Supporting the C2 of Training Exercise Management: The Design of a Decision-Centered Scenario Management Tool

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Project Hypotheses

- The Exercise Planners and Managers must be able to design effective scenarios that:
  - Are explicitly linked to the exercise objectives and
  - Take advantage of known complicating factors
    in order to
  - Create cognitively challenging situations for the participants

- The Exercise Planners and Managers must be able to detect deviations from the scenario and effectively redirect entities to achieve the objectives

- To design an effective scenario management support tool, we must represent:
  - The complexities and interdependencies between scenario events
  - The relationship between scenario events and underlying basis
  - The mapping from exercise objectives to scenario events

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Project Objectives

Overall objective:

- Design and demonstrate a system to improve management of large-scale Live, Virtual, and Constructive (LVC) exercises

Specific objectives:

- Design advanced visualization methods of complex exercises to provide *observability* of the objectives and behaviors of the entities working toward achieving those objectives
- Design innovative control techniques to provide *directability* to exercise managers so that they can manipulate entities to achieve the objectives
- Design a framework for the intelligent collection and fusion of real-time entity behavior characteristics to provide the information necessary for the visualizations and transmit direction from the control techniques

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# Analysis and Design Approach
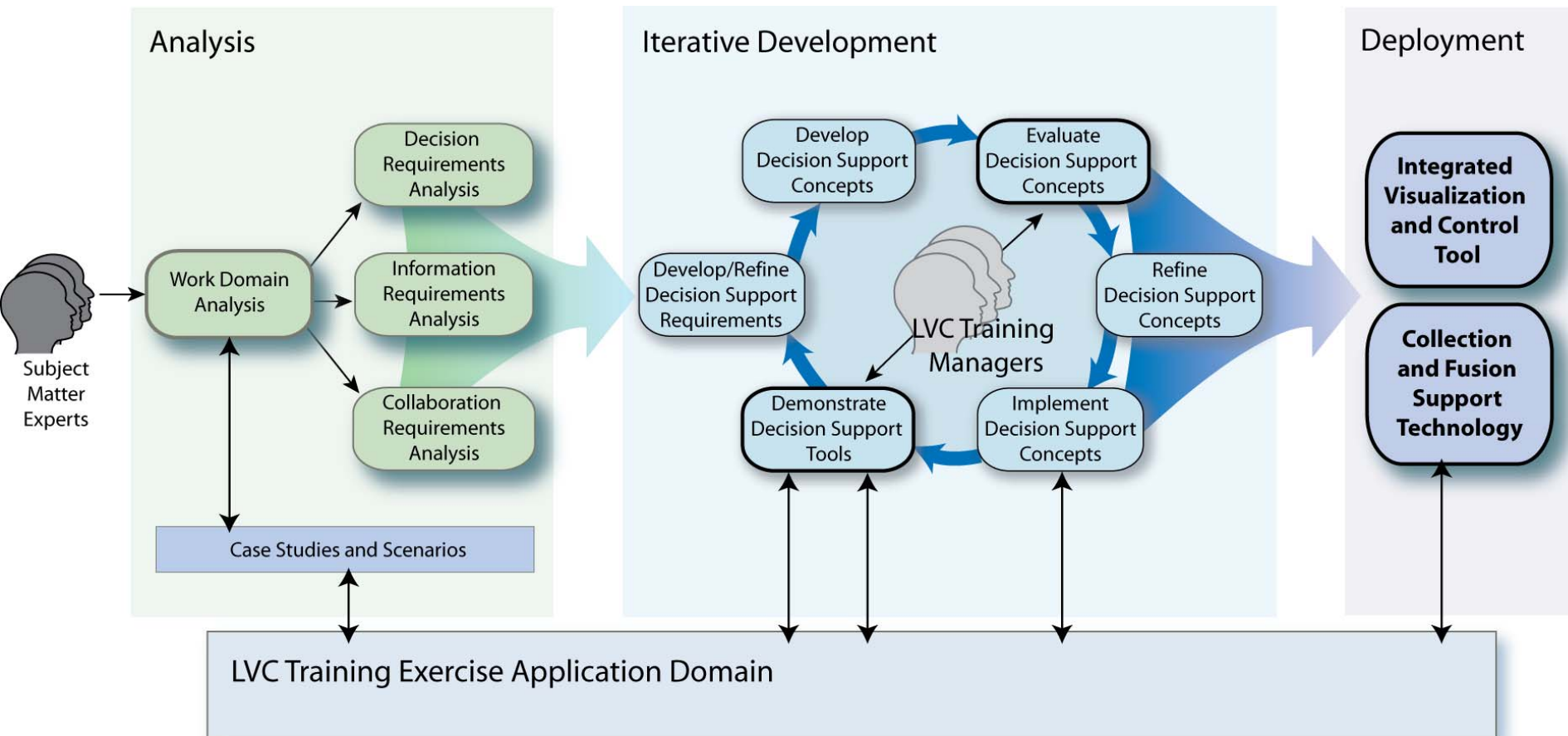
Analysis: Approach
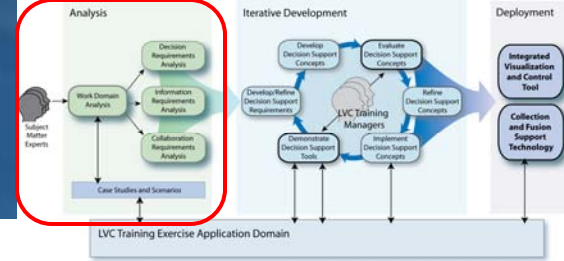
- Identify critical decisions to be supported

- Define the domain complexities that make decision-making difficult:
  - Complicating factors and interactions;
  - Time pressure;
  - Contextual issues;

- Identify information and meta-information requirements for successful decision-making

- Define the nature of expertise in the work domain:
  - Expert strategies
  - Expert knowledge
  - Expert workarounds

- Dependent on the scenario but also supports the scenario development

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Analysis: Results
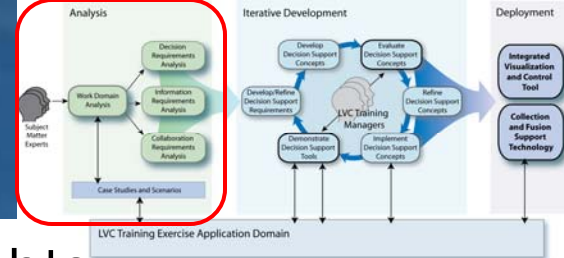
- Exercise Planning and Management... key insights from knowledge elicitation:

  - Lack of rigor vs. wealth of experience

  - Lack of continuity in planning – management team(s)

  - Ill-defined and over-constrained objectives

  - Loose coupling between scenario events and exercise objectives

Analysis: Results
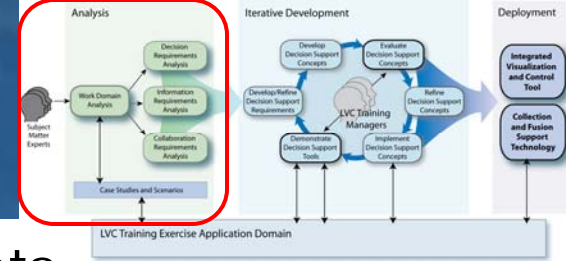
- Scenario Design and Management… key insights from knowledge elicitation:

  - Lack of support or guidance for scenario design

  - Lack of support for real-time scenario management

  - No representation of world / system / participant events and activity

  - No specification of decision-making demands imposed on participants

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LVC Training Exercise Application Domain
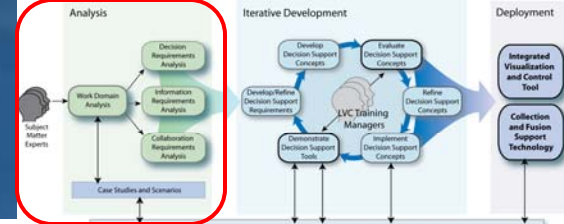
Complicating Factors	Description / Scenario Characteristics
Garden path problems	Conditions start out with the situation appearing to be a simple problem (based on strong but incorrect evidence) and domain practitioners react accordingly. However, later correct symptoms appear, which the domain practitioners may not notice until it is too late.
Missing information	Key indicators may be missing due to failed sensors, lack of sensors, poor communication or lack of informants on the ground. For example may not know the location of friendly forces.
Misleading information	Misleading information may be provided due to inherent limitations of reports (e.g., stale information, inherent limitations of predictions, distortions resulting from indirect reports, secondary sources, translations) or explicit intent to deceive through misinformation. It can also result reliance on indirect indicators that are usually correlated with the information of interest, but not in that situation.
Masking Activities	Activities of other agents, or other automated systems may cover up or explain away key evidence.
Ambiguous Situations / Multiple lines of reasoning	Situations can occur where it is possible to think of significantly different explanations (e.g., in ambiguous situations) or response strategies, all of which seem valid at the time, but which may be in conflict (or a source of debate and disagreement by the operating crew).
Situations that change, requiring revised situation assessments	Once domain practitioners have developed a situation assessment and have started acting on it, it is often very difficult for them to recognize that there is new information or new conditions that requires them to change their situation assessment.
Side effects	Situations can arise where the effects of human or automated system actions, or effects of the initial failure, have side effects, which are not expected or understood.
Late changes in the plan	The situation is being managed according to a prepared plan, and then for some reason changes are required late in the situation. Domain practitioners can become confused as to next steps; the plan is no longer well tested and can contain flaws, or the whole "big picture" gets lost by those managing the event.
Impasses	The situation contains features where, at some point, it is very difficult for the domain practitioners to move forward, such as when the COA no longer matches the conditions, or assumed available personnel or resources are not available.
Trade offs	Domain practitioners must make impromptu judgments about choices between alternatives, such as when to wait to see if a problem develops (and may get out of control) versus jumping in early before it is clear what has caused the problem (just one of many examples).

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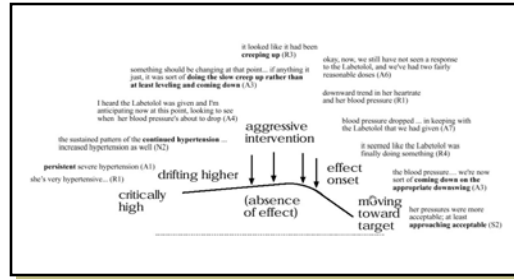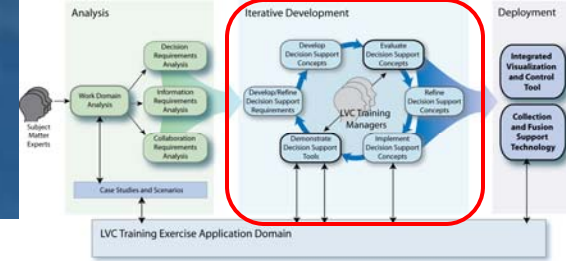
Analysis: Results
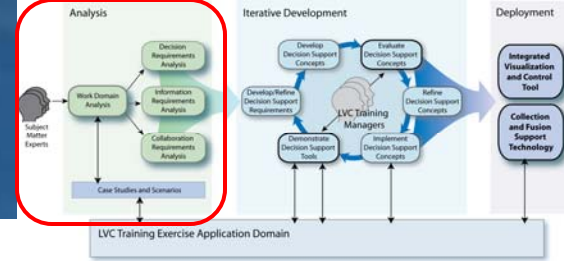
- MSEL
  - Events based on timestamp
  - No relationships between events
  - Objectives indicated by reference
  - Highlighting of information
  - No temporal relationships
  - No distinction between world and system events
  - No anticipated events
  - No indication of rationale behind events
  - No provisions for deviations
  - No ability to adapt

Visualization and Control Design: Approach

Events – Highlight spatial and temporal events. Representations should reveal the dynamics, evolution and future paths for the process in question. Events are temporally extended behaviors of the device or process involving some type of change in objects or situations.
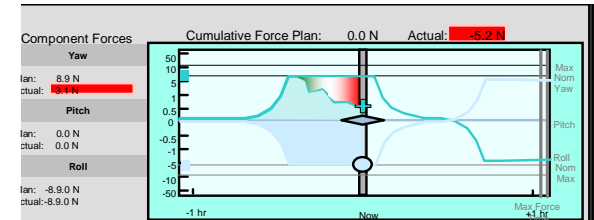

Contrast – Highlight contrasts. Meaning lies in contrasts – some departure from a reference or expected course. Representing contrast means that one indicates the relation between the contrasting objects, states or behaviors.

Frames of Reference –
Discover frames of reference that capture meaningful relationships in the work domain. Each frame of reference is like one perspective from which one views or extracts meaning from data about the underlying process or activity.
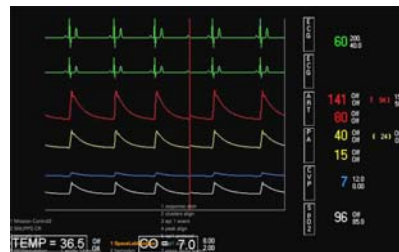
Context – Put data into context; the context of related values and around important issues in the work domain. One prerequisite is to know what relationships are informative in what contexts in the field of practice.

Visualization and Control Design: Overview
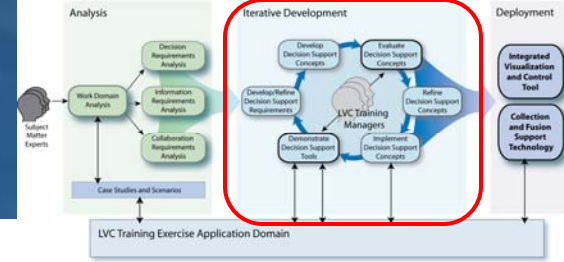
- **Design Concept:**
  - **Scenario Management:**
    - Represents the scenario in three inter-connected layers:
      - World Events
      - System Events
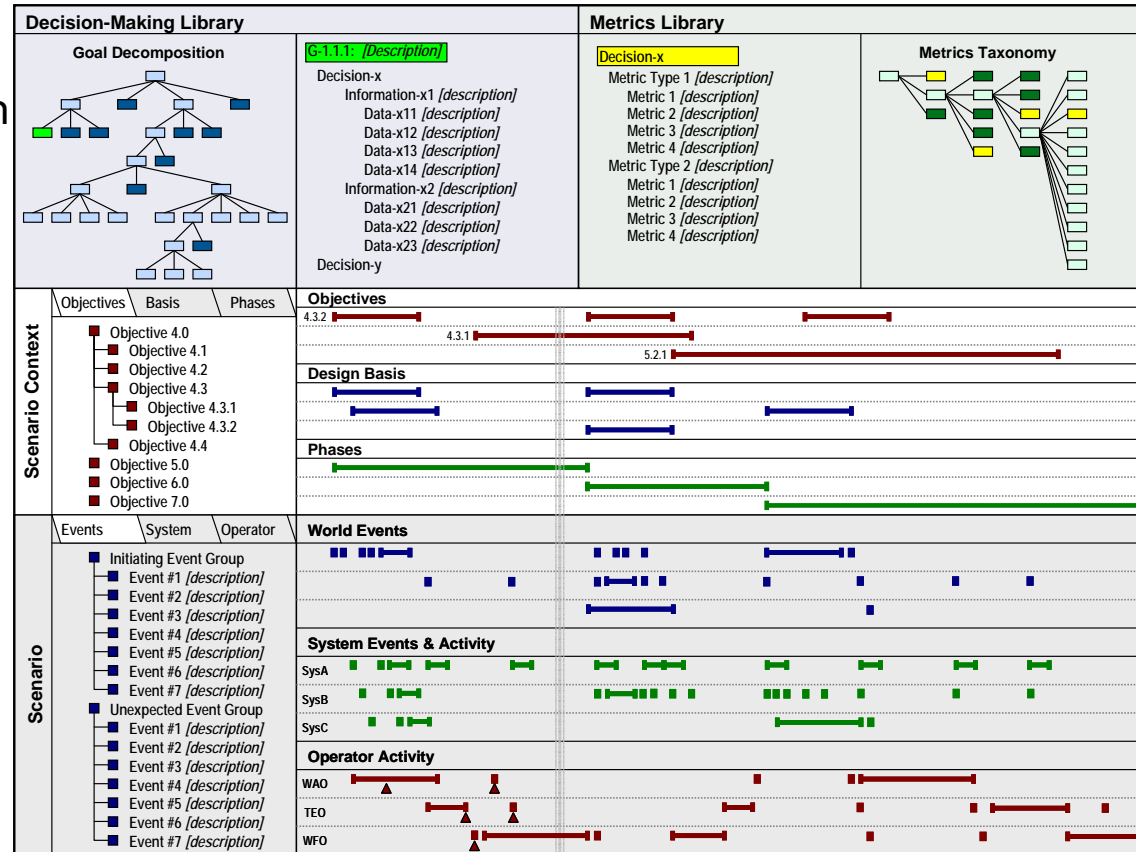   - Operator Activity
  - **Scenario Context:**
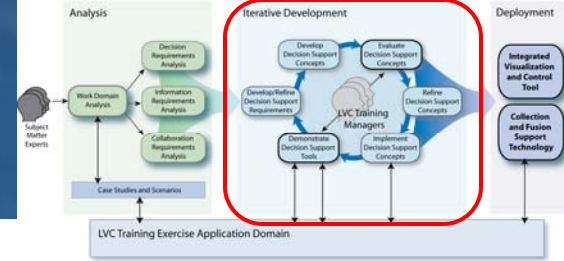   - Establishes the mapping from scenario events to:
      - Scenario Design Basis
      - Scenario Phases
      - Exercise Objectives
  - **Decision-Making and Metrics Library**
    - Defines the decision-making challenges of the scenario and associated metrics
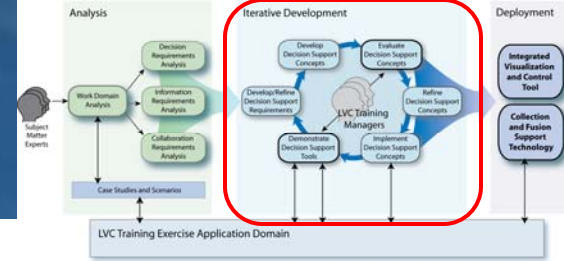
Visualization and Control Design: Detailed View (1 of 3)

- Scenario Management:
  - Three interconnected layers:
    - Temporal depiction and functional / physical distinction
    - Links to objectives and basis as well as other layers of scenario activity

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- Scenario Context / Objectives:
  - Three higher-level characterizations of the scenario:
    - Supports planning and management at multiple levels of abstraction
    - Provides rich, multi-dimensional "grounding" for scenario specifics

- Decision-Making and Metrics Library:
  - Provides a cognition and collaboration grounding for the scenarios
  - Facilitates re-use and adaptation

Decision-Making Library

Goal Decomposition

G-1.1.1: *[Description]*

Decision-x
- Information-x1 *[description]*
  - Data-x11 *[description]*
  - Data-x12 *[description]*
  - Data-x13 *[description]*
  - Data-x14 *[description]*
- Information-x2 *[description]*
  - Data-x21 *[description]*
  - Data-x22 *[description]*
  - Data-x23 *[description]*

Decision-y

Metrics Library

Decision-x
- Metric Type 1 *[description]*
  - Metric 1 *[description]*
  - Metric 2 *[description]*
  - Metric 3 *[description]*
  - Metric 4 *[description]*
- Metric Type 2 *[description]*
  - Metric 1 *[description]*
  - Metric 2 *[description]*
  - Metric 3 *[description]*
  - Metric 4 *[description]*

Metrics Taxonomy

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Proof-of-Concept Demonstration: Results

- ## Software Demo:
  - ### Phase Hierarchy:
    - Captures the temporal and hierarchical ebb and flow of the scenario
    - Mapping from scenario events to phase (many-to-one)

  - ### Scenario Objectives:
    - Captures the hierarchical structure of exercise objectives
    - Mapping from scenario events to objectives (many-to-many)
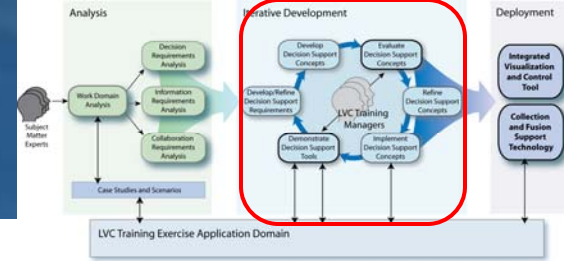
Proof-of-Concept Demonstration: Results
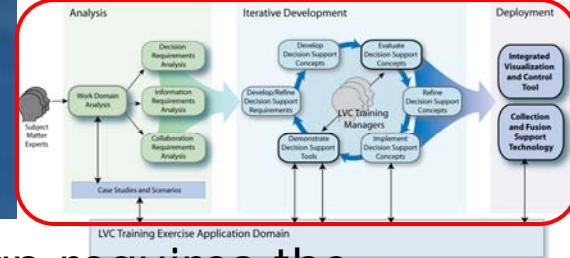

- Software Demo:
  - Scenario Management:
    - Captures the temporal and hierarchical relationships between events
    - Dependent and independent events
    - Planned vs. actual events
    - Planning and real-time management

  - Scenario Context:
    - Explicit identification of the Phase and Objectives

  - Event Summary and Schedule
    - Specifics about the selected event

Summary / Conclusions

- Practitioners use a variety of techniques to simplify the process of planning exercise scenarios

- The research community is constructing a basis for designing cognitively challenging scenarios

- Effective exercise planning and management requires the explicit representation of the linkage from scenario events to exercise objectives

- Scenario design requires the representation of the relationships between World Events, System Activity, and Operator Behavior

- Scenario design requires the ability to specify different types of events to accurately depict the richness of the exercise

- Effective exercise planning and management requires a rich library of operator decisions and metrics for assessing decision-making effectiveness

Follow-On Recommendations (part 1)

- **Scenario Construction**
  - Improving the support for scenario construction
  - Integration with MSELs (import and export)

- **Design Basis**
  - Integrating Complicating Factors in scenario development

- **Real-time Alerts for Disruptions**
  - Alerting mechanisms for detection and reporting of disruptions

- **Organizational Scheme for Decision-Making Library**
  - Leverage functional decomposition framework

- **Decision Effectiveness Metrics**
  - Need to go beyond compliance and timeliness

- **Distributed Operations**
  - Provide support for Exercise Management *Team*
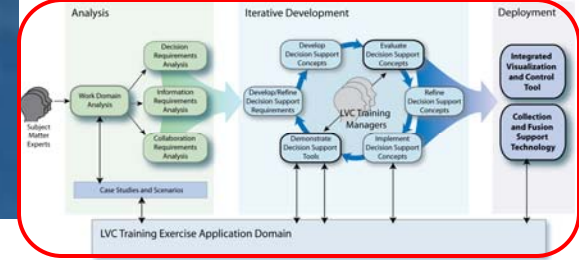
Follow-On Recommendations (part 2)
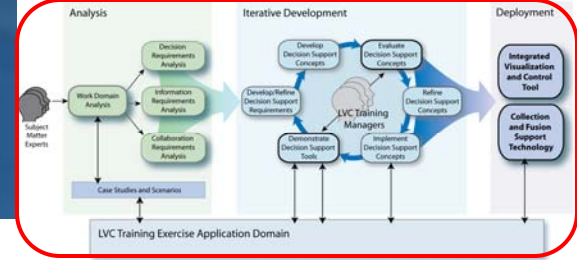
- Concept Evaluation
  - Human-in-the-loop evaluation
  - Assess degree of support for scenario design *and* management

- Realistic Scenario for Evaluation
  - Representative scenario(s) that can exercise the concept

- Data Collection and Management Technologies
  - Entity monitoring and assessment based on requirements

- Design Iteration
  - Leverage insights from evaluation and scenario construction

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