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Automated Workflow Reconstruction for C2 Experimentation

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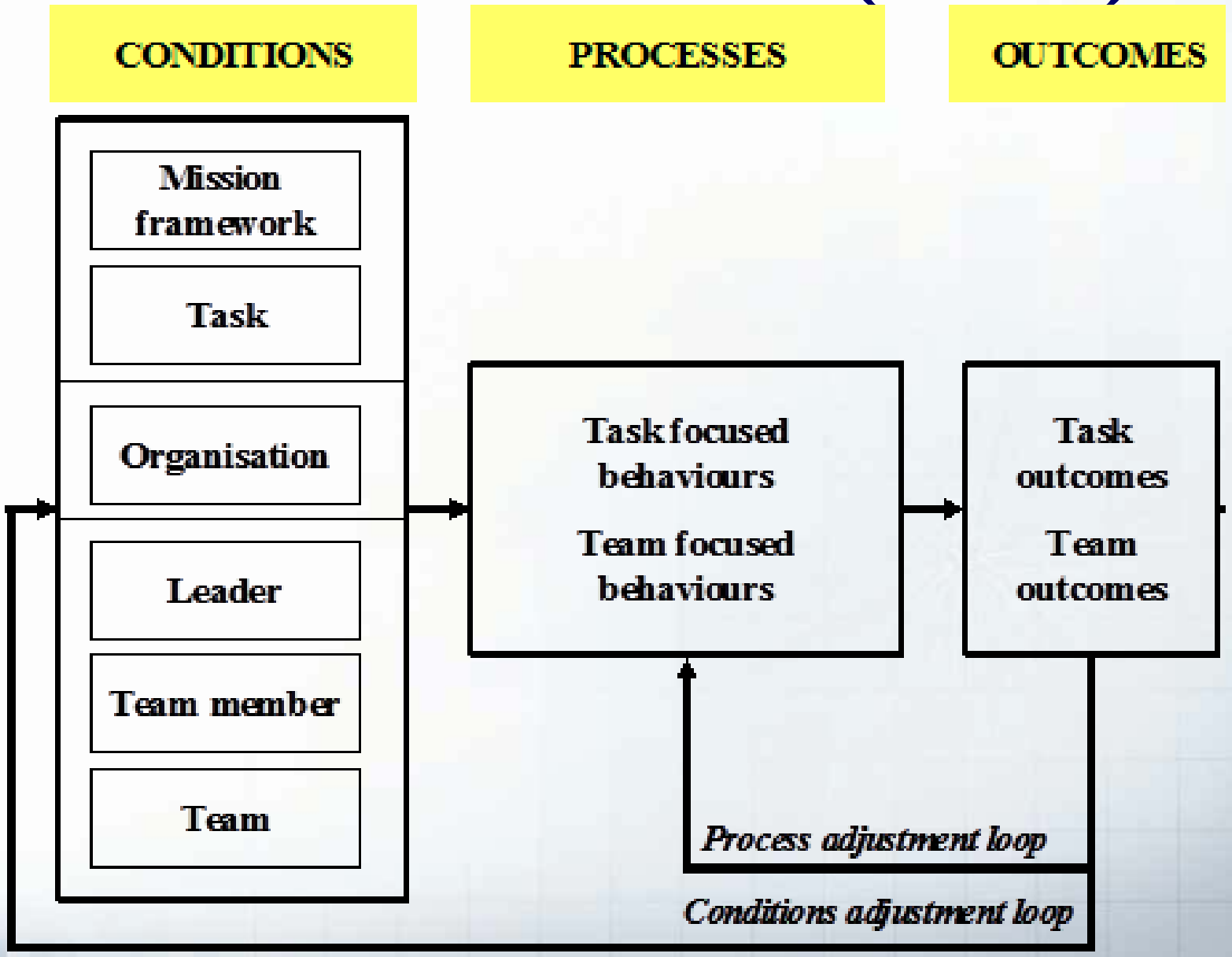
Outline

1. Command and Control Assessment Framework
2. Process Assessment Limitations/Issues
3. Automated Tool to Process Reconstruction
4. Evolution of C2 Assessment and Experimentation Methodology
5. Conclusion

Key Elements to C2 Assessment

- C2 assessment needs to include team and cannot be limited to a single individual.
  - "C2 deals with distributed teams of humans operating under stress and in a variety of other operating conditions." D. Albert, COBP for C2 assessment. CCRP, 2002.
- Need to incorporate people, process, and technology and their interfaces:
  - Interfaces: People-people, people-technology, people-process, process-technology, etc.
- Assessment needs to go beyond controlled experiments and include observation studies where room is provided for agile behaviour.

NATO Command Team Effectiveness Framework (CTEF)

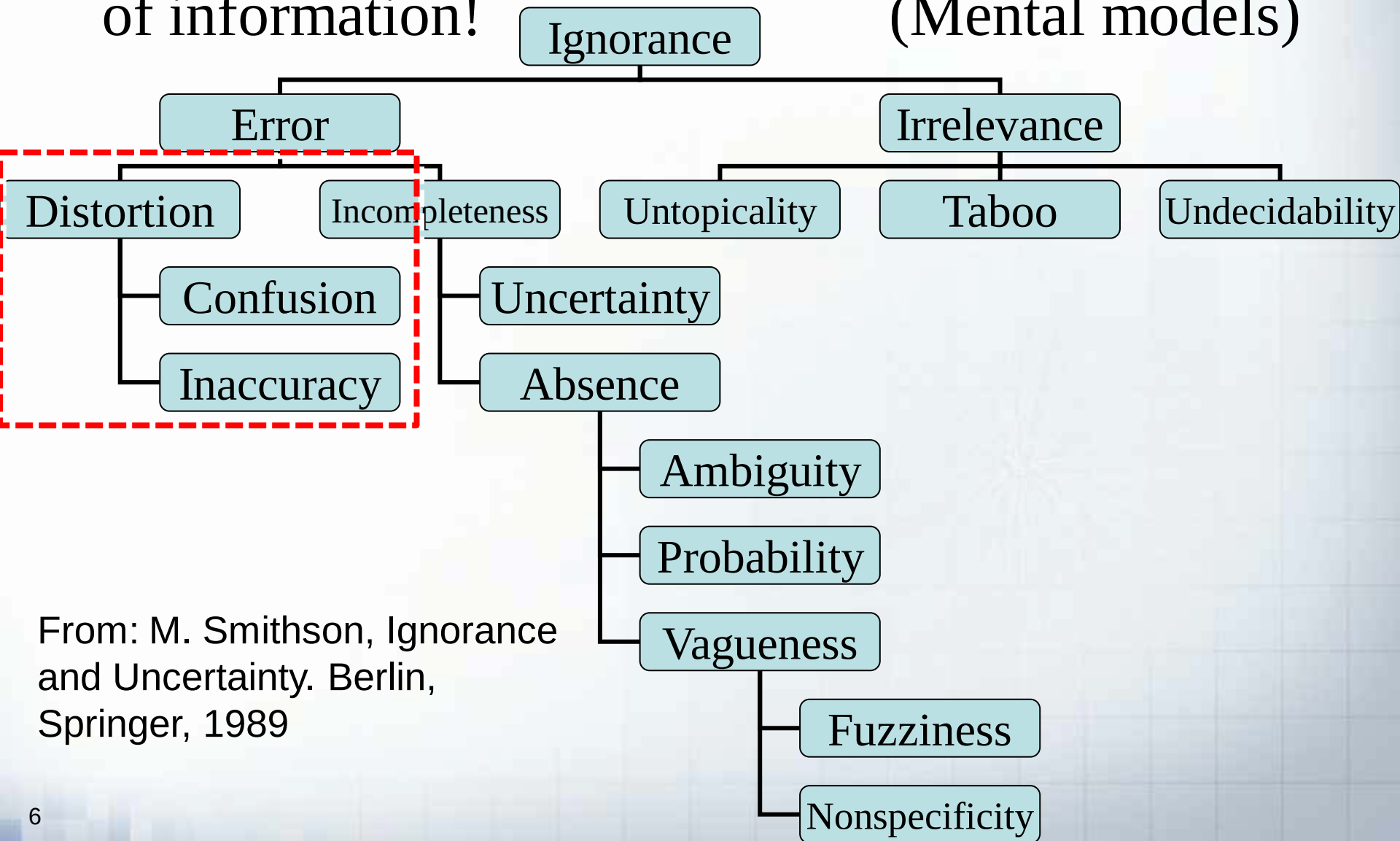


Relevant Models to Assess C2

- NATO SAS-065: C2 Maturity Model
  - Rough C2 classification based on distribution of information (outcome), patterns of interaction (process), and allocation of decision rights (condition).
- Decision-Making:
  - OODA Loop (Boyd)
  - Klein's Recognition Prime Decision
  - Gigerenzer's Fast&Frugal
- Group/Team Dynamic:
  - Ajzen's Theory of Planned Behavior (Capability, Authority, Responsibility – CAR)
  - Webb's factor for ineffective collaboration
  - Weick's Contextual Rationality

Common Missing Ingredient: Expectation

- Impact on the perception of authority and validity of information! (Mental models)



From: M. Smithson, Ignorance and Uncertainty. Berlin, Springer, 1989

Process Analysis Issues

- Missing information flow data:
  - Direct information exchange through email, chat logs, phone easier to capture than indirect exchange.
- Increase used of complex C2 systems to transfer information.
  - Some with limited logs.
  - Acquired through FMS Case with limited access to modify.
  - Limited capability to interfere with database when in Secure mode.
- Various processes or instances of the same process occurring simultaneously.

Type of Processes Investigated

- C2 process in support of missions such as:
  - Fire support request
  - Troops in contact
  - Medical Evacuation
  - Close Air Support (including GCAS, XCAS)
  - Close Combat Attack

Process Capture and Mining Requirements

- Capture the processes performed by a distributed team of operators performing their work on computers.
- Capture context in which actions are performed (information available to the operators performing a given action).
- Allow replay of captured data in a synchronous manner.
- Support the search and mining of captured data.
- Support an autonomous identification of specific actions and the computation of statistics of sequence of actions.
- Support the comparison of expected vs. observed processes.

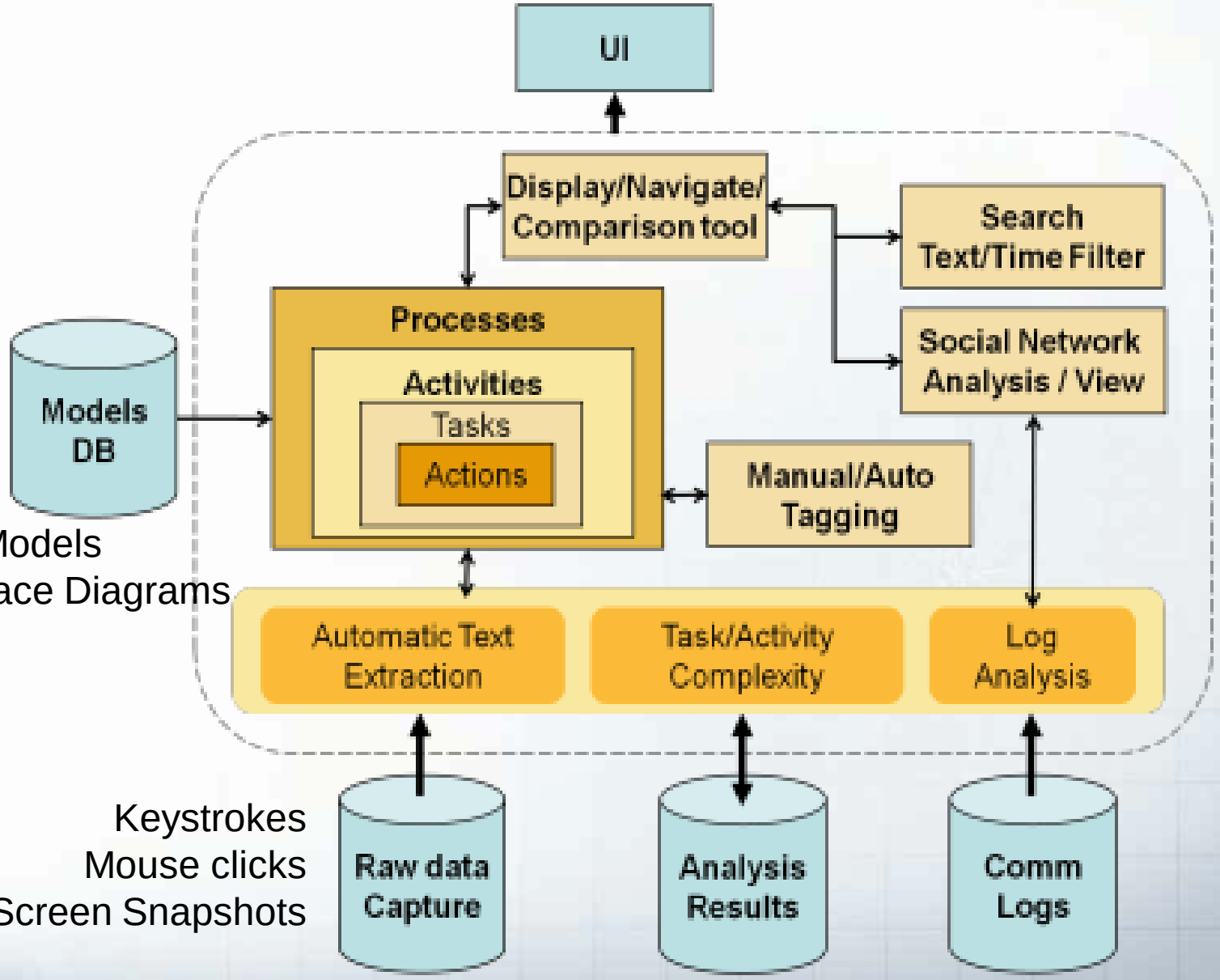
Terminology Used

- **Action**: Complete observable movement performed by an operator (e.g., striking a key, a set of continuous eyes saccade).
- **Task**: Activity that is accomplished by a single operator or performed simultaneously by a group of operators and which leads to a single output (e.g., producing a brief).
- **Approach**: Attitude or manner (modus operandi) to perform some task.
- **Method**: Way of accomplishing specific tasks.
- **Procedure**: Series of actions specifying a precise way of accomplishing a task.
- **Process**: Collection of causally related tasks, which solve a particular issue. It includes: the set of interrelated tasks; resources assigned to the tasks; the set of expected outputs or goals; the set of possible triggers (WorkFlow Net).

Data Capture

- The content of the audit trail includes:
  - Logs from communication tools (chat, email, phone, etc.)
  - All keytrokes time tagged
  - All mouse click time tagged + location in screens
  - Capture of screen snapshots at user specified intervals (~5 Hz).

Data Mining and Analysis Overview



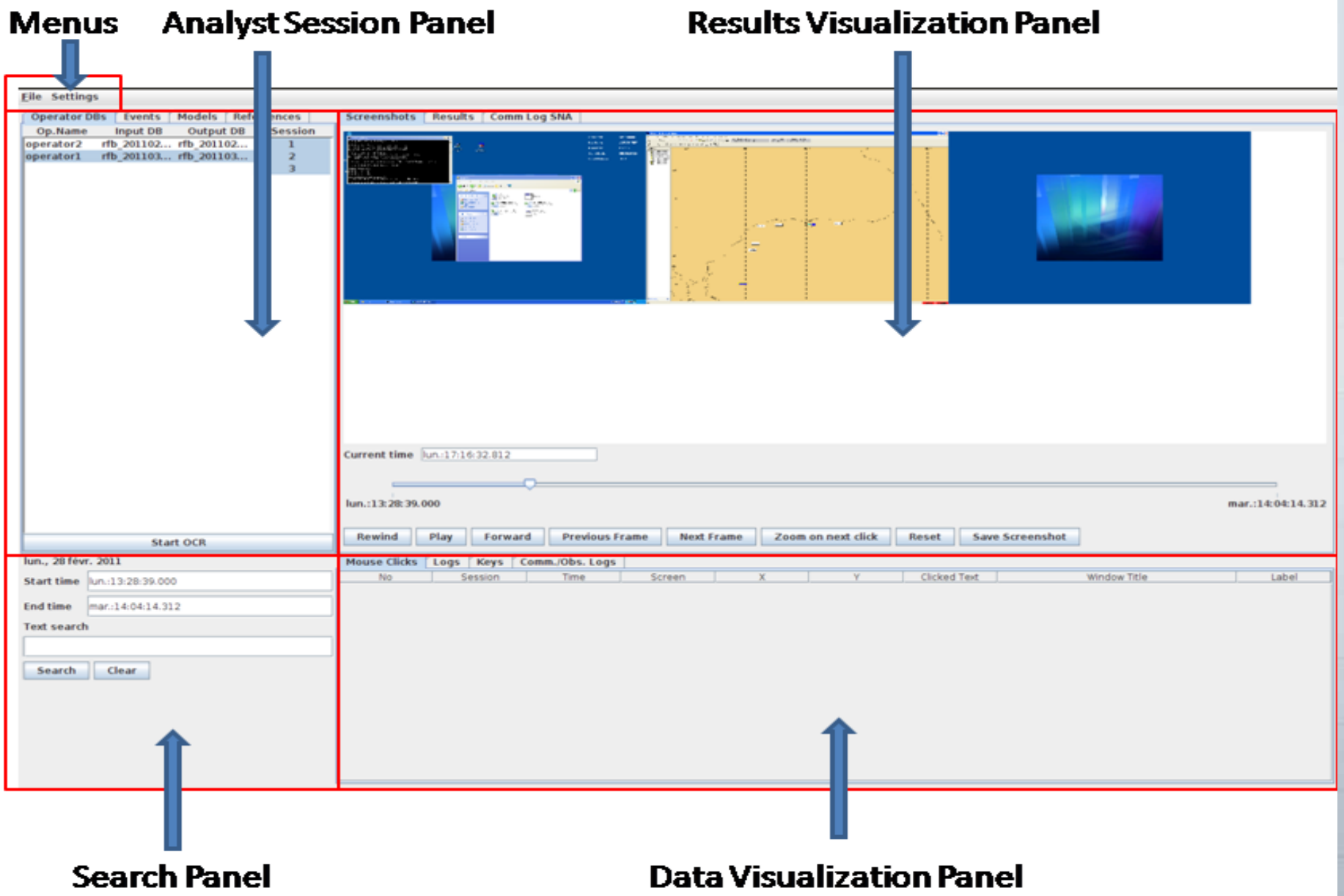
Activity Models
Event-Trace Diagrams

Keystrokes
Mouse clicks
Screen Snapshots

Data Mining and Analysis Components

- An audit trail browsing component to review and vet the captured data;
- A text extraction component to identify the information content within the operators displays (from the screen snapshots);
- A search functionality to mine all extracted data;
- A tagging functionality to cluster and label particular actions;
- An association functionality to associate a set of actions with a given task;
- A results visualization module.

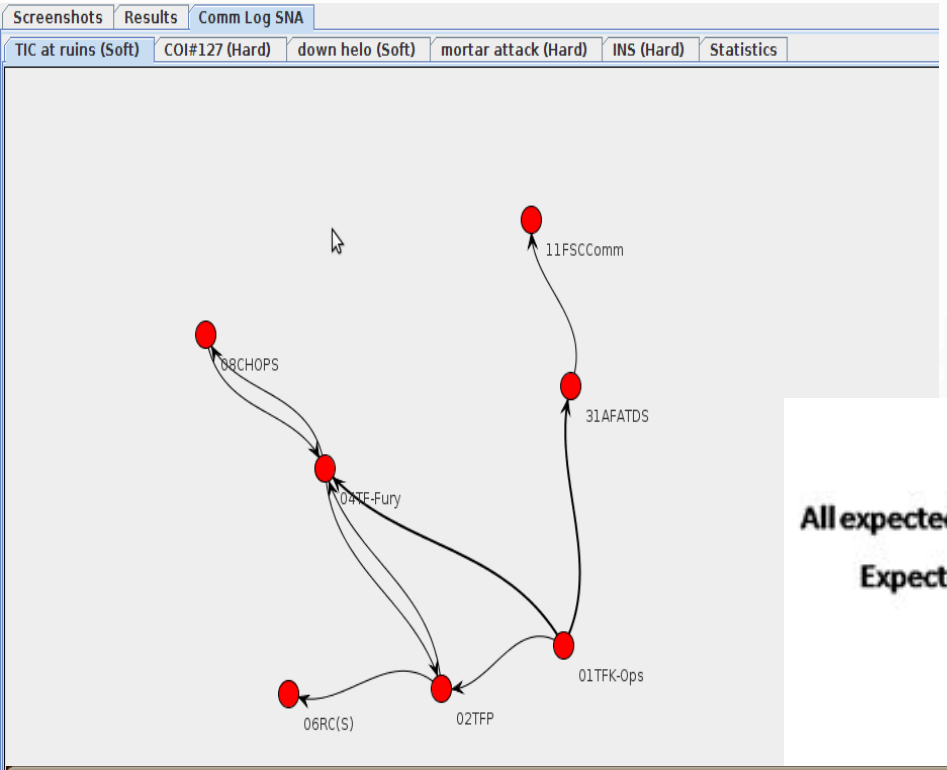
User Interface Components

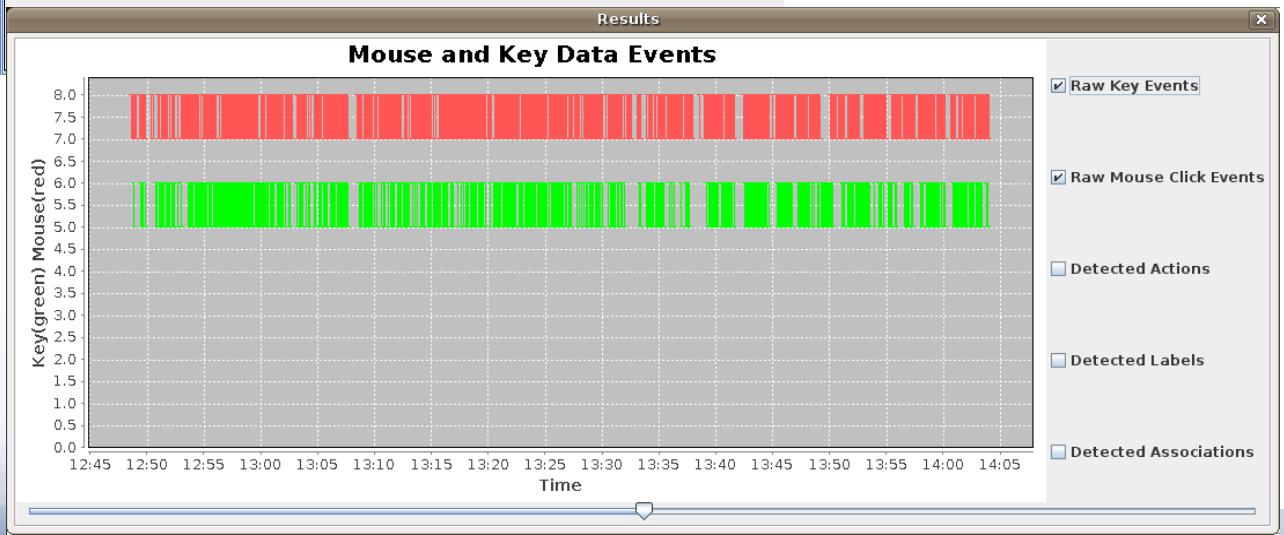


System Particularities

- Text Extraction: An Optical Character Recognition identifies screen snapshot contents (uses various transformation: Hough, Hue-saturation, etc.).
- Data Mining: Levenshtein distance used for including incorrect entries.
- Tagging: Both manual and automated tags. Leads to the clustering of associated events.
- Visualization: Gantt charts, Graphs, Networks
  - SNA based on communication logs
  - Time sequenced SNA
  - Operators statistical data
  - Comparison expected vs. observed processes

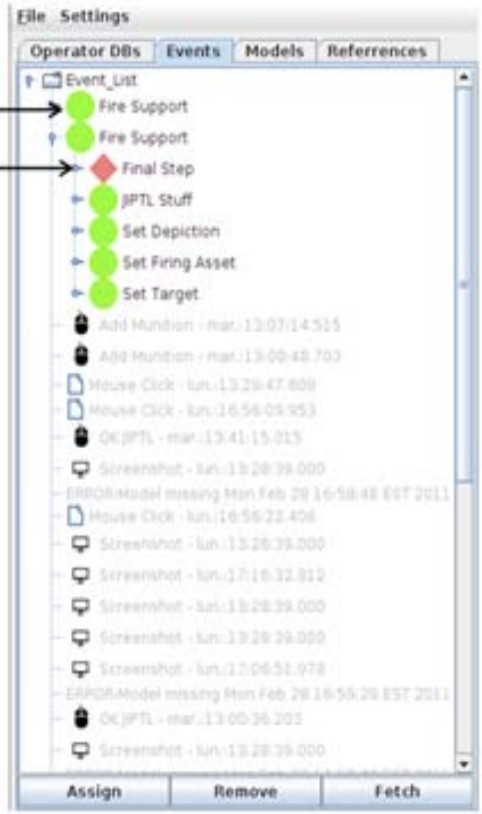
Visualization Examples





All expected events were observed

Expected events not observed



Process Capture and Mining Benefits

- Benefits will include:
  - Improved investigation of team synergy and synchronicity (not always obvious to operators)
  - Testing of established Tactics, Techniques, and Procedures (TTPs).
  - Review of context leading to human errors.
  - Operators ability to review own actions and learn.
  - Support the expansion of the Canadian Forces Warfare Centre role from experimentation into organizational learning role.

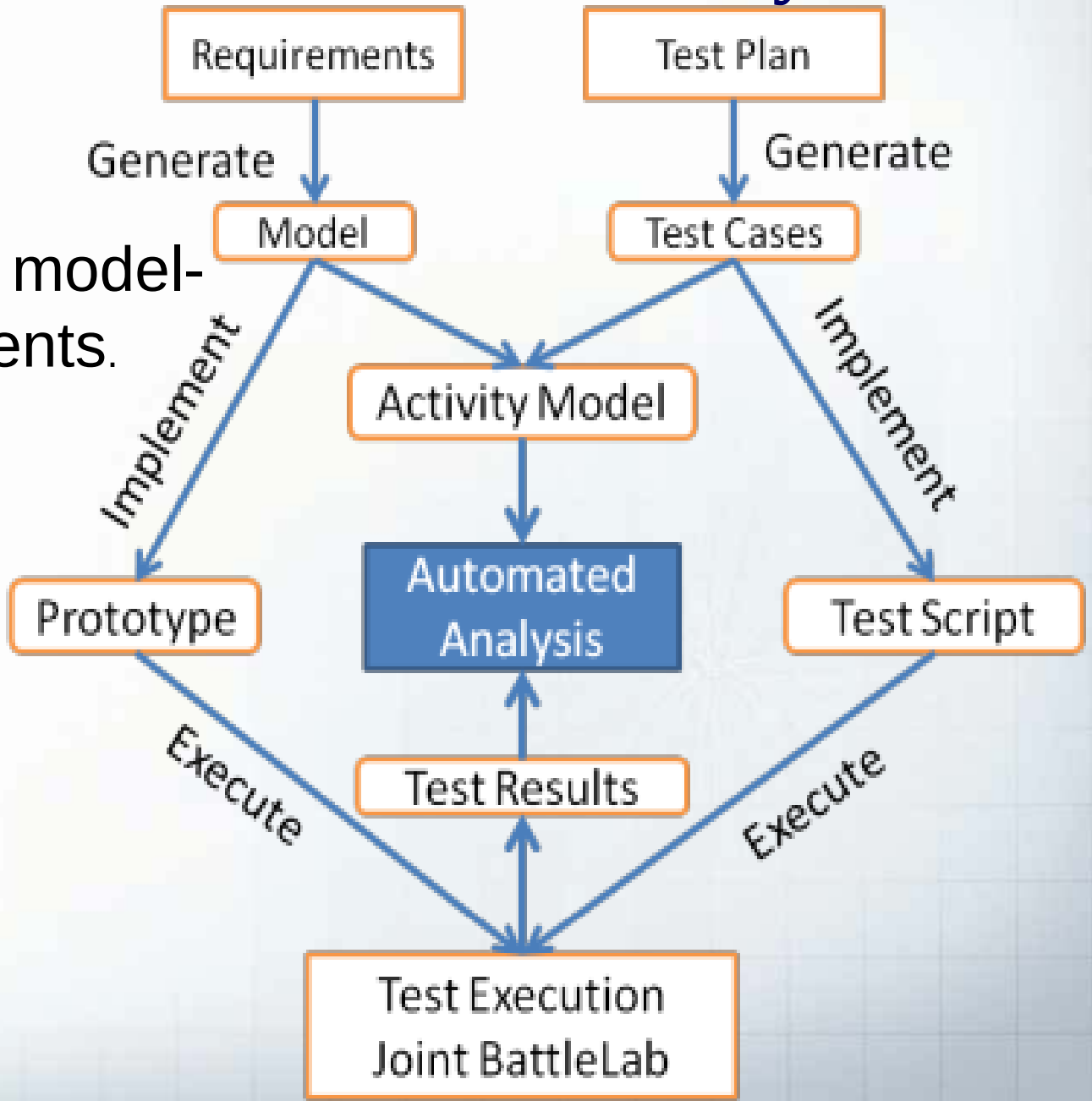
Broadening the Experimentation Approaches

- Equivalence between software testing and experimentation methodologies:

Software Testing	Experimentation	Particularities
Manual testing	Table-top experiment	Abstract Case Studies
Script-based testing	Simulation-driven experiment	Detailed script encapsulated in M&S
Keyword-driven testing	Adaptive simulation-driven experiment	Script driven testing with human adaptation
Model-based testing	Model-based experiment	Models are used to guide the testing

Importance of the Automated Analysis Tool

Key element to model-driven experiments.



Conclusion

- C2 is a complex socio-technical entity requiring a broad (people, process, technology) and careful assessment.
- Process assessment is difficult due to the distribution of the process, non-direct communication, and often lack of data.
- Contextual data is required for adequate interpretation and review of activities.
- Detailed manual analysis is possible for a small team of operator and short experiments but automation is needed in other situations.
- The automated process mining and analysis tool allows the testing of TTPs and the development of model driven experiments leveraging architecture framework models.

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Questions?