Battle Command System Analysis Methodology in the Cross Command Collaboration Effort (3CE) Environment

Command and Control Research and Technology Symposium

1 June 2006

Purpose of Brief

To use a 3CE event as an illustrative example of an analysis methodology being developed to build the 3CE environment.

Endstate

To give the audience an understanding of the 3CE environment, its challenges and recommendations on how to determine what the toolkit should consist of.

"Out of intense complexities, intense simplicities emerge."

-Winston Churchill

Outline

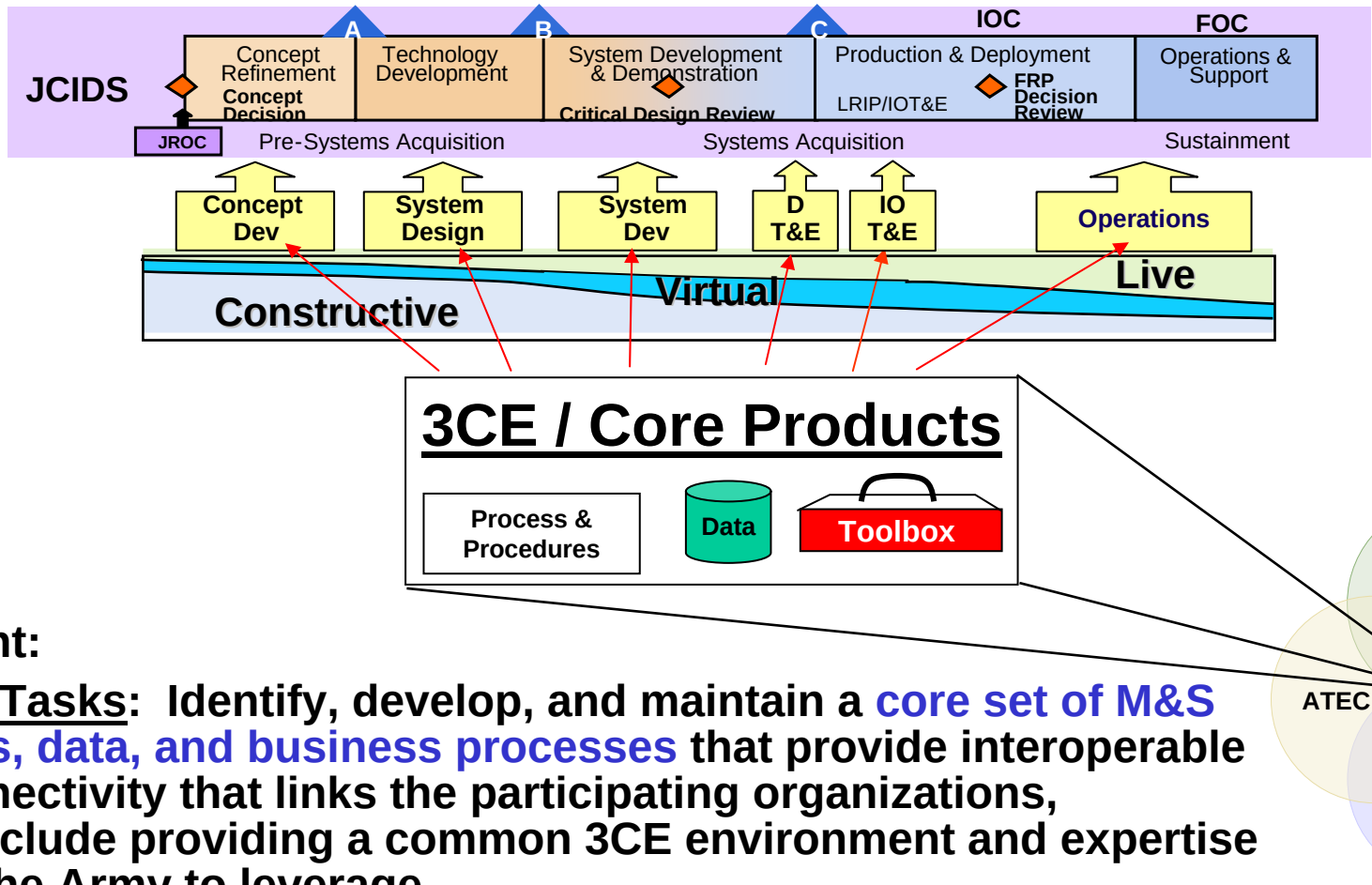
- 3CE Overview
  - Purpose
  - Mission and Intent
  - Objectives
  - Significant Activities
- Analysis
  - Purpose
  - Approach
    - Mission Threads
  - Execution
- Lessons Learned
- Recommendations

3CE Purpose

- **3CE objective per the MOU (July 2003):**
  - **Maximize the rapid availability of transformational technology to the field soldier by leveraging the synergy gained from integrating the activities of each of the three commands into a holistic cooperative effort.**
- **DUSA OR Task to PM FCS MSMO:**
  - **Ensure compatibility among the respective M&S capabilities of TRADOC, RDECOM, ATEC, and the FCS LSI in order to support concept exploration, systems integration, analysis, and acquisition of the FCS BCT SoS.**
- **3CE purpose per the MOA (December 2004):**
  - **Develop cross command Army M&S and data environments that will be used in Systems of Systems (SoS) design, development, integration, and test of FCS FoS components, systems, and prototypes within a realistic FCS BCT context.**

3CE Mission and Intent

Mission: Develop a cross command Army M&S and data environment for design, development, integration, and testing of capabilities, systems, and prototypes.



Intent:

Key Tasks: Identify, develop, and maintain a core set of M&S tools, data, and business processes that provide interoperable connectivity that links the participating organizations, to include providing a common 3CE environment and expertise for the Army to leverage.

End State: A 3CE environment that meets the common requirements of all three commands and PM FCS BCT to conduct distributed DOTMLPF development.

3CE Desired “Effects”

- **Establish a common problem analysis, requirements development and engineering methodology across the three commands technical community.**
- **Establish a common language and perspective of M&S technology domains.**
- **Develop capabilities that are traceable to user needs and design requirements.**
- **Implement capabilities for the Army “to be” M&S and data environment.**

Enable analysis and evaluation through distributed M&S LVC capabilities.

3CE Significant Activities

- **Establishing and documenting procedures for development, control, and use of 3CE.**
- **Maintaining a cross-command, distributed network capable of supporting a live, virtual, and constructive (LVC) environment using existing capabilities.**
- **Establishing a Systems Engineering approach.**
- **Developing a capabilities catalogue.**
- **Establishing a support framework to enable interoperability.**

Identifying analysts and evaluators' needs to drive technical development

Purpose of the Analysis

- **PURPOSE: The purpose of the analysis was to identify "best of breed" M&S tools for inclusion in the notional 3CE tool box.**
- **METHOD: Comparative analysis of select systems based upon user requirements. Analysis occurred during the spiral events leading to DTE5 event, as well as during DTE5, scheduled for 22 August – 2 September 2005.**
- **END STATE: Recommendation of "best of breed" capabilities for the notional 3CE toolbox.**

Constraints – Limitations - Assumptions

- Study Constraints
  - The two communications systems under comparison were not co-located.
  - DTE 5 was a time ordered event list (TOEL) driven event that did not allow for dynamic operations.
- Study Limitations:
  - The basic premise of the M&S comparison relies on the assumption that M&S systems designed for specific and different purposes (experimentation and test) could be compared on the basis of similar user requirements. For the most part, the analysis team validated this assumption. However the analysis was limited by the fact that there were significant differences in functional capability because the respective commands did not have the requirement to develop some of the functionalities examined in this comparison.
  - The enumeration mappings between the Distributed Interactive Simulation (DIS) and High Level Architecture (HLA) federates were inconsistent, which prevented the HLA unit icons from being displayed correctly on the C2 systems in the DIS environment.
  - The time available for the M&S component comparisons, given other priorities for DTE 5 and the spiral events, limited the observation portion of the analysis to three days (30 August to 1 September 2005).
  - The stability of the federation-to-federation bridge limited the battle command data collection and analysis effort. The battle command surrogates at UAMBL lost all situational awareness (SA) information on the common operating picture (COP) when the federation-to-federation bridge stopped working. Consequently, data collection ceased until the bridge was restored.
  - The TOEL-driven scenario did not support end-to-end mission threads analysis thus preventing the examination of the operational component of the model comparison.
- Validated Assumptions:
  - The a priori assumption that there are redundant capabilities across the commands was validated to some extent. Additional analysis is required to determine which capabilities should be carried forward.
  - The assumption that the information gathered by the subject matter experts (SMEs) and the Commands' responses to the 3CE Comparison Questionnaire would provide sufficient data to support the analysis was validated for the technical and functional comparisons.

Analytic Approach

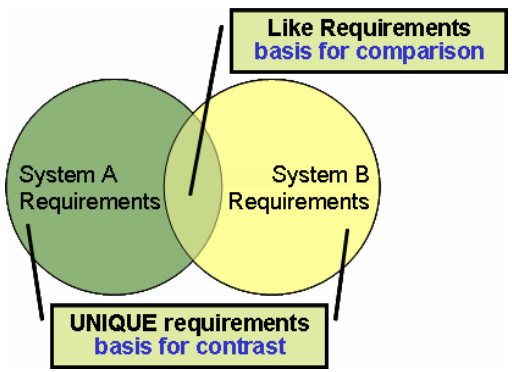
- **PHASE I: Determine basis of comparison.**
  - **Dates: 1 May 2005 - 30 June 2005**
  - **Description: Determine comparison requirements based upon analytical user requirements of the specified tools. Meet with technical and user representatives to develop knowledge base. Develop and document in a data collection management plan the systems, metrics, and data element requirements to answer the metrics.**
- **PHASE II: Verify data collection capability and validate analytical approach.**
  - **Dates: 1 July 2005 – 19 August 2005**
  - **Description: Verify data collection, finalize Analysis Plan, DCMP, test threads and validate analytical methodology during Spirals 6 and 7.**
- **PHASE III: Conduct data collection and analysis.**
  - **Dates: 20 August 2005 – 30 days after DTE5 ENDEX**
  - **Description: Collect data, conduct analysis, and write the report.**

Analytic Approach

- *Statement of the Problem*
- *Background Research*
- *Assumptions/Constraints*
- *Essential Elements of Analysis*
- *Alternatives*
- *Approach*
- *Scenario*
- *Measures of Merit*
- *Data*
- *Determine operational effectiveness and cost of alternatives*
- *Comparison of Alternatives*
- *Sensitivity Analysis*
- *Resource/Force Implications*
- *Recommendations*

Phase I: Develop draft Analysis Plan and DCMP, begin to collect user requirements

Phase II: Finalize user Requirements, Analysis Plan and DCMP; assess and rehearse data collection procedures



Phase III: Execute DTE5, collect, reduce and analyze data, and document results

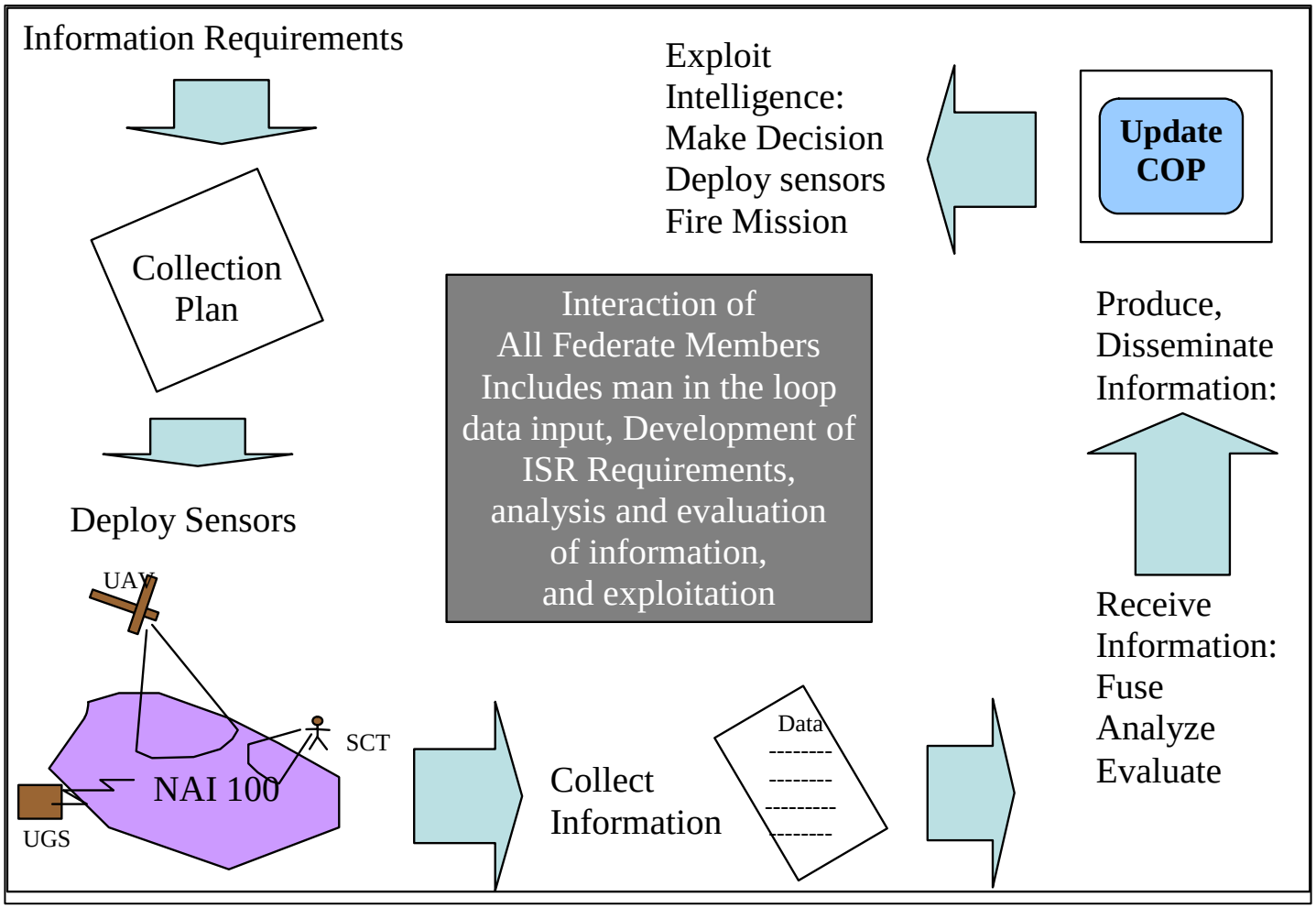
DCMP Purpose

- **Codifies user requirements and recasts them in analytical terms (issues, EEAs, MOMs)**
- **Crosswalks the objectives, issues, EEAs and MOMs for the Battle Command and Communications 3CE M&S component comparisons**
- **Identifies sources for data collection (model, SMEs, Interviews or Surveys)**
- **Identifies the context in which the data for each MOM will be collected (standalone or using an operational thread (Fires, Intel, SA, …)**
- **Guides the Analysis Team effort during DTE5**

BC DCMP Example

Objective Description	Issue Number	Issue Description	EEA Number	EEA Description	MoM_Num	MoM_Desc	MC2 Data	RPWS Data	Threads
Which Battle Command System best supports the 3CE force development environment?	1.1	Does the BCS support scaling of the COP?	1.1.1	How well does the BCS support scaling of the COP?	1.1.1.1	Level of difficulty in scaling the COP	x	x	x
					1.1.1.2	Flexibility (by echelon, by BFA, etc)	x	x	x
					1.1.1.3	Ability to store multiple pre-set scaled views	x	x	x
	1.2	How robust is the Intelligence Functionality within the BCS?	1.2.1	How well does the system's Intelligence Functionality perform?	1.2.1.1	Friendly Info (locations, status, etc.)	x	x	x
					1.2.1.2	Automated requirements management and asset visibility	x	x	x
					1.2.1.4	Current enemy situation (fusion of ISR and Intel/FS/AD/ Space sensors data)	x	x	x
					1.2.1.3	Track and determine ISR requirement satisfaction	x	x	x
			1.2.2	How well does the user-interaction Intelligence Functionality perform?	1.2.2.1	Friendly Info (locations, status, etc.)	x	x	x
					1.2.2.2	Current enemy situation (ISR and Intel/FS/AD/ Space sensors)	x	x	x
					1.2.2.3	Dynamic adjustment of the ISR synchronization plan	x	x	x

Illustrative Example of Thread to Support Analytic Process



Using operational threads, such as ISR (shown above), fires and SA dissemination, in varying levels of load, collect on applicable MOMs.

Execution CONOPS

WHO, WHAT, and WHERE

UAMBL

- MC2
- RPWS

Task: Collect data on the Battle Command systems through observations and demonstrations.

Purpose: To identify functional capabilities and limitations of the M&S system.

ALCES & NPST

Task: Collect data on the communications effects server through observations and demonstrations.

Purpose: To identify functional capabilities and limitations of the M&S system.

HUACHUCA

ORION & EMEW

Task: Collect data on the communications effects server through observations and demonstrations.

Purpose: To identify functional capabilities and limitations of the M&S system.

Surveys

Task: Collect data through surveys.

Purpose: To identify business processes, policies, and procedures for using M&S for each command.

HOW

Technical

Functional

Mission Threads Checklist

- ❑ Item 1
- ❑ Item 2
- ❑ Item 3
- :
- ❑ Item n

Technical

Functional

Mission Threads Checklist

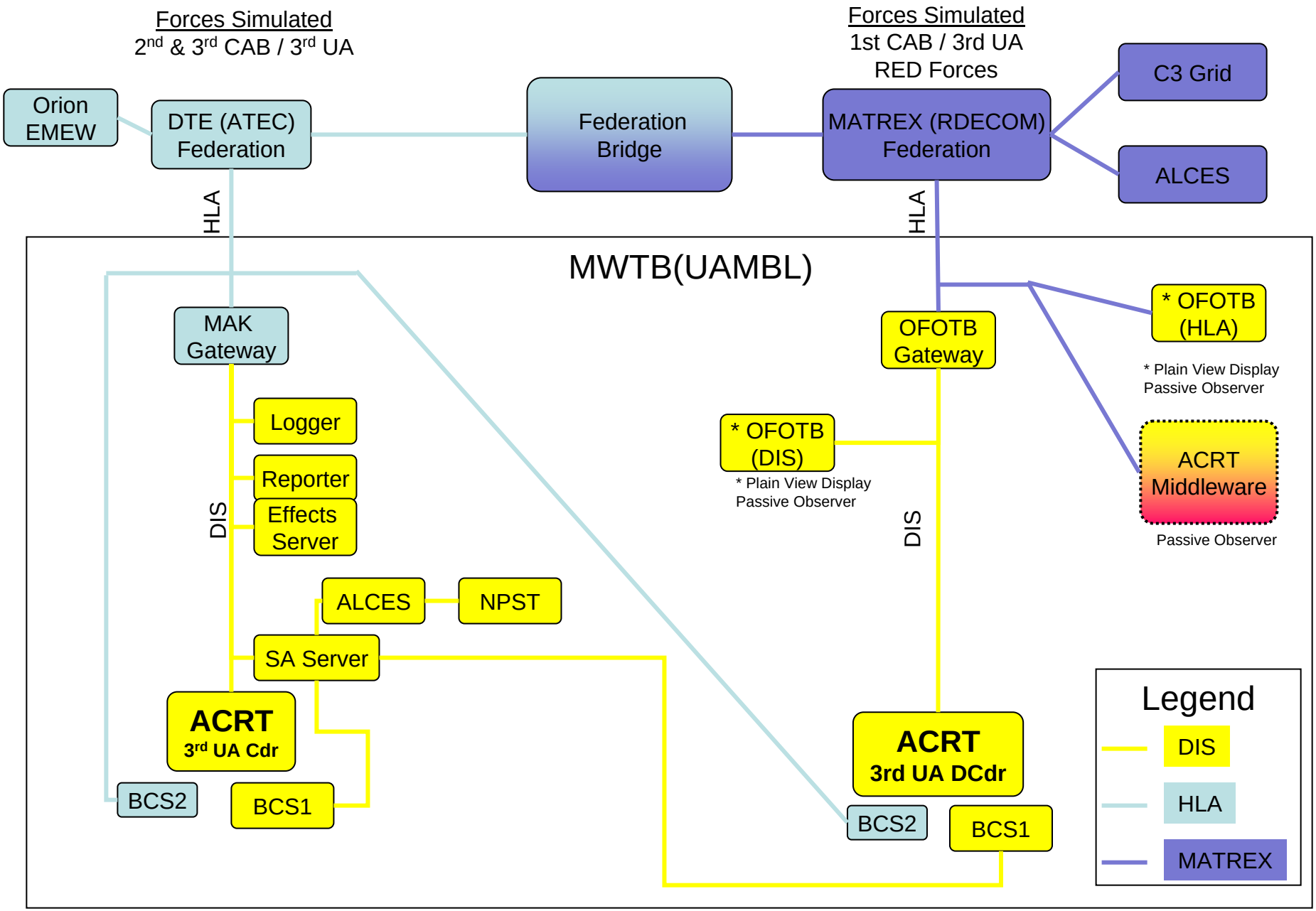
- ❑ Item 1
- ❑ Item 2
- ❑ Item 3
- :
- ❑ Item n

M&S Survey

- ❖Item 1
- ❖Item 2
- :
- ❖Item n

- Data from technical and functional observations and survey results will be used to:
  - Assess M&S
  - Conduct comparison
  - Create summary of M&S capabilities, limitations, and requirements
- M&S output data will be used to:
  - Assess M&S
  - Conduct comparison
  - Validate capabilities

DTE05 Simulation Plan



Functional Area Results

Area of Examination	BCS1	BCS2
COP Functionality	G	A/G
Intelligence Functionality	A/R	R
Fires & Effects Functionality	A/R	R
C2 Functionality	A/R	A/G
Collaboration Functionality	A/R	R
Mob/CM/Surv Functionality	A/R	A/R
Sustainment Functionality	A/R	A/R
Maneuver Functionality	A/R	A/R
Training Functionality	R	A/R
Stimulate Tactical Systems	R	G

3CE Comparative Analysis Lessons Learned (1 of 3)

- Planning: the systems under comparison, as well as the required capabilities, must be identified up front and have the buy-in of all participating Commands
  - Must be an integral part of the overall planning (i.e., technical architecture, federates, scenario, data collection requirements, and support).
  - Roles and responsibilities associated with the comparison must be clearly defined.
  - Care must be exercised in the selection of models and systems for comparison (i.e., avoid the comparison of dissimilar systems).
  - Must identify all command-specific requirements for each of the functional areas under comparison.
  - Systems under comparison must be in the proper places and thorough integration testing must be completed prior to the comparison.
- Data Collection: Must support technical, functional and operational requirements
  - Must have a central data repository where users have remote access and community products are shared (including post-event access).
  - All users must have input *a priori* to the data repository structure to ensure their data collection and analysis needs are met.
  - Must have an integrated database system. The current data repository segregates DIS, HLA, HLAM, TENA (ILH) and tactical messages into separate databases making it extremely difficult and time consuming to conduct end-to-end mission thread analysis.

3CE Comparative Analysis Lessons Learned (2 of 3)

- Operational Analysis: Must develop process to be able to track end-to-end threads
  - Significant challenges arise with HLA and DIS federations, and with instability of federations (with systems up and down it leaves gaps that do not support analytical requirements)
  - The 3CE TOEL is not conducive to operational analysis (end-to-end threads); events are disjoint and do not represent a complete operational flow of information
- Technical Stability: Architecture and components must be fully operational during testing
  - Must improve the stability of the 3CE Federation for future events. The instability of the federation and its infrastructure makes it impossible to isolate what works and what does not work, and produces unacceptable gaps in the data for analytical purposes.
  - Must address the significant challenges that arise with linking HLA and DIS federations, and with instability of the federations or their federates (with systems periodically up and down it leaves gaps that do not support analytical requirements).

3CE Comparative Analysis Lessons Learned (3 of 3)

- Consistent time stamping and entity ID mechanisms across the federation
  - Entity mappings between federates (HLA and DIS) was not completed prior to STARTEX; resulted in MC2 icons all reflecting Unknown
  - Different federations within the 3CE environment handle entity identification differently (bumper #'s, URNs) and this must be resolved
- Scenario
  - Scenario/ TOEL did not require C2 systems to be utilized in an operational mode (players were merely following TOEL)
  - The size of the scenario was such that no performance benchmarks could be assessed (570 entities is classified as a light load)
  - The scenario/ TOEL must support comparison requirements (mission threads, load testing, and data collection) (i.e., events were disjointed and did not represent a complete operational flow of information).
- Exercise Support
  - Must have more robust support systems (need separate technical/ testing and Exercise Control (EXCON) communications assets, and federation management tools)
  - Need more green suiters on the systems being compared and for use as SMEs

3CE Comparative Analysis Process Recommendations (1 of 3)

- Analytic Methodology: 3-Phased approach should be maintained
  - Must do better job of obtaining buy-in on comparison(s) from all Commands
  - Must be proactive in identifying common 3CE requirements, sharing exit criteria and products (through membership on appropriate WG/CGs)
  - Systems being compared should be co-located; static and dynamic testing preferred
  - If exit criteria are not met, 3CE Management must be briefed and corrective actions must be agreed upon and implemented prior to proceeding
- Phase I: Determine basis of comparison
  - Must do better job of identifying valid 3CE requirements (need consensus from all Commands); should use FCS ORD, UFD, ATEC FCS SEP and JC2 ORD/CDD
  - Requirements identification must be worked through applicable WG/CGs
  - Operational requirements (mission threads) must be identified early on and data/ scenario requirements coordinated with applicable WG/CGs (Scenario and Data at a minimum); mission threads must be conducted with the environment under load
  - Products for Phase I (issues, EEA, MoMs, Data Elements, Draft Analysis Plan, and a Draft Data Collection Management Plan (DCMP)) must be developed ICW representatives from each Command
  - Exit Criteria for Phase I must be fully vetted with all Commands and include:
    - All stakeholders concur that their users' requirements are contained in the DCMP
    - The issues, EEAs and MoMs for the 3CE comparison(s) are adequate to proceed to Phase II
    - All stakeholders concur that the Analysis Plan and the DCMP capture their requirements and, when successfully executed, will provide the information needed to make an informed decision with respect to the comparison(s)

3CE Comparative Analysis Process Recommendations (2 of 3)

- Phase II: Verify data collection capability and validate analytical approach
  - Analysis Team ICW DAT WG/CG must verify that the data collection mechanisms (and data repository structures) are sufficient to meet DCMP requirements (especially end-to-end mission thread analysis); if they are not, then resolution must be reached prior to commencing Phase III
  - All stakeholders must agree that the event scenario/ vignette (and TOEL) supports the analytic approach and data collection requirements (If it does not, then changes must be made.)
  - Products for Phase II (validated analytic approach and finalized Analysis Plan and DCMP) must be coordinated with representatives from each Command
  - Exit Criteria for Phase II must be fully vetted with all Commands and include:
    - All stakeholders concur that the analytic methodology is executable and that the Analysis Plan and the DCMP capture all of their requirements
    - The decision to proceed to Phase III is contingent on achieving the Phase II Exit Criteria and successfully competing all Integration Tests
- Phase III: Conduct data collection and comparative analysis
  - Adequate time and resources must be dedicated to the Technical, Functional and Operational testing outlined in the DCMP
  - Data collected and archived in 3CE databases must be readily available to the Analysis Team (implies distributed access for all stakeholders until the analysis is completed)
  - Comparative analysis results must be briefed to 3CE management as soon as practical (NLT 60 days following ENDEX)

3CE Comparative Analysis Process Recommendations (3 of 3)

- Post-Event Actions/ Activities:
  - Responses to the questionnaire developed to identify business processes, policies, and procedures for using M&S in each command should be completed and returned in a timely manner.
  - Changes must be made that will allow the use of federation output data to support future events:
    - The scenario/ TOEL must support a dynamic operational environment so that federation output data can be used to support the analysis of mission threads (Intelligence, Situational Awareness, Fires, and Sustainment).
    - The manner in which future DTE 5 and 3CE databases are built must support cross-walking the events and entities associated with the mission threads.
    - Access to simulation output data must be made available for post-event analysis efforts.
  - The stability of the federation and its infrastructure (DTE-MATREX Bridge) must be improved for analysts to isolate what works and what does not work, and to eliminate gaps in the data for analytical purposes.