-environment (SE) congruence,
- ⊕ Process-environment (PE) congruence, and
- ⊕ Structure-Process (SP) congruence