Experimenting with C2 Applications and Federated Infrastructures for Integrated Full-Spectrum Operational Environments in Support of Collaborative Planning and Interoperable Execution

Command & Control Directorate

Communications Electronics Research, Development and Engineering Center (CERDEC)

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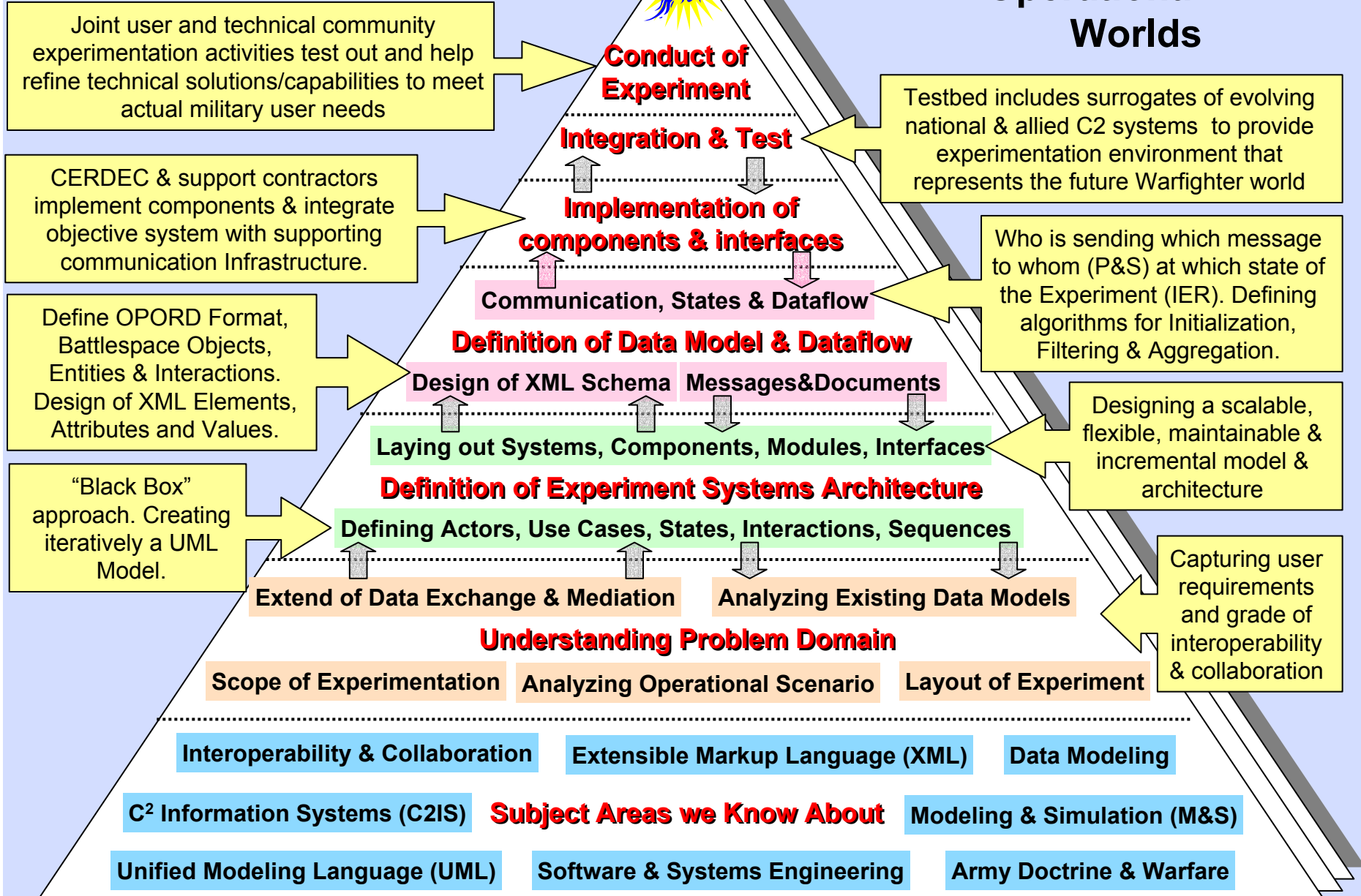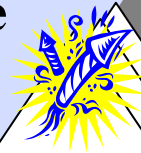
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C2 Technology Integration Test Bed

Why is it needed?

- Need to integrate a diverse set of technologies addressing abroad problem space into an appropriate comprehensive capability

- Army is transitioning from a self-centered C2 environment to a network-centric system

- Operational emphasis is on use of real-time Situation Awareness (SA) and Collaboration in execution Future Operations

- Need an experimentation environment that

  - Allows us to see how things fit together and work before investing in expensive system solutions

  - Enables operational users to experiment with new technology and operational concepts, tactics and procedures

- To test and evaluate technical and operational interoperability interfaces with US Joint and Coalition Partners

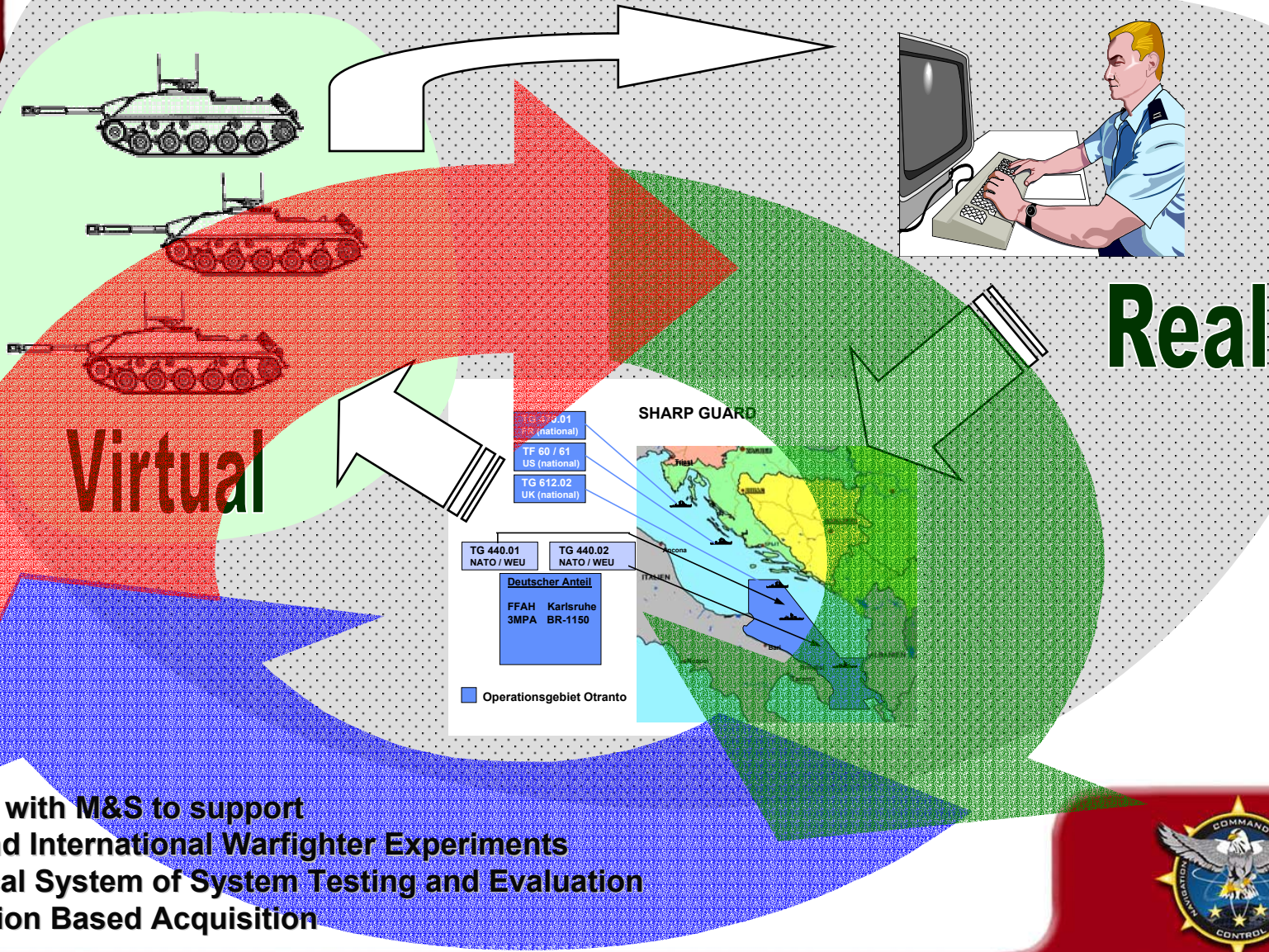- Required to support Network Enabled Battle Command effort and future C4ISR experimentation activities

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The C2 Integration Problem Space

Bridging Technical & Operational Worlds

Joint user and technical community experimentation activities test out and help refine technical solutions/capabilities to meet actual military user needs

Conduct of Experiment

Integration & Test

Testbed includes surrogates of evolving national & allied C2 systems to provide experimentation environment that represents the future Warfighter world

CERDEC & support contractors implement components & integrate objective system with supporting communication Infrastructure.

Implementation of components & interfaces

Communication, States & Dataflow

Who is sending which message to whom (P&S) at which state of the Experiment (IER). Defining algorithms for Initialization, Filtering & Aggregation.

Define OPORD Format, Battlespace Objects, Entities & Interactions. Design of XML Elements, Attributes and Values.

Definition of Data Model & Dataflow

Design of XML Schema   **Messages&Documents**

Laying out Systems, Components, Modules, Interfaces

Designing a scalable, flexible, maintainable & incremental model & architecture

"Black Box" approach. Creating iteratively a UML Model.

Definition of Experiment Systems Architecture

Defining Actors, Use Cases, States, Interactions, Sequences

Extend of Data Exchange & Mediation   **Analyzing Existing Data Models**

Capturing user requirements and grade of interoperability & collaboration

Understanding Problem Domain

Scope of Experimentation   **Analyzing Operational Scenario**   **Layout of Experiment**

Interoperability & Collaboration   **Extensible Markup Language (XML)**   **Data Modeling**

C² Information Systems (C2IS)   **Subject Areas we Know About**   **Modeling & Simulation (M&S)**

Unified Modeling Language (UML)   **Software & Systems Engineering**   **Army Doctrine & Warfare**

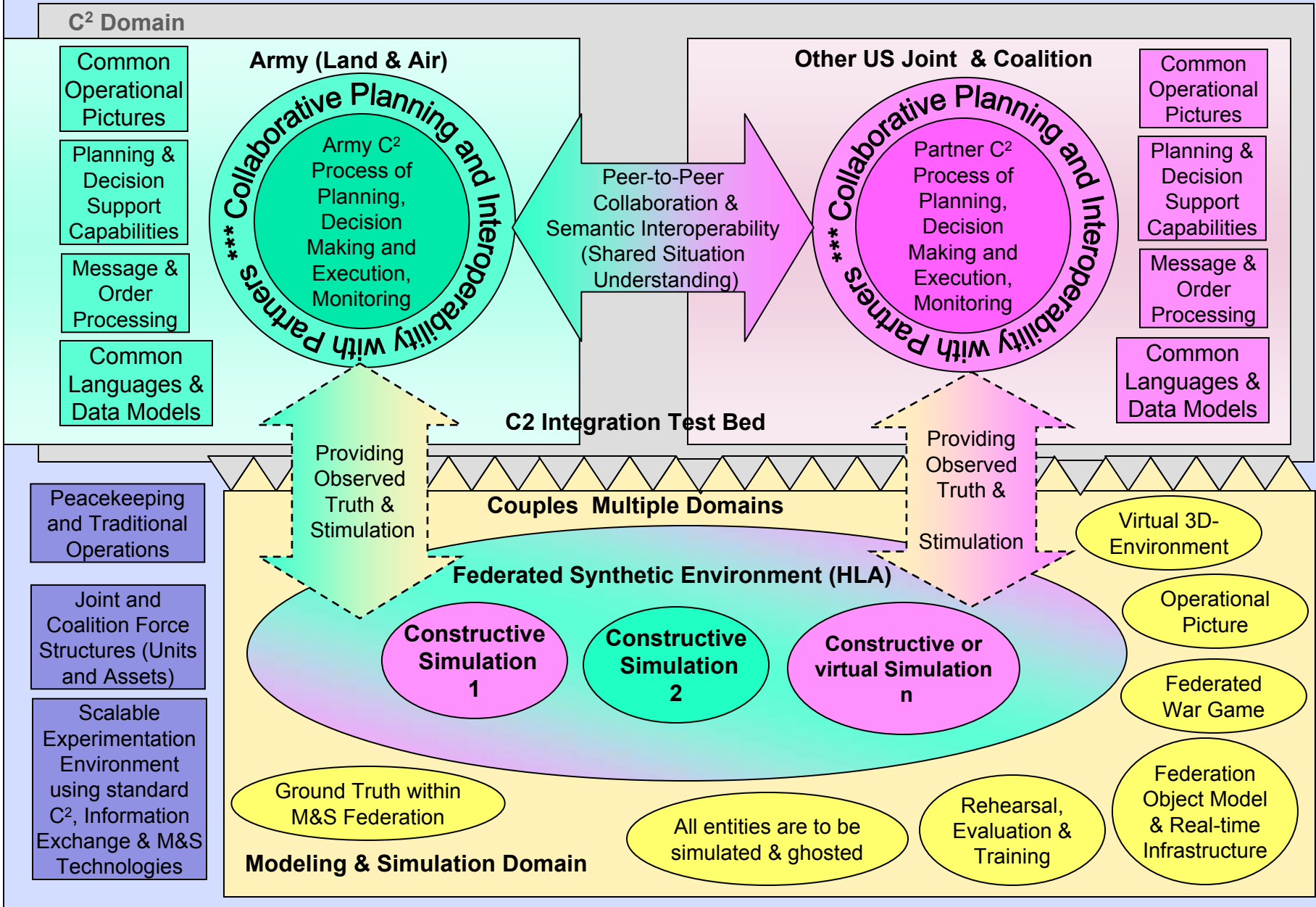# C2 Technology Integration Test Bed Vision

Real

Virtual

SHARP GUARD

TG 470.01 FR (national)
TF 60 / 61 US (national)
TG 612.02 UK (national)
TG 440.01 NATO / WEU
TG 440.02 NATO / WEU

Deutscher Anteil

FFAH   Karlsruhe
3MPA   BR-1150

Operationsgebiet Otranto

Link C2IS with M&S to support
- **Joint and International Warfighter Experiments**
- **Technical System of System Testing and Evaluation**
- **Simulation Based Acquisition**

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Supports Joint & Coalition Force Interoperability & Collaboration Experiments

C² Domain

Army (Land & Air)

Collaborative Planning and Interoperability with Partners *

Army C² Process of Planning, Decision Making and Execution, Monitoring

- Common Operational Pictures
- Planning & Decision Support Capabilities
- Message & Order Processing
- Common Languages & Data Models

Peer-to-Peer Collaboration & Semantic Interoperability (Shared Situation Understanding)

Other US Joint & Coalition

Collaborative Planning and Interoperability with Partners *

Partner C² Process of Planning, Decision Making and Execution, Monitoring

- Common Operational Pictures
- Planning & Decision Support Capabilities
- Message & Order Processing
- Common Languages & Data Models

C2 Integration Test Bed

Providing Observed Truth & Stimulation

Providing Observed Truth & Stimulation

Couples Multiple Domains

- Peacekeeping and Traditional Operations
- Joint and Coalition Force Structures (Units and Assets)
- Scalable Experimentation Environment using standard C², Information Exchange & M&S Technologies

Federated Synthetic Environment (HLA)

- Constructive Simulation 1
- Constructive Simulation 2
- Constructive or virtual Simulation n

- Virtual 3D-Environment
- Operational Picture
- Federated War Game
- Federation Object Model & Real-time Infrastructure

- Ground Truth within M&S Federation
- All entities are to be simulated & ghosted
- Rehearsal, Evaluation & Training

Modeling & Simulation Domain

C2Sim Proxy Server – Key Interoperability Agent

Collaborative Decision Making Products Interface
• Currently based on CERDEC CAPES/MC2 collaborative Mission Planning and Execution Mgmt. SW
• Interface to Defense Collaboration Tool Set (DCTS) and other products planned

DCTS is OSD Mandated

CS
P&S Adapt Data

Existing & Evolving Army C2 Sys Interface
• Supports ASAS Lite and MCS Lite via legacy Joint Common Data Base (JCDB) information exchange mechanisms
• Also supports national C2 Sys Message Exchange via use of US CMP

Coalition C2 Sys Interoperability Interface
• Automated exchange of Coalition Common Operating Picture (CCOP) & SA
• Based on Multilateral Interoperability Program (MIP) C2 Information Exchange Data Model (C2IEDM)

Future Army C2 Info Exch will be via C2IEDM and XML mechanisms

DMA
P&S Adapt Data

DEM
P&S Adapt Data

Becoming US National Joint C2 Sys Interoperability Interface

Coalition Domain Manager *** Publish, Subscribe, Filter, Store ***

XML/JAVA Communication Infrastructure

Web-based C2 Collaboration Portal (WCP)
• Supports real-time viewing of CCOP
• Supports Collaborative Planning & Decision Making Activities between Army and Joint/Coalition partners
• Implements Digitized, XML-based OPORD and OPLAN info exchange mechanisms

IIS
P & S

HRF
Adapt Data P&S

Simulation Sys Interoperability Interface
• Automated exchange of simulated Unit location, state & control information between simulator and C2 systems
• Based on HLA Federated Object Model data exchange mechanisms (IEEE Std).

US National Simulation Sys Interoperability Interface Std

Web Service Implementation for Global Information Grid/ DCTS Enterprise Environments

Other C2Sim Proxy Server Features

- Implemented as a loose federation of external enterprise system interface ports and data adaptor/translation services

- These system/data adaptor services are Web-based service request oriented agents/clients

- These data adaptor services automatically map information from external system unique formats and data representations into a common digitized OPORD/OPLAN XML-based representation and vice versa. (One to "n" solution)

- C2Sim Proxy Server implements information exchange between system ports via a rule-based controlled Publish and Subscribe data exchange mechanism

- Designed to manage and control flow of trusted information between ports/ users

- Also provides selected Information Aggregation and filtering services

Current US SINCE Test Bed Implementation

Simulation & C2 Info Sys Connectivity Experiments (SINCE)

US Execution Monitoring
- Tactical Picture & Execution Alerts
- Monitor Joint DB for Plan Contingencies

US Planning System

Automated Reasoning & Decision Support Tools

| Mission Analyze |
| COA Dev. |
| COA Analysis |
| COA Compare |
| COA Approval |
| Orders Gen. |

JCDB Connection

CAPES
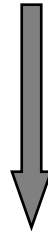
Decision Making Process

Visualization & Collaboration

Collaborative Decision Making

C2Sim Proxy Server

JCDB

Lt. ASAS

US C2COP

CS
P & S

DMA
P & S

CDM

DEM
P & S

MIP

C2IEDM DB

MIP Data Replication Interface

To GE Coalition Partner C2 Sys

Coalition COP Data Exchange

• Common XML-Based Information Model
• Publish & Subscribe Info. Distribution Manager

Coalition Web C2 Portal

IIS
P & S

P & S

HRF
P & S

OneSAF
Test Bed
Simulation System

US C2Sim Proxy HRF

HLA

Ground Truth

HLA GW

GE PABST M&S

Other HLA M&S Sys.

DIS

SINCE HLA Gateway

OTB

Control Measure Editor

Execution Monitoring

Display Message Header

Task Force Eagle Web-Based...

Task Force Eagle Web

Select the Situation Map of Interest

Unit Editor

Mission Editor
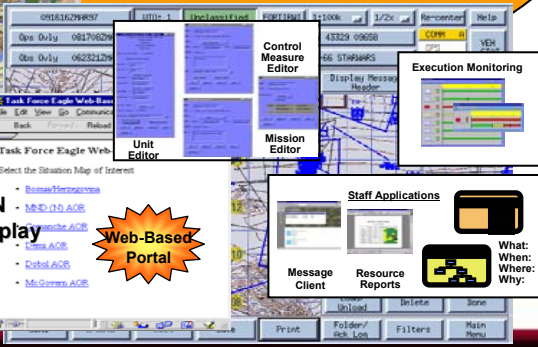
COALITION PLANNING

• Digitized, XML OPORD/OPLAN
• Web-based Coalition COP Display
• Web Collaboration Interface

Web-Based Portal

Staff Applications

Message Client

Resource Reports

What: When: Where: Why:

The Web-based C2 Portal & Common XML Information Model

Typical Portal Display

- Weather Forecast Window
- Portal Navigation Window
- Coalition COP Unit Position Map/Graphic SA View Window
- Coalition Force OPORD/OPLAN View Window
- Coalition Force UTO, etc View Window
- Mission Critical Event Alert View & Set Window/Chat
- Coalition Force SYNC Matrix View Window
- Message & Chat View Window
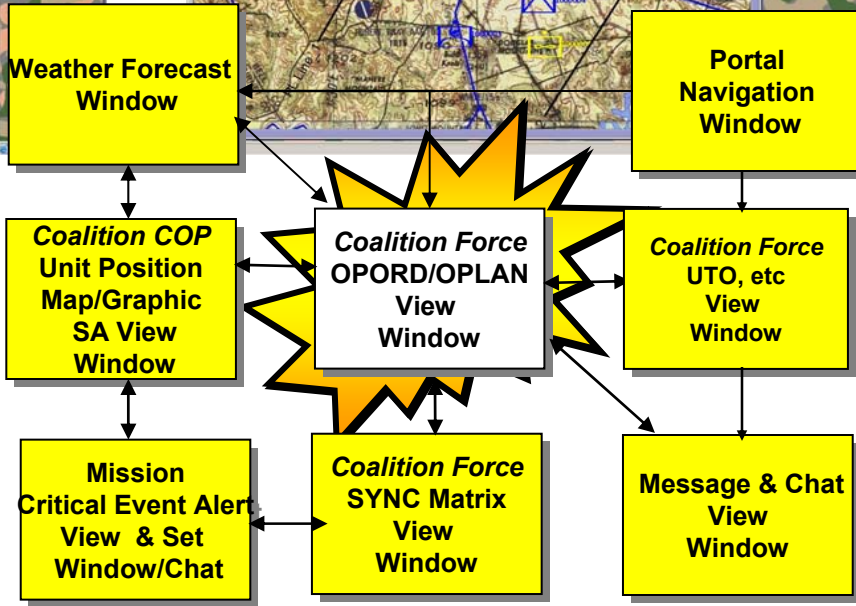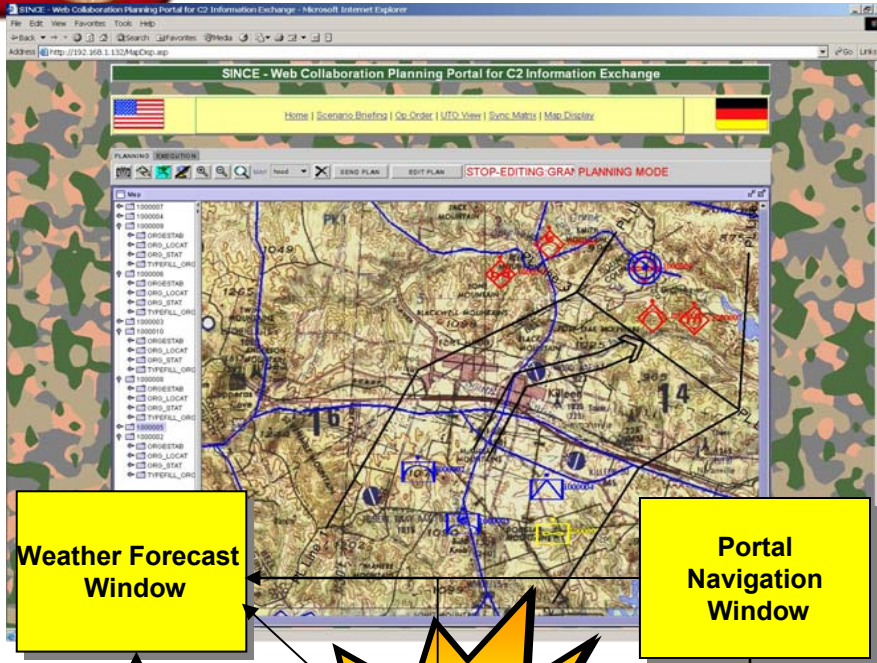
➔ Gateway between National & Coalition C2 Planning Systems

➔ Displays, Sees and Operates on only Coalition C2IEDM based Information

➔ Standard user interfaces & Common Info Battle Mgmt. Language (BML), Graphics, Xml-based representations for exchange of planning Info

➔ Interactive OPORD building and Info Exchange

Typical OPORD/OPLAN Text Parsed by W6H Rules

| Why | Who | Where | When | How | What | Which |

OPORD Text represented in XML

Situation Picture at D+3, H+6
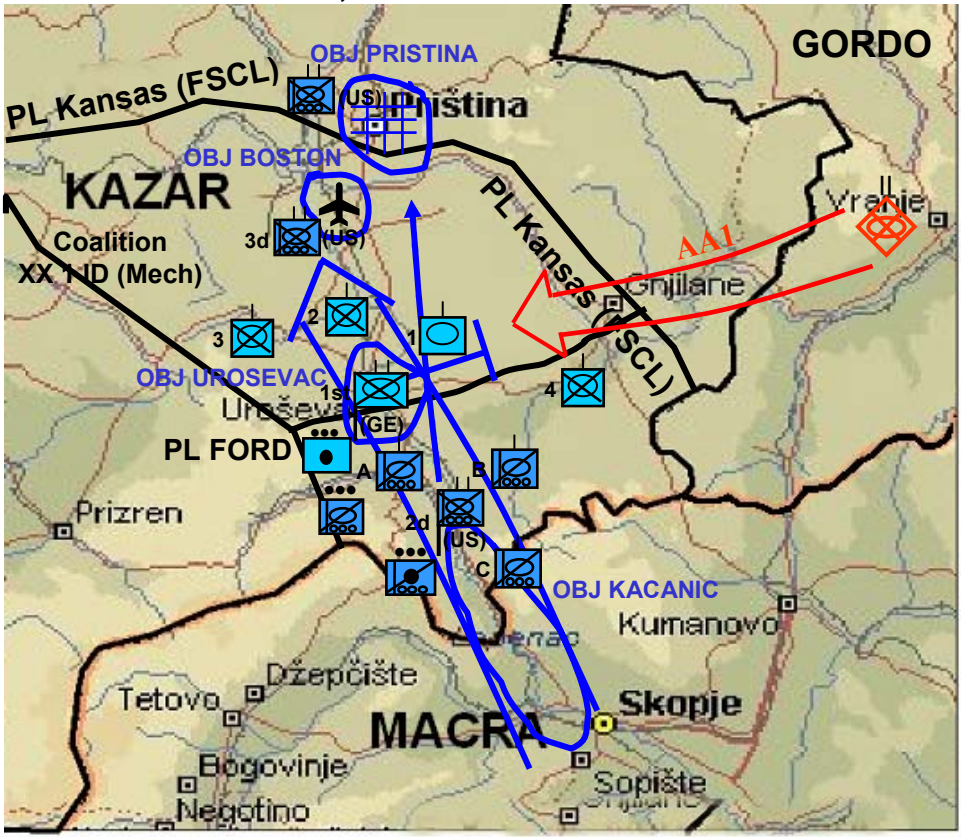
XML Description of Picture in Operational Order (OPORD)

```xml
<prdC2 dsg="ORD0000" type="doc\OPORD" fmt="XML">
 <tpcHdr id="0" name="HEADER"/>
 <tpcSIT id="1" name="SITUATION">
  <cmpFoe id="1.a" name="Enemy\Threat">
   <fctUnit id="1.a.0" name="Initial">
    <unit name="3rd MIBG" role="Mech/IN" size="Bn" aff="enmy\GN" dsg="EGN010303"/>
   </fctUnit>
  </cmpFoe>
  <cmpFrnd id="1.b" name="Friendly\Coalition">
   <fctUnit id="1.b.0" name="Initial">
    <unit name="1st BCT (US)" role="cbt" size="BdeTm" aff="frnd\US" dsg="FUS0001">
     <unit name="1st IN Bn (GE)" role="Mech/IN/cbt" size="Bn" aff="frnd\GE" dsg="FGE000101">
      <unit name="Bn HQ" role="C2/Mech" size="Co/Bn" aff="frnd\GE" dsg="FGE0001010"/>
      <unit name="1st AR Co" role="AR/Mech/IN" size="Co/Bn" aff="frnd\GE" dsg="FGE0001011">
       <asset>
        <strength><trp type="mnt"><qnty>4</qnty></trp>
         <eqp type="MBT" model="GE\L2A5" name="Leopard-2"/>
          <qnty>6</qnty>
        </strength>
       </asset>
       <disposition>
        <location>
         <at type="gridPnt" name="unitPositionCM" rep="lat/lon" fmt="DD">
          <atCrd><lat rep="DD">+42.45000</lat><lon rep="DD">+21.35000</lon></atCrd>
         </at>
        </location>
       </disposition>
      </unit>
      <unit name="2nd Co" role="Mech/IN/cbt" size="Co/Bn" aff="frnd\GE" dsg="FGE0001012"/>
      <unit name="3rd Co" role="Mech/IN/cbt" size="Co/Bn" aff="frnd\GE" dsg="FGE0001013"/>
      <unit name="4th Co" role="Mech/IN/cbt" size="Co/Bn" aff="frnd\GE" dsg="FGE0001014"/>
      <unit name="Mortar Co" role="FA/cbtSpt" size="Co/Bn" aff="frnd\GE" dsg="FGE0001015"/>
     </unit>
     <unit name="2nd IN Bn (US)" role="Mech/IN/cbt" size="Bn" aff="frnd\US" dsg="FUS000102">
      <unit name="Bn HHQ" role="C2/Mech" size="Co/Bn" aff="frnd\US" dsg="FUS0001020"/>
      <unit name="A Co" role="Mech/IN/cbt" size="Co/Bn" aff="frnd\US" dsg="FUS0001021"/>
      <unit name="B Co" role="Mech/IN/cbt" size="Co/Bn" aff="frnd\US" dsg="FUS0001022"/>
      <unit name="C Co" role="Mech/IN/cbt" size="Co/Bn" aff="frnd\US" dsg="FUS0001023"/>
      <unit name="AT Co" role="AT/cbtSpt" size="Co/Bn" aff="frnd\US" dsg="FUS0001024"/>
      <unit name="Mortar Plt" role="FA/cbtSpt" size="Plt/Bn" aff="frnd\US" dsg="FUS00010202"/>
      <unit name="Scout Plt" role="RSTA/Mech/IN" size="Plt/Bn" aff="frnd\US" dsg="FUS00010201"/>
     </unit>
    </unit>
   </fctUnit>
  </cmpFrnd>
  <cmpCiv id="1.c" name="Non-Combatants"/>
  <cmpNeutral id="1.d" name="Neutral Forces"/>
  <cmpEnv id="1.e" name="Environment"/>
 <tpcSIT/>
 <tpcMSN id="2" name="MISSION"/>
 <tpcEXE id="3" name="EXECUTION"/>
 <tpcSS id="4" name="SERVICE SUPPORT"/>
 <tpcC3 id="5" name="COMMAND AND SIGNAL"/>
 <tpcTO id="A" type="Annex" name="Own Unit Task Organization"/>
 <tpcINT id="B" type="Annex" name="Intelligence"/>
</prdC2>
```


CAPES — Web-Portal — MIP — LC2DB

CS — IIS/HTML — DEM

Coalition Domain Item Exchange

DMA — HLA/FOM

JCDB

C2COP, ASAS Lt. — M&S, HLA-GW/OTB

*** Coalition Domain Manager *** Publish, Subscribe, Filter, Store ***

PSDB

XML/JAVA Communication Infrastructure

Context Space&Data Adaptors
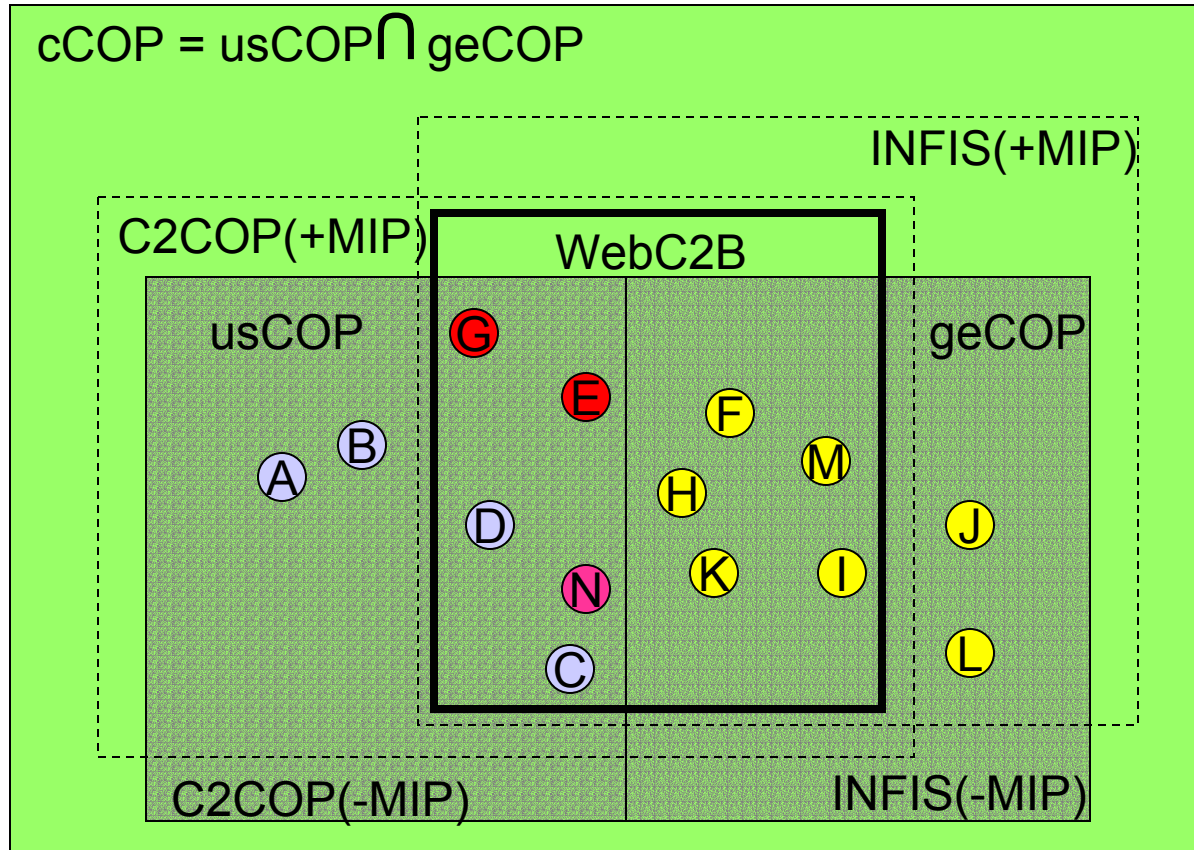
Coalition Context — US C2 Context — AL C2 Context — M&S Context

C2 COP Domains

sCOP = sCOP(c) ∪ sCOP(g)

cCOP = usCOP ∩ geCOP

INFIS(+MIP)

C2COP(+MIP)

WebC2B

usCOP

geCOP

C2COP(-MIP)

INFIS(-MIP)

usCOP= {A, B, C, D, E, G, N, H, K, F, M, I }
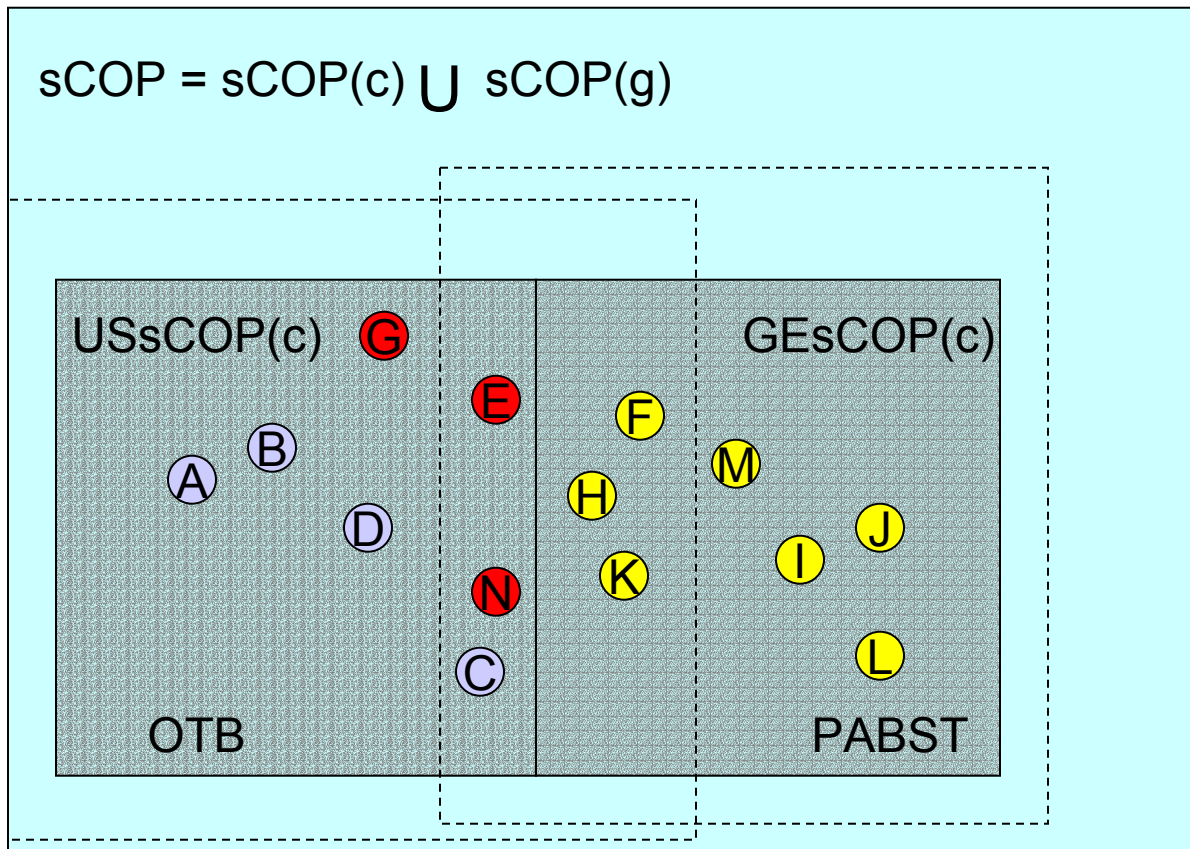geCOP = {F, H, I, J, K, L, M, E, N, C, D, G}
cCOP = {E, C , D, G, H, K, F, N, M, I}

Simulation COP Domains

$$cCOP = usCOP(c) \cap geCOP(c)$$

$$sCOP = sCOP(c) \cup sCOP(g)$$

USsCOP(c) = {A, B, C, D, E, G, N }
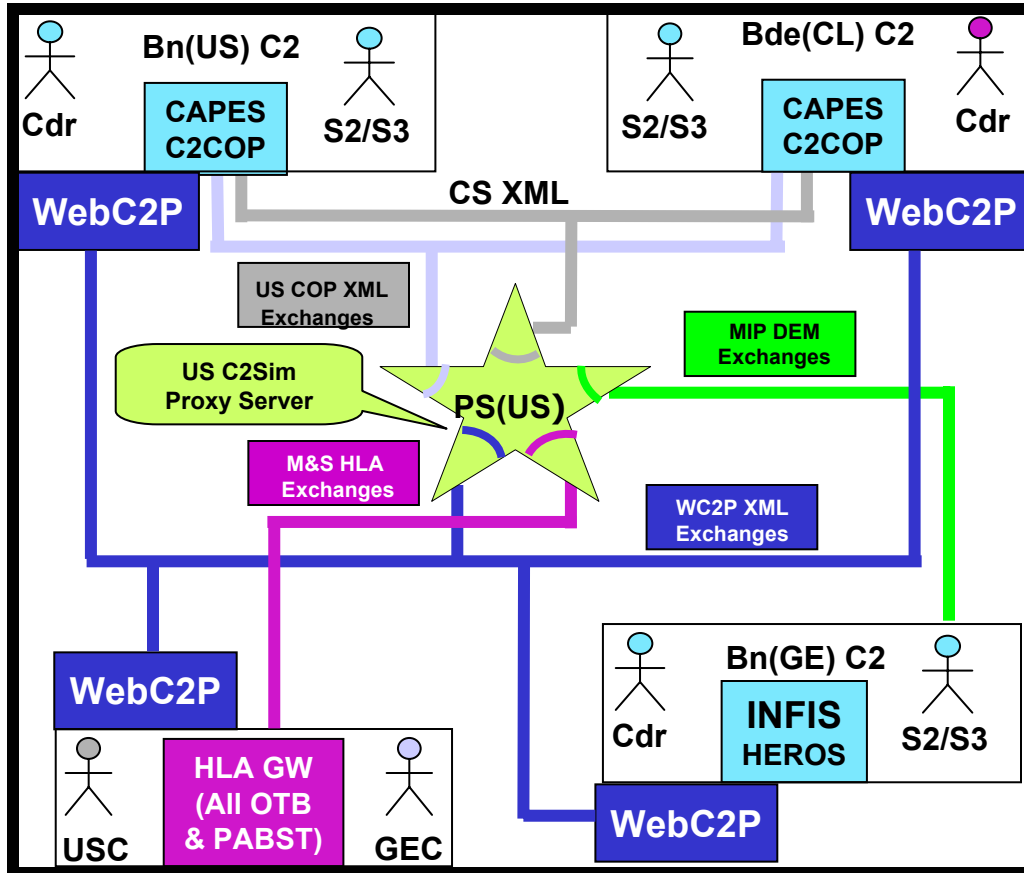USsCOP(g) = {F, H, K }, USsCOP(-g) = {M, I, J, L }
GEsCOP(c) = {F, H, I, J, K, L, M}
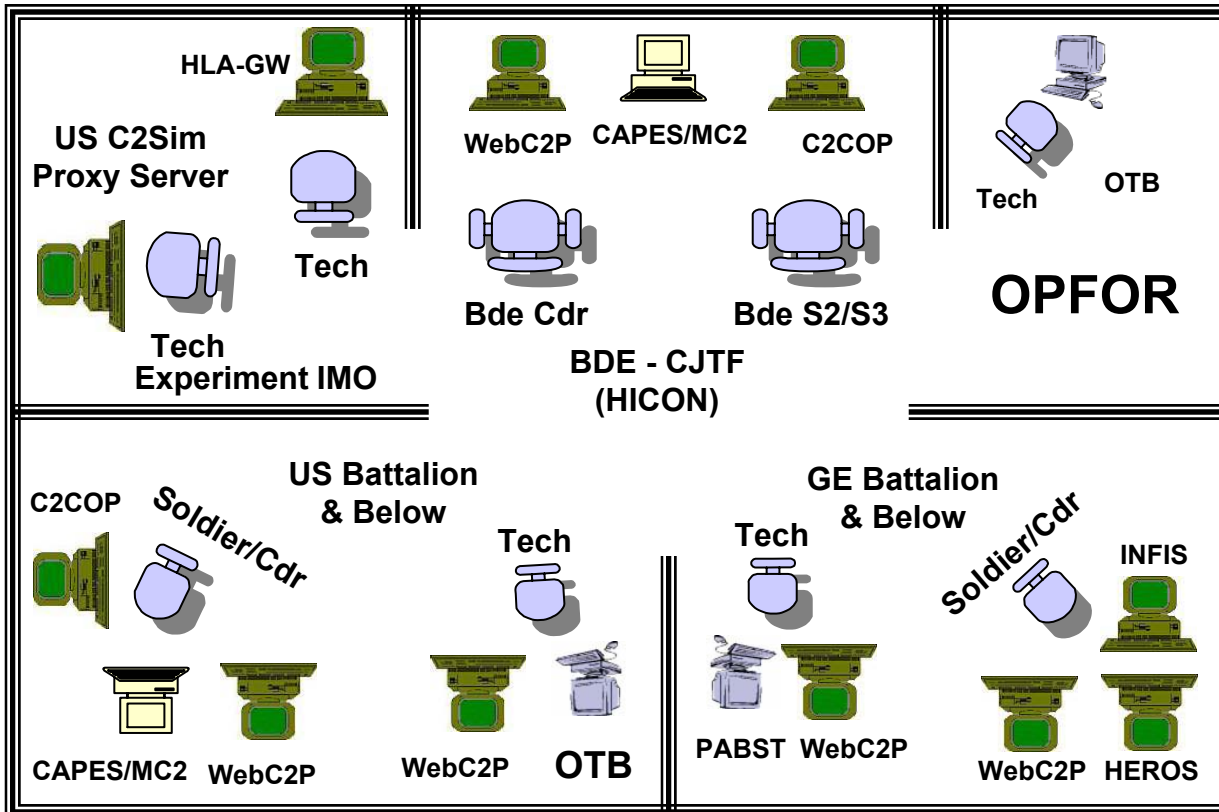GEsCOP(g) = {E, N, C }, GEsCOP(-g) = {A, B, D, G }

Experiment / Test Report

Report # ———— **Report Subject :** ————————————

————————————————————————

Report Type::	**Outcome**	**Timing**	**Deficiency**	**Incompatibility**	**Limitation**	**Recommendation**

:

Report Criticality —————— Date —————— Time ——————

Phase I,   II,   III,   IV   Pass 1,   2,   3,   4

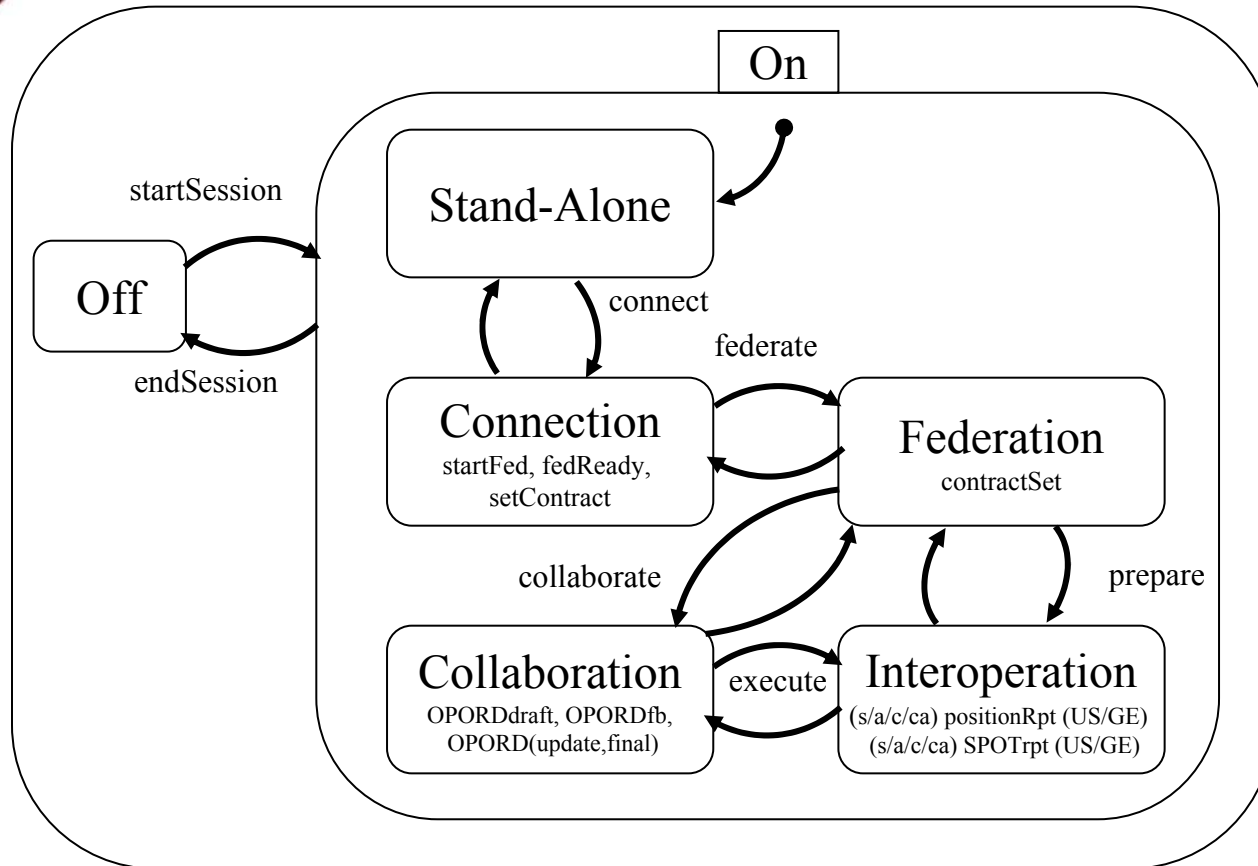Federate Name ——————————, Federate # ———— IER # ————

Screen Capture File name: _____

Database Snapshot File name: _____

Description/Comment/Solution:

State Diagram of SINCE PS (US) & Federates

SINCE Test Cases & Use Cases

Test Case 1a (Initialization)

- Interconnect System
- Federate System
  - Initialize Federate

$COP(@\ t = t_0)$ & draft OPORDs

$COP(@\ t = t_0)$

Test Case 2a (Planning for $t \geq H > t_0$)
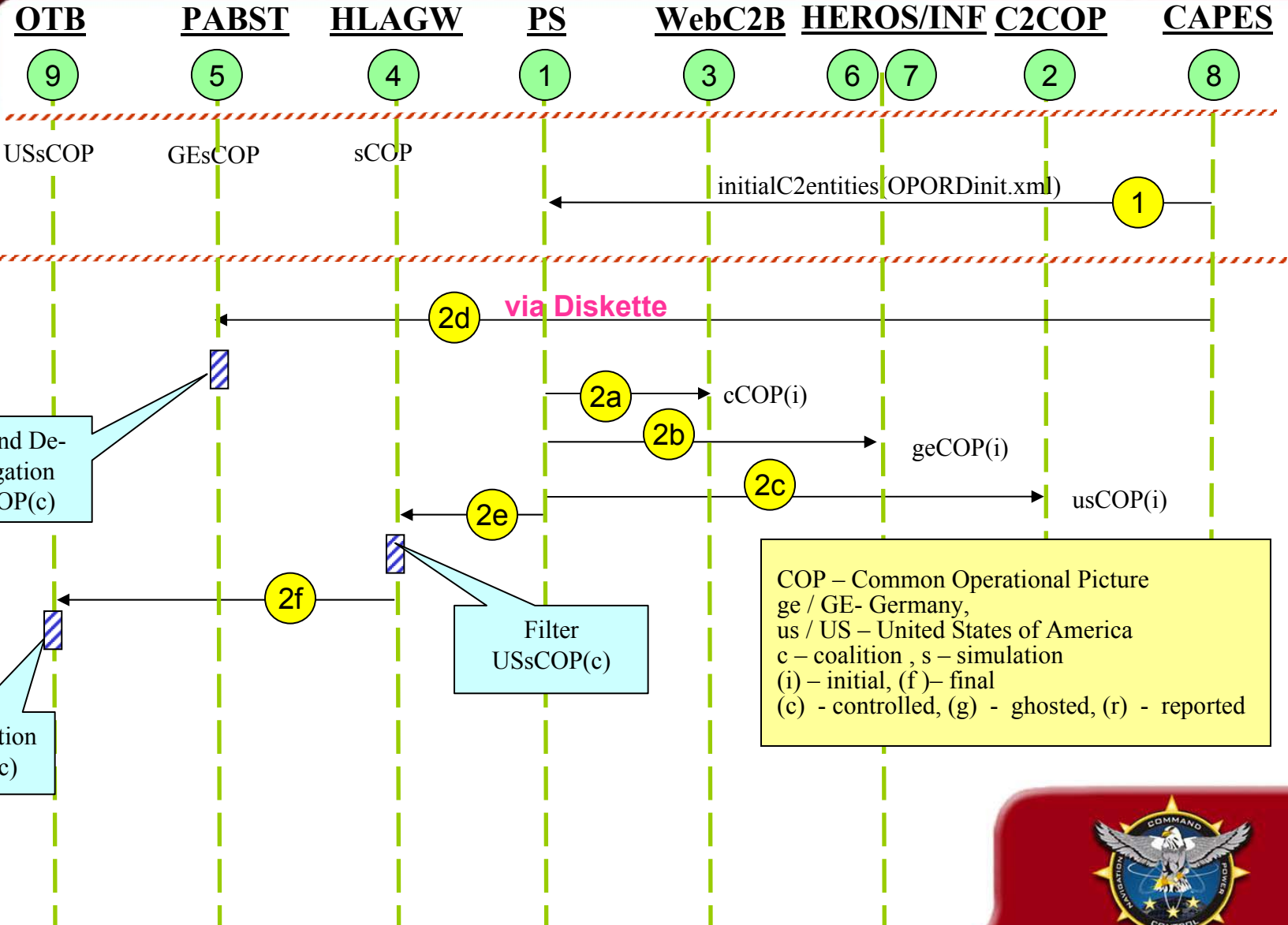
final OPORDs

Test Case 3a (Execution @ $t > t_0$)

- Collaborate with Coalition Federate (to Plan operation)

- Stimulate Federate
- Interoperate with Coalition Federate (to Monitor Execution)

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Test Case #1a (COP Initialization)

OTB PABST HLAGW PS WebC2B HEROS/INF C2COP CAPES

9 5 4 1 3 6 7 2 8

USsCOP   GEsCOP   sCOP

initialC2entities (OPORDinit.xml)   1

2d   **via Diskette**

Filter and De-aggregation GEsCOP(c)

2a → cCOP(i)

2b → geCOP(i)

2c → usCOP(i)

2e

Filter USsCOP(c)

2f

De-aggregation USsCOP(c)

COP – Common Operational Picture
ge / GE- Germany,
us / US – United States of America
c – coalition , s – simulation
(i) – initial, (f)– final
(c) - controlled, (g) - ghosted, (r) - reported

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Test Case #2a (OPORD Draft & Collaboration)

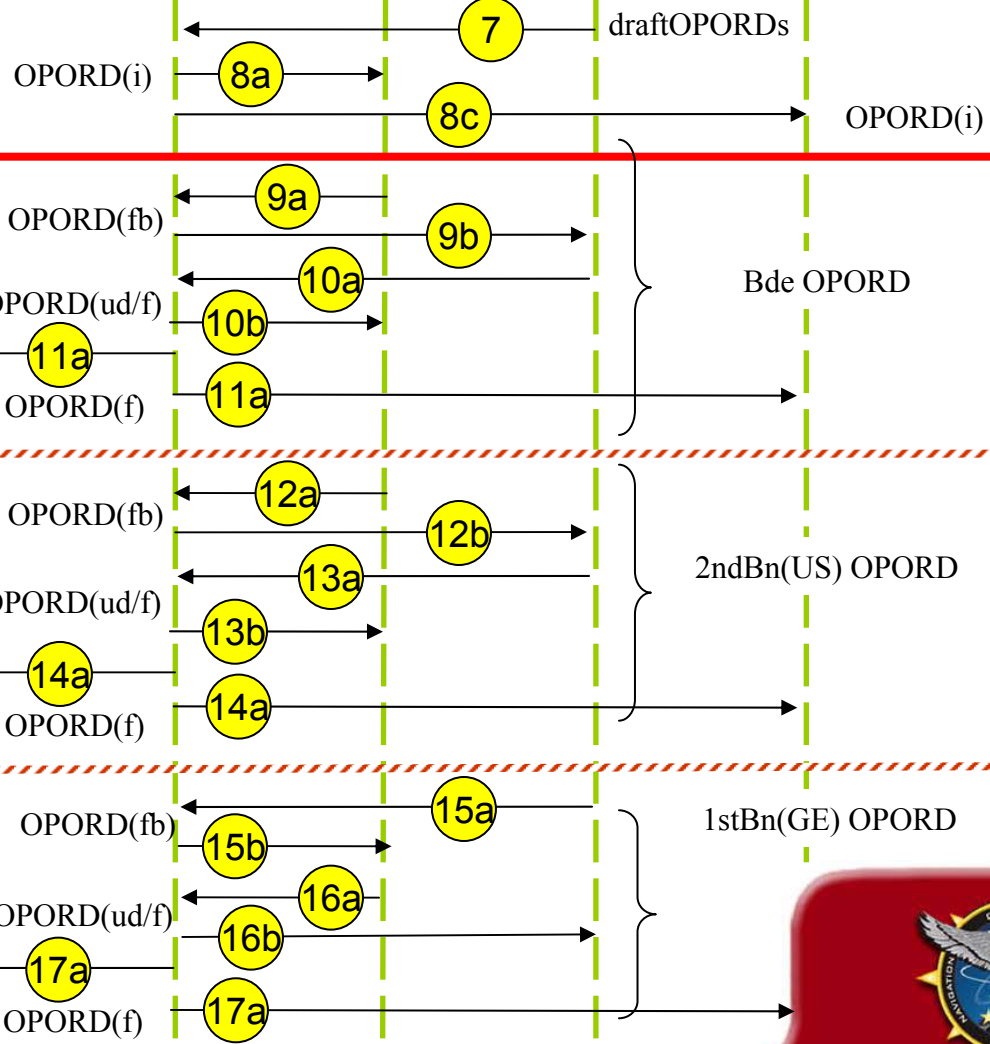| OTB	PABST	WebC2B(MS	PS	WebC2B(C2)	CAPES	C2COP
9	5	3'1	1	3	8	2

7 — draftOPORDs

OPORD(i) — 8a

8c — OPORD(i)

OPORD –Operational Order
ge / GE- Germany,
us / US – United States of America
(i) – initial, (f)– final
(fb) – feedback, (ud) – update

9a

OPORD(fb) — 9b

10a

OPORD(ud/f) — 10b

Bde OPORD

11a

task OPFOR — 11b — OPORD(f) — 11a

12a

OPORD(fb) — 12b

13a

OPORD(ud/f) — 13b

2ndBn(US) OPORD

14a

task BLUFOR (US) — 14b — OPORD(f) — 14a

15a

OPORD(fb) — 15b

16a

OPORD(ud/f) — 16b

1stBn(GE) OPORD

17a

task BLUFOR (GE) — 17b — OPORD(f) — 17a

Test Case #3a (COP Execution)

OTB 9 · PABST 5 · HLAGW 4 · PS 1 · WebC2B 3 · HEROS/INF 6 7 · C2COP 2 · CAPES 8

USsCOP · GEsCOP · sCOP

- 3a: GEsCOP(r)
- 3b: GEsCOP(r) — GEsCOP(g)
- 4a: USsCOP(r)
- 4b: USsCOP(r) — USsCOP(g) — Re-aggregation/Filtering
- 5: sCOP(r)
- Re-aggregation/Filtering
- 6a: cCOP(f)
- 6b: geCOP(f)
- 6c: usCOP(f)

COP – Common Operational Picture
ge / GE- Germany,
us / US – United States of America
c – coalition , s – simulation
(i) – initial, (f)– final
(c) - controlled, (g) - ghosted, (r) - reported

SINCE Experiment 1a Results

- SINCE Experiment 1a demonstrated *New Information Exchange Interoperability and Collaboration Capabilities* between US/German C2I and M&S Systems

- Demonstrated *automatic initialization* of all Test Bed C2 and M&S systems and confirmed *that all displayed the same starting*
  - *Common Operating Picture (COP),* i.e.- Blue and Red Force Unit locations
  - Appropriate BDE and BN level OPORD/OPLAN *mission and unit tasking*
  - *Initialization process* was *completed in approximately 5 minutes* and validated for correctness by military users

- Demonstrated that *simulated Blue and Red Force movement* generated by ONESAF Test Bed or PABST M&S systems could be *displayed in real-time* on *all US & German C2 systems, the WC2P and M&S systems*
  - Real-time Blue and Red Force *COP tracking and synchronization* between C2 and M&S systems *demonstrated to approximately the 600-entity level*

- Demonstrated *interactive Web Portals enabling* coalition force *commanders to collaboratively plan, modify and synchronize OPS* via use of Xml-based, OPORD/OPLAN information exchange mechanisms.
  - US/GE military *users positively praised* the value of this *evolving capability*

- The US and GE military users indicated that *SINCE successfully demonstrated the linking of real C2 and M&S systems* thereby opening potential for use of real-world warfighter C2 systems in simulation-based training exercise