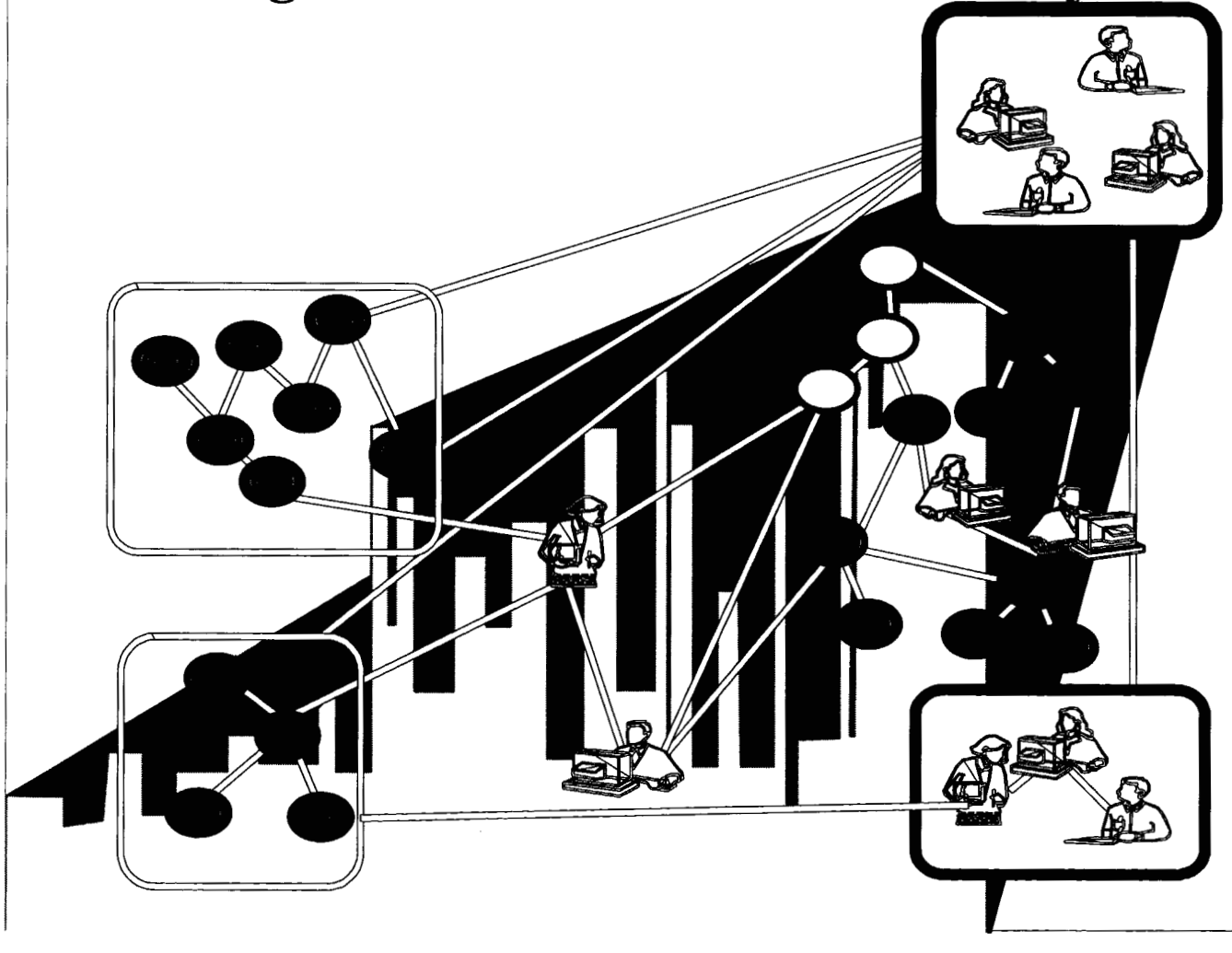
Team X Modeling and Experiments

Craig Schreiber and Kathleen Carley



Carnegie Mellon

CASOS

Center for Computational Analysis of Social and Organizational Systems

Craig Schreiber

Kathleen Carley

Carnegie Mellon University

Pittsburgh, PA 15213

Tel: - 1-412-268-5866

Email:
craigs@andrew.cmu.edu

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Outline

- The model used – Construct-TM
- Team X modeling changes
- Experiment 1
  - The tradeoff btw point design and trade space exploration for different Facilitators
- Experiment 2
  - Turnover risk of key personnel
- Summary

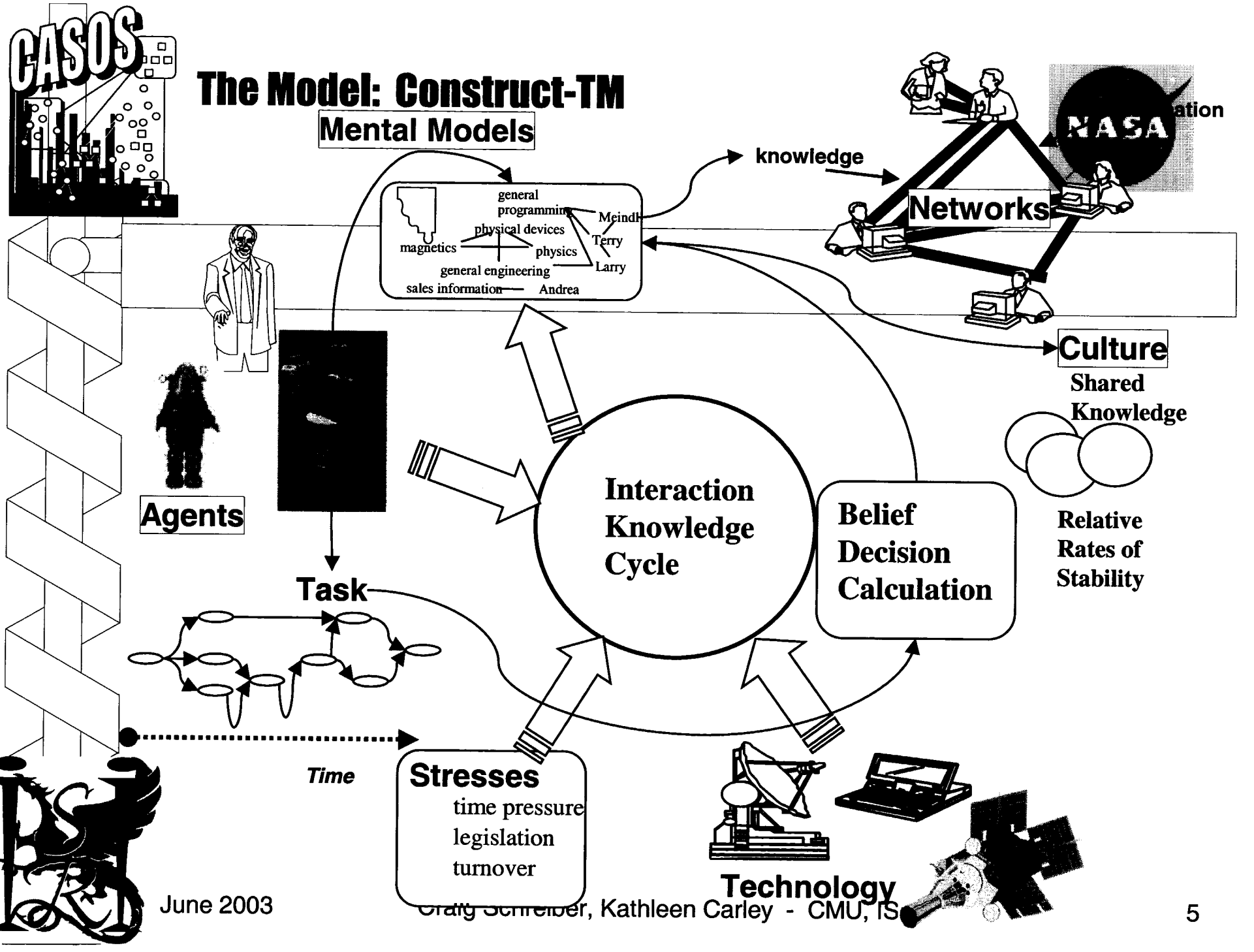
Construct-TM

- Construct-TM is a multi-agent model whereas agents communicate, learn and make decisions in a continuous cycle
  - Non-linear system – systems that generate complex temporal behavior due to variables that have dynamic relationships
  - Structuration – a theoretical perspective of construction and reconstruction of the social system through human interaction based on rules and resources
  - Social network analysis – defining and analyzing networks and relations

Construct-TM Validated

- Carley (1990)
- Carley and Krakchardt (1996)
- Carley and Hill (2001)
- Schreiber and Carley (2003)

The Model: Construct-TM



Team X Modeling Changes

Collected observational, survey and interview data on the CSSR mission design sessions of Team X. Based on these data the following changes to the Construct-TM model are suggested:

- **publish/subscribe system (done) ***
- **large screen broadcast tech. (done) ***
- **past missions database (done) ***
- **sidebars (done) ***
- **interdependencies**
  - **human network**
  - **technology network**
- **pooled, sequential, reciprocal tasks**
- **multi-tasking**
- **error cascades**

*** - These changes were implemented first because they are key to the team's strategic management of the interdependencies and tasks as well as being channels for error propagation**

Team X Modeling Changes Completed – Publish/Subscribe

Publish/Subscribe System

- Knowledge between subsystems is passed through a central database. The publishing of knowledge is not voluntary and transfer is forced. Subscribing ensures that only relevant knowledge is sent to each subsystem – only a fraction of the total knowledge available is obtained by each subsystem and the subsystems often receive different knowledge. The transfer of this knowledge is virtually transparent, seamless and immediate (low latency). This transfer mechanism alleviates the human agents from having to incur the time costs of lengthier transfer interactions.
- Modeled as an archival database whereas agents are forced to periodically publish and subscribe knowledge. Each agent publishes a subset of their knowledge and subscribes to a subset of the database's knowledge. Each agent subscription does not necessarily access the same subset of database knowledge and is often times accessing different knowledge.

Team X Modeling Changes Completed – Broadcast Technology

Broadcast Technology

- The three large screens at the front of the room broadcast knowledge to the entire team. Most information broadcast is archival, such as the systems worksheet. But some is non-archival, such as the customer presentation at the beginning of the session. This technology transfers the same knowledge at the same time to everyone on the team.
- Modeled as both archival and non-archival broadcast technology. The archival type is associated with an existing database. A subset of the database's knowledge will be broadcast to all the agents in a particular time period. The exact same knowledge is transferred to every agent. The non-archival type is similar whereas every agent receives the same knowledge in a time period. But it differs from archival in that once the broadcast (presentation) is done there is no way to retrieve the knowledge later unless it is re-broadcast.

Team X Modeling Changes Completed – Past Missions Database

Past Missions Database

- The past missions database contains archived knowledge of the designs for past missions. This database is not as central within the Team X design sessions as is the publish/subscribe system and the broadcast technologies. Team members can access this database on an individual basis as needed but actual use of this database is low as indicated by the survey. The past missions database seems to be used more in the pre-session.
- This is modeled as a combination task and referential database. The database contains prior task knowledge such as the systems worksheet and referential knowledge such as who worked on what subsystem. This database can be accessed by any agent at any time.

Team X Modeling Changes Completed – Sidebars

Sidebars

- Sidebars are when subgroups emerge within Team X to handle complex problems. These sidebars mainly coordinate through human interactions. Interdependencies are involved in the emergence of these subgroups.
- Modeled so that agents can either interact 1:1, 1:n or work alone in any given time period. The interaction choice is agent specific and not global within a time period. In other words, in a given time period some agents will be 1:n while other agents will be 1:1 while still other agents will be working alone.

Team X Modeling Changes
Items not completed

- Interdependencies
  - Human network – data was collected for this. The interdependencies are complicated and more time is needed to accomplish this change. Data on other mission designs would help to determine if this data can be generalized to overall Team X design.
  - Technological network – partial data was collected. Further data collection is needed as this network is central to knowledge transfer in the team.
- Pooled, sequential, reciprocal tasks – no data was collected. Observations conclude this to be an important model variable for future data collection.
- Multi-tasking – no data was collected. Observations conclude this to be an important model variable for future data collection.
- Error cascades – no data was collected. Observations conclude this to be an important model variable for future data collection.

Experiment 1
Facilitator Style Tradeoff

The tradeoff between point design and trade space exploration for different Facilitators

- Purpose – To test if facilitator styles impact point design and trade space exploration differently
- Definitions
  - Point design – consensus decision making to converge knowledge and integrate design.
  - Trade space exploration – exploration of an agents own position domain to make accurate decisions. This includes coordination with other position domains that are closely related.

Experiment 1 Variables

- Independent variables
  - facilitator knowledge
  - perception of dependencies on facilitator
  - perception of facilitator dependencies on others
  - design strategy (point design, trade space exploration)
- Dependent variable
  - performance

Experiment 1
Observations and Survey Data

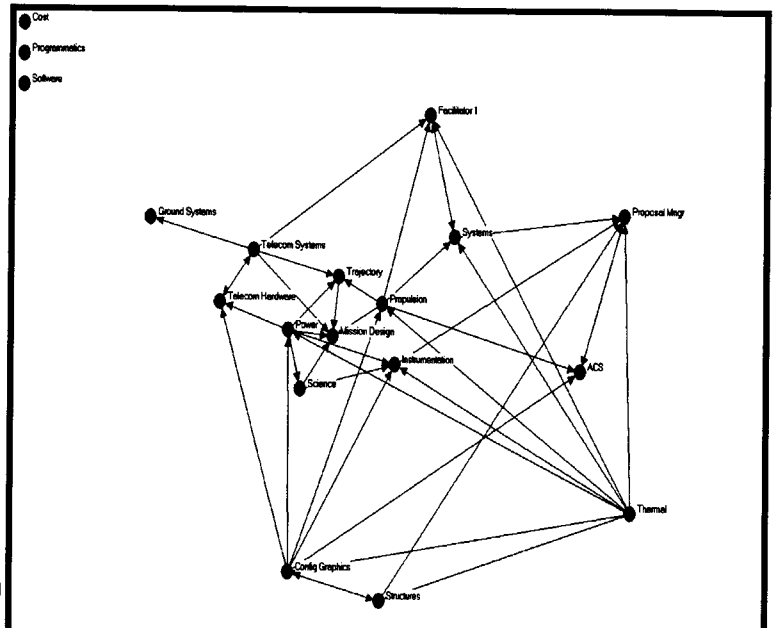
Observations indicate that facilitator management style varies greatly. This is the motivation for the experiment.

Survey data from Team X collected (data on 2 facilitators was obtained)

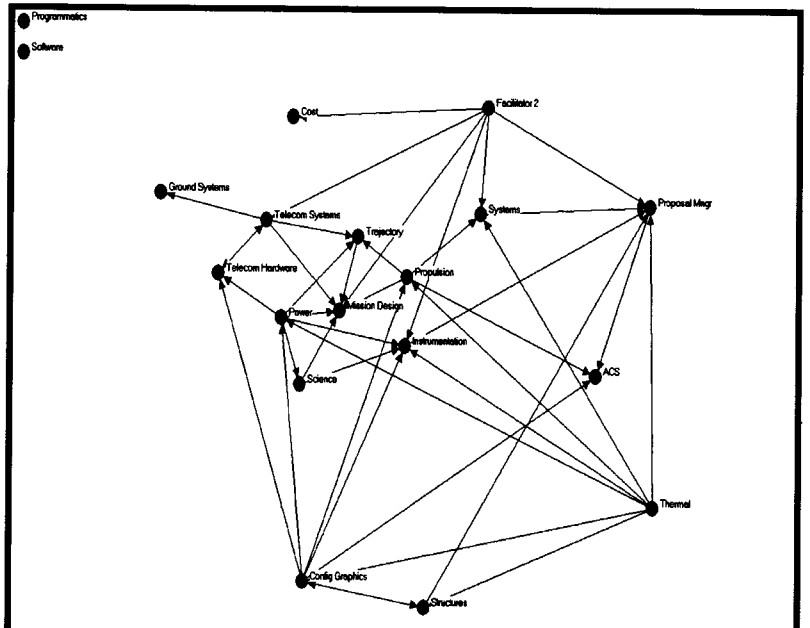
- the knowledge every team member has of each subsystem on a 4 point scale where 0 = none, 1 = beginner, 2 = intermediate, 3 = expert
- The perception of the degree of task dependence each member has on other members. This is on a 4 point scale where 0 = none, 1 = little, 2 = moderate, 3 = enormous

Experiment 1
Dependencies show style difference

The two network pictures of task dependencies show that there is a style difference for facilitators 1 and 2. Team members have task dependency on facilitator 1 whereas facilitator 2 has task dependency on the team members.

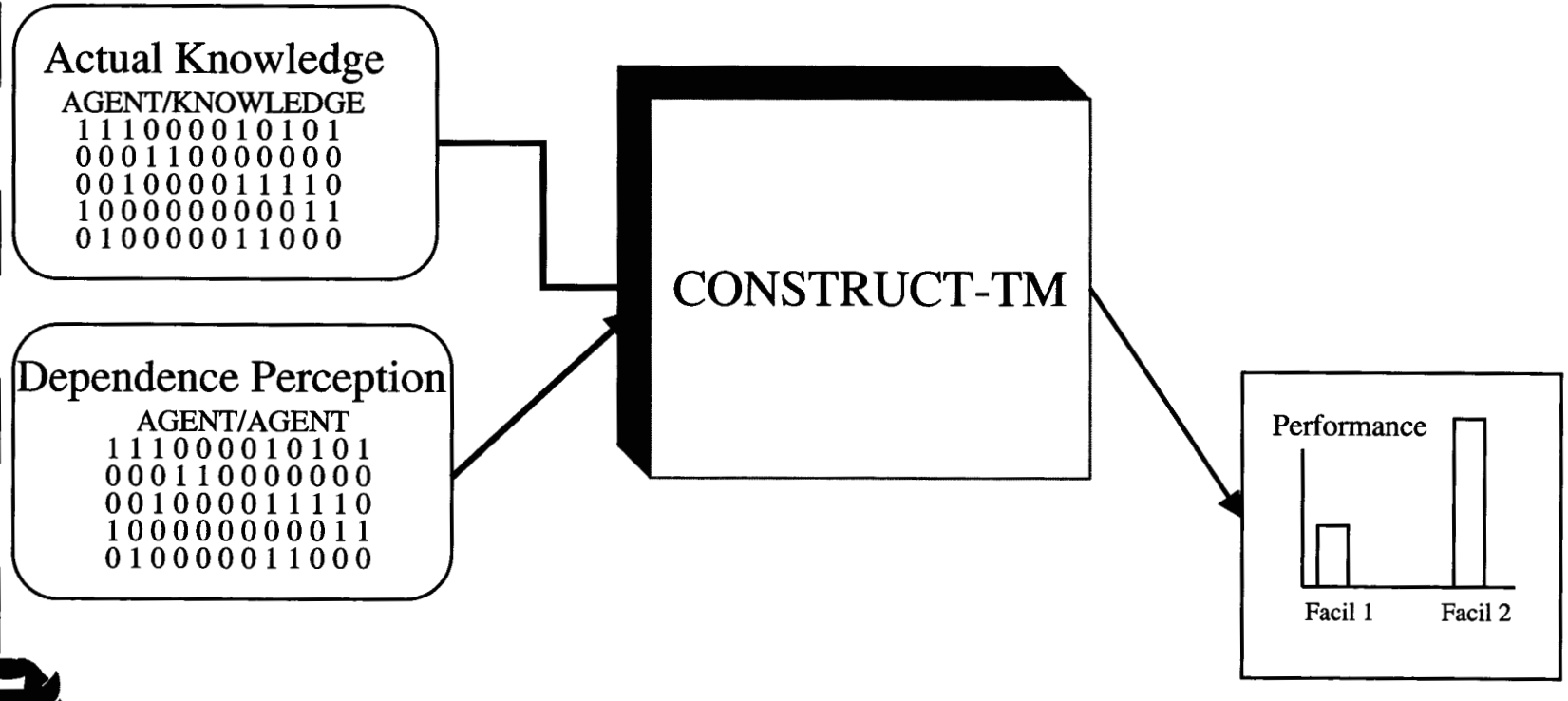


Ties are of strong task dependence

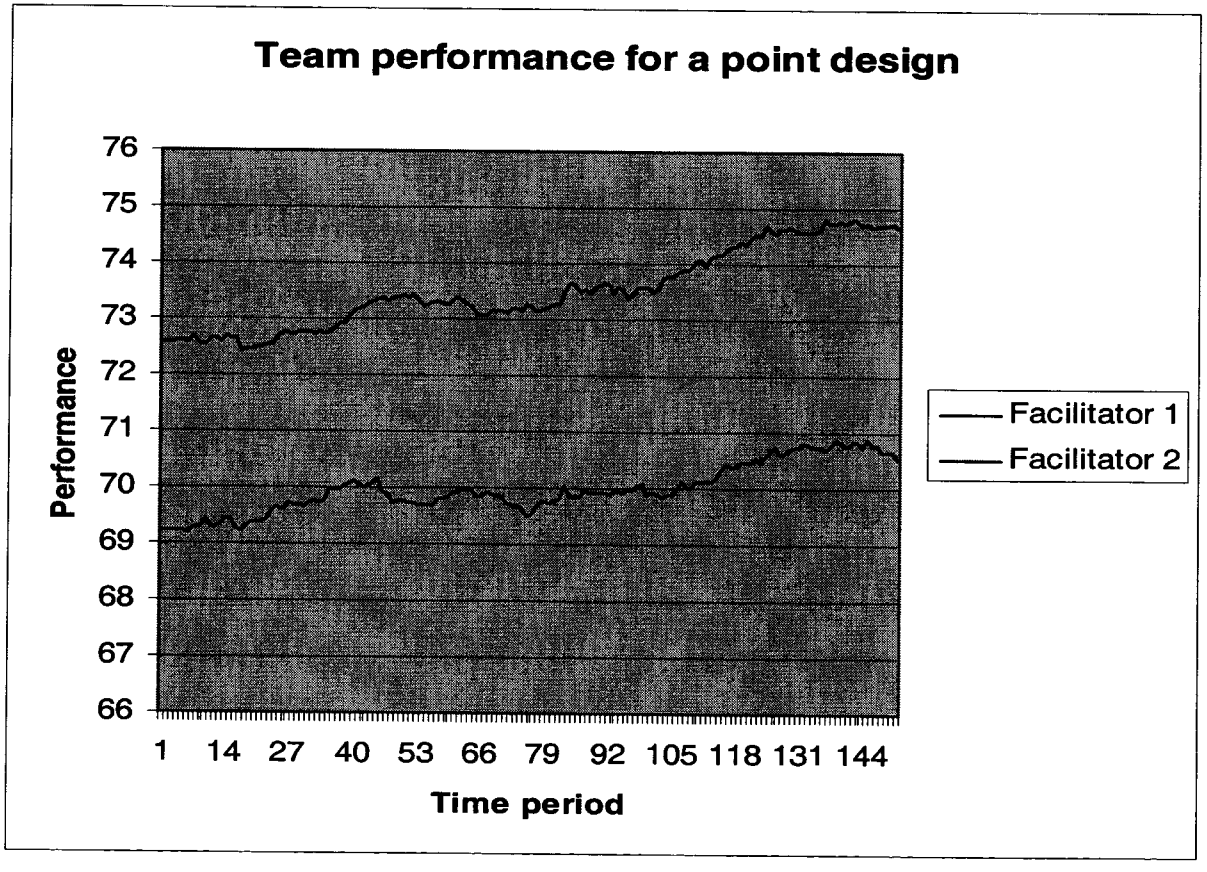


Ties are of strong task dependence

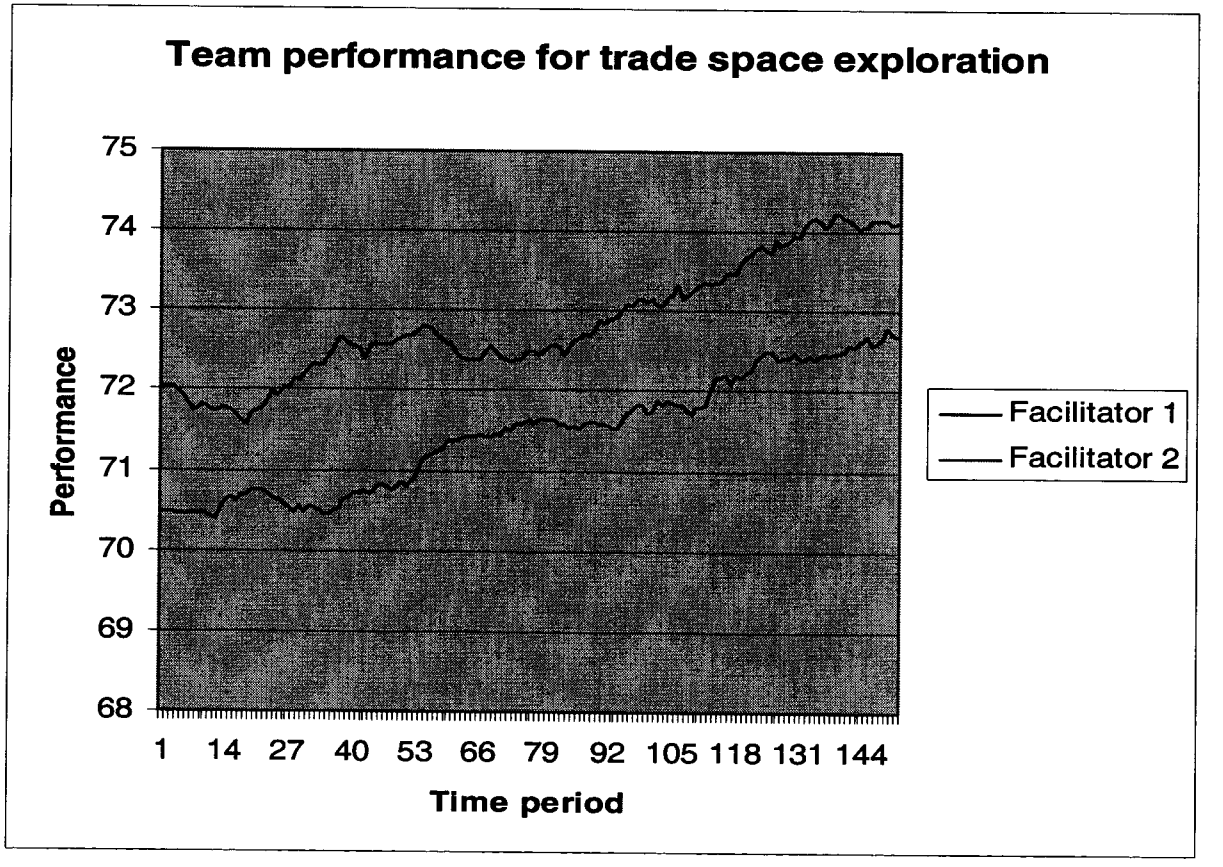
Experiment 1 Overview



Experiment 1
Results – Point Design



Experiment 1
Results – Trade Space Exploration



Experiment 1 Conclusion

The tradeoff between point design and trade space exploration for different Facilitators

- Better team performance
  - Point design - Facilitator 1's management style
  - Trade space exploration - Facilitator 2's management style
- Knowledge reported for each facilitator does not differ much
- Dependencies for work completion vary
  - Facilitator 1
    - Depends less on team members
    - Team members depend more on facilitator 1
  - Facilitator 2
    - Depends more on team members
    - Team members depend less on facilitator 2

Experiment 1 Conclusion

The tradeoff between point design and trade space exploration for different Facilitators

- Dependencies and simulation show that facilitator 1 drives the sessions
  - Tighter control over the interactions and tasks performed
  - Agents more engaged in consensus building and convergence of the system
- Dependencies and simulation show that facilitator 2 opens up the sessions and decentralizes
  - The system emerges from bottom up
  - Agents will naturally explore their trade space if given the opportunity to do so
- The tradeoff is for productivity and effectiveness

Experiment 2
Turnover Risk

Turnover of Team X key personnel

- Purpose – To test if the turnover of key Team X personnel have a negative impact on performance
- Independent variables
  - Team composition
    - CSSR staffing
    - key leadership change
    - key experts change
- Dependent variable
  - performance

Experiment 2
Team X Metamatrix used for ORA

	People	Technology	Knowledge	Tasks
People Relation	**Social Network** *Who knows who*	**Technology Network** *Who uses which tech.*	**Knowledge Network** *Who knows what*	**Assignment Network** *Who does what*
Technology Relation		**Operability Network** *Which tech. interfaces with which tech.*	**Encoded Network** *What is in which tech.*	**Tool Network** *Which tech. helps perform which task*
Knowledge Relation			**Interdependency Network** *What informs what*	**Needs Network** *What is needed to perform which task*
Task Relation				**Precedence Network** *Which tasks must be done before which tasks*

Experiment 2
Key Personnel

ORA identifies key personnel

knowledge exclusivity	potential knowledge workload	actual knowledge workload	cognitive load
4.5 (therm)	0.91 (therm)	0.048 (facil)	0.23 (therm)
2.2 (facil)	0.66 (system)	0.046 (therm)	0.20 (facil)
1.8 (missn)	0.63 (facil)	0.041 (system)	0.20 (system)

Experiment 2
Key Personnel

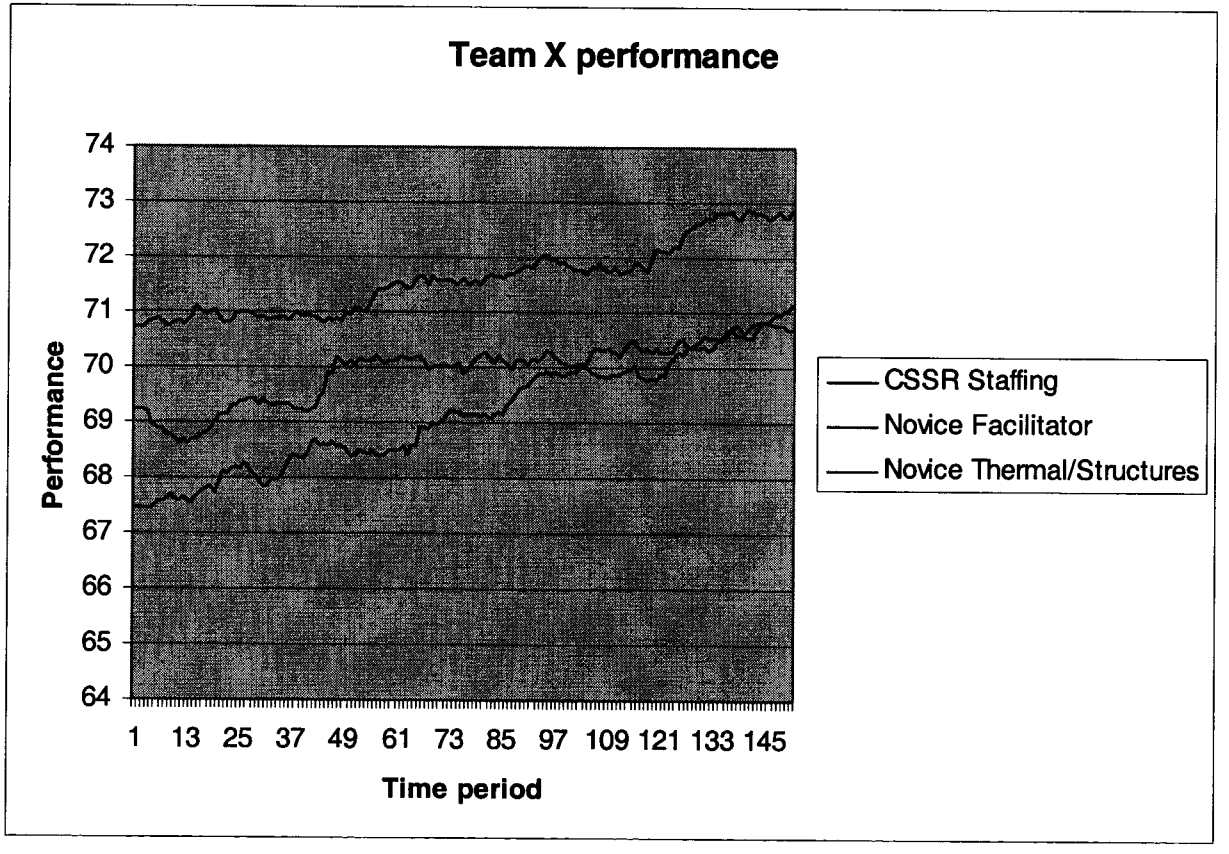
Top three personnel risks as identified by ORA

- Thermal
- Facilitator
- Systems

Experiments were run substituting less experienced personnel in key positions and comparing results to the original CSSR staffing:

- Facilitator – leadership change
  - All other positions retain the same CSSR staffing
- Thermal and Systems – key leader in charge but having less experienced staff in place of expert personnel
  - All other positions retain the same CSSR staffing

Experiment 2 Results



Experiment 2 Conclusion

Turnover of Team X key personnel

- Team X relies heavily on key expert personnel
  - Lost expert knowledge will have a negative effect on performance – loss in productivity and effectiveness
- Facilitator is the top key position and has the highest turnover risk
- The personnel staffing the Thermal and Systems positions also present a turnover risk
- The personnel are the expert turnover risk but particular positions may produce better experts due to increased exposure to system-wide interdependencies and effects
- This is a knowledge management challenge

Modeling and Experiments Summary

- Major changes have been made to the Construct-TM model to represent the Team X process
  - Publish/Subscribe system, Broadcast technology, Past missions database, Sidebars
  - Additional changes are planned to iteratively improve the representation of Team X
- Experiments conclude
  - Facilitator management styles have differing affects on point design and trade space exploration (productivity vs. effectiveness)
  - Team X has substantial risk for key personnel turnover (loss in both productivity and effectiveness)
    - Facilitator
    - Thermal and Systems

Modeling Lessons Learned

- Observation and interviews are essential
  - Modeling of the teams and process could not be done without it
- Survey data improves granularity
  - Augments the modeling from observation and interviews
  - Realistic group representation for experiments
  - Not essential for the first iteration of modeling
- Role of the information technology is not captured in the survey data
  - Additional data collection is needed to focus on the integration of the human and technological networks
- Need to model other NASA teams
  - Current changes should be applicable to other teams (VIPeR, ISS-MC)
  - Secondary validation

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