RDECOM

Intelligent Agents for Battle Command Services – TITAN ATO ID&M

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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RDECOM   **ABSTRACT**   **★CERDEC**

In this presentation we'll provide a brief background on intelligent agent technology, motivate and describe the approach, design and initial implementation results obtained from prototyping intelligent agents as part of a suite of battle command services. These services are currently under development as part of the Tactical Information Technology for Assured Network Operations (TITAN) Army Technology Objective - Development (ATO-D) Program focused on Information Dissemination and Management (ID&M) for Battle Command (BC) Services. The Program was initiated by the Army in October 2008 leveraging the results of the Army Intelligent Agent Sub-IPT to span and integrate available resources associated with ID&M, Network Management (NM) Information Assurance (IA) technologies. This talk, however, will be limited to ID&M area. The objective of TITAN IM&D is to develop a set of core BC Support Services that will reside with the BC Common Services servers to be fielded as part of the Army Current Force BC systems in support of net-centric BC interoperability and collaboration. This core set consists of the following BC Support services: a) OPORD, b) Battle Book, c) Alert and Warning, d) Smart Filtering, e) Workflow Orchestration, f) Initialization and Continuity of Operations, g) Product Dissemination, h) Early Warning, i) MultiMedia, and j) BC Query. All of the above services are supported by a single BC Warfighter Machine Interface with tailorable plugins and a single Message Object Library, based upon a single C2 Product–oriented XML Schema. The primary approach of this effort is to leverage Intelligent Agent Technology and build upon the success of the previous related programs. TITAN software agents are responsible for the functionality and behavior of TITAN BC Services. In this presentation we will describe four types of computational behaviors associated with Commander's Critical Information Requirements (CCIR) that were derived in response to general requirements associated with the Military Decision Making Process. They include area protection, route protection, hotspot recognition and route deviation.

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Intelligent agents are:

- Software agents that exhibit a set of behaviors.

- Situated computational processes— instantiated programs existing within an environment that they sense and affect.

- Actively receive inputs from environment.

- Responses may manipulate and affect the environment.

Being situated in an environment is a key property of agents

- **Autonomous.** Agents may perform their own decision-making, and need not necessarily comply with commands and requests from other entities.

- **Proactive.** Agents need not wait for commands or requests and may initiate actions of their own accord.

- **Interactive.** Agents may observably respond to external signals from the environment, e.g. reacting to sensed percepts or exchanging messages.

- **Continuous.** Agents are typically a long-lived thread of execution.

- **Social.** Agents interact significantly with other agents in achieving their tasks.

- **Mobile.** Agents may migrate between computing devices—temporarily pausing execution, transferring to another host, and there continuing execution.

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- **Agents** implement the application. Achieve the intended functionality of the system.

- **Frameworks** provide functionality specific to agent software, acting as an interface or abstraction between the agents and the underlying layers. (ex. JADE, COUGAAR, etc.)

- **Platforms** provide more generic infrastructure from which frameworks and agents are constructed and executed. (ex. Windows, Linux, etc.)

- **Hosts** are the computing devices on which the infrastructure and agents execute. (ex. PC, PDA, etc.)

- **Environment** is the world in which the infrastructure and agents exist.

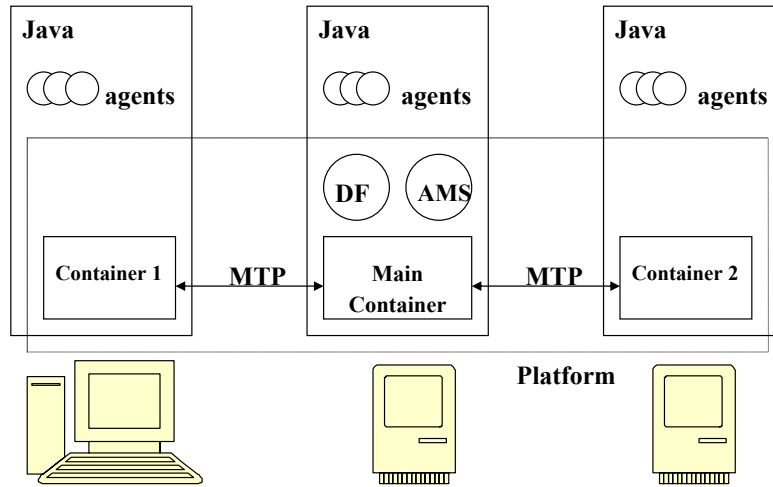*TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.*
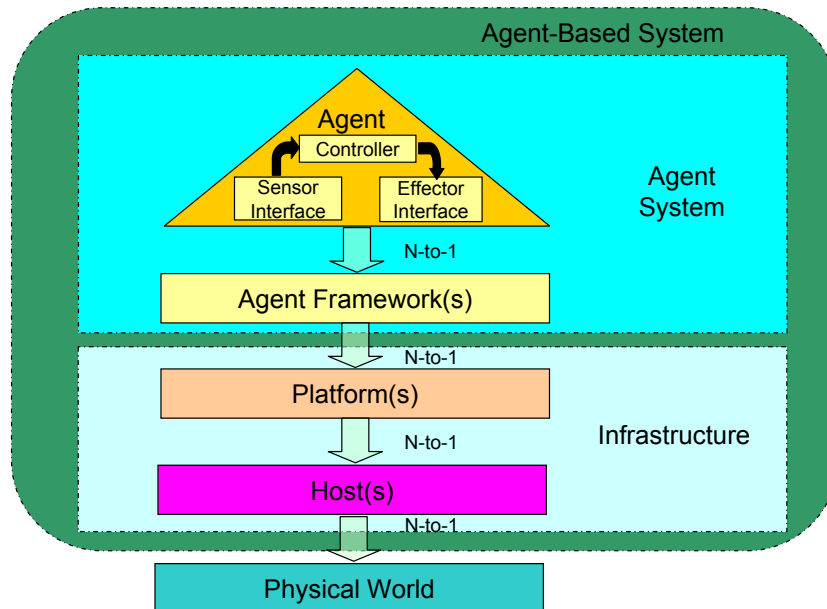
*Agent-Based Systems Reference Model

(See http://gicl.cs.drexel.edu/people/regli/reference_model-v1a.pdf)

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JADE: Java Agent DEvelopment Framework

- FIPA-Compliant Multi-Agent Platform
  - Full Communication model - FIPA-ACL, ontologies, transport (RMI, IIOP, HTTP)
  - Support of Abstract Architecture
    - AMS (Agent Management System) – "white pages"
    - DF (Directory Facilitator) – "yellow pages"
    - ACC (Agent Communication Channel) – message routing
- GUI for remote management, monitoring, control
- Directory Facilities (DFs) can be federated allowing one GUI to control agents on other agent platforms (even non-JADE)
- Efficient Parallel Behavior One thread per agent
  - Multiple concurrent behaviors cooperatively scheduled

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Platform

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Distributed Battle Command Tracking

◆ How can we improve execution monitoring

◆ When, where, why, and how should a subordinate Unit/Asset, executing its part of the plan, alert its partners and/or its HQ that it is not or cannot continue on time with the current Course of Action?

New Plan ———
Actual Track ———
Updated Plan - - - - - -
Actual Deviation ——▶

Target X: 35˚15'22"N 116˚41'24"W

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FM 6-0

Types of Orders
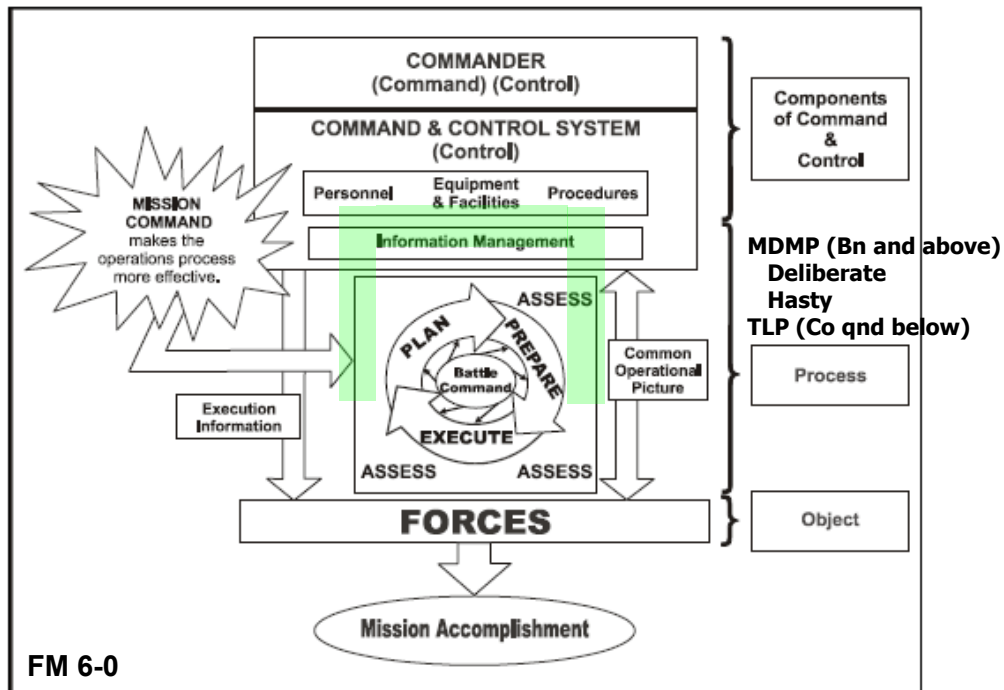
- Administrative Orders
- Combat Orders
  - Warning Order (WARNO)
  - Operations Order (OPORD)
  - Fragmentary Order (FRAGO)

Combat Orders

- **WARNO**
- Preliminary Notice "Heads up", Facilitates Time Management
- Provides operational details
- Outlines key events for mission execution (focus on mission preparation),
  Detail dependent on:
  – Information and time available
  – Information needed by subordinates for proper planning & preparation
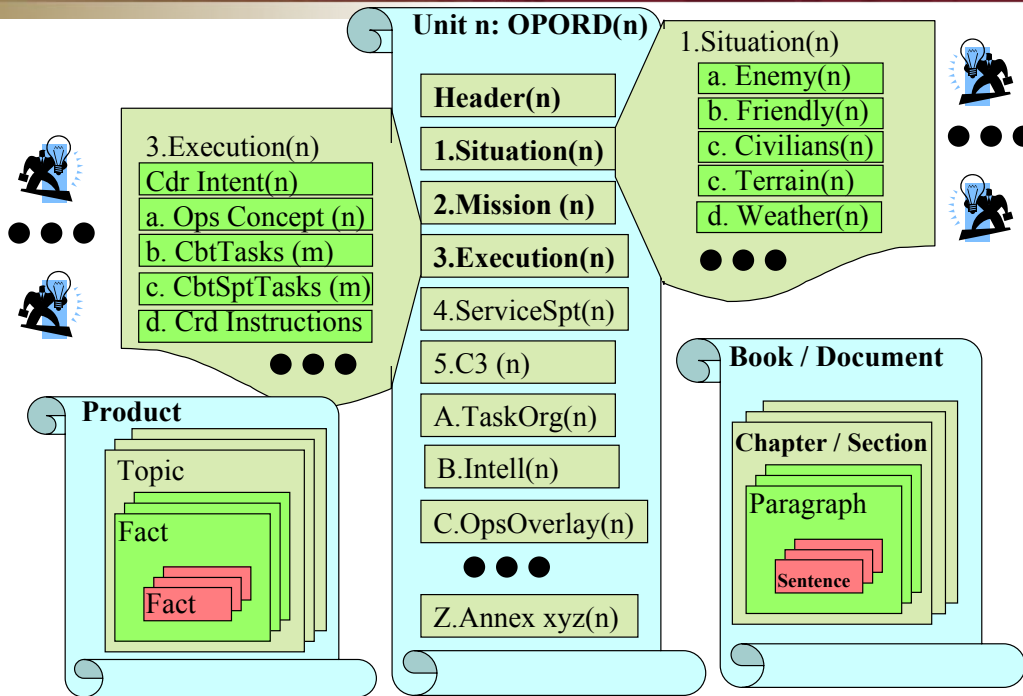- **OPORD**
- Directive issued to subordinate commanders,
- Information to effect execution of an operation
- Always specifies execution time and date
- Focus is on what to do, not how to do it
- Explains why the mission is important
- **FRAGO**
- Address only parts of the OPORD that change
- A brief outline of the changes and instructions

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OPORD - A Basic Outline

- Situation
  – Enemy Forces
  – Friendly Forces
  – Attachments and Detachments
- Mission
- Execution
  – Concept of the Operation
    - Maneuver
    - Fires
  – Tasks to Maneuver Units
  – Tasks to Combat Support Units
  – Coordinating Instructions
- Service Support
  – General
  – Materiel and Services
    - Supply
    - Transportation
    - Maintenance
    - Medical Evacuations
  – Personnel
- Command and Signal
  – Command
  – Signal

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Unit n: OPORD(n)

Header(n)

1.Situation(n)

2.Mission (n)

3.Execution(n)

4.ServiceSpt(n)

5.C3 (n)

A.TaskOrg(n)

B.Intell(n)

C.OpsOverlay(n)

• • •

Z.Annex xyz(n)

1.Situation(n)
- a. Enemy(n)
- b. Friendly(n)
- c. Civilians(n)
- c. Terrain(n)
- d. Weather(n)

• • •

3.Execution(n)
- Cdr Intent(n)
- a. Ops Concept (n)
- b. CbtTasks (m)
- c. CbtSptTasks (m)
- d. Crd Instructions

• • •

Product

Topic

Fact

Fact

Fact

Book / Document

Chapter / Section

Paragraph

Sentence

Fact = {Who(unit/asset), What(do), Whom(unit/asset), When(on), Where (at), Why (to), How(by) ,…}

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*See FM 5-0 e.g. p.202/FM 6-0

(OPLANs, WARNOs, OPORDs, FRAGOs)
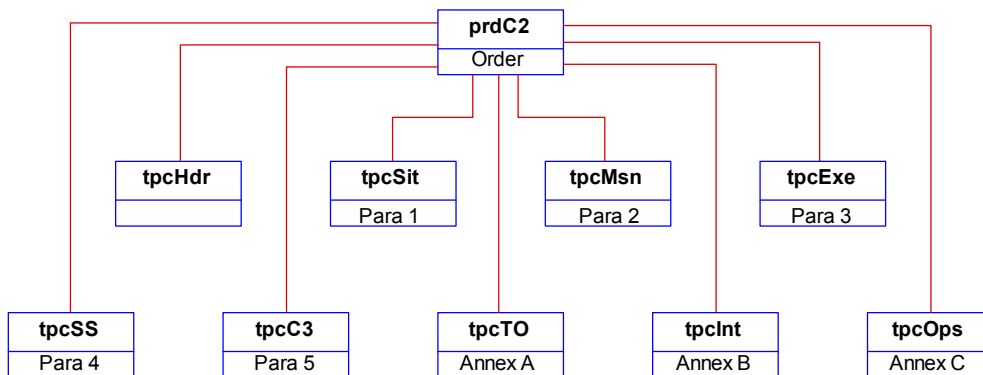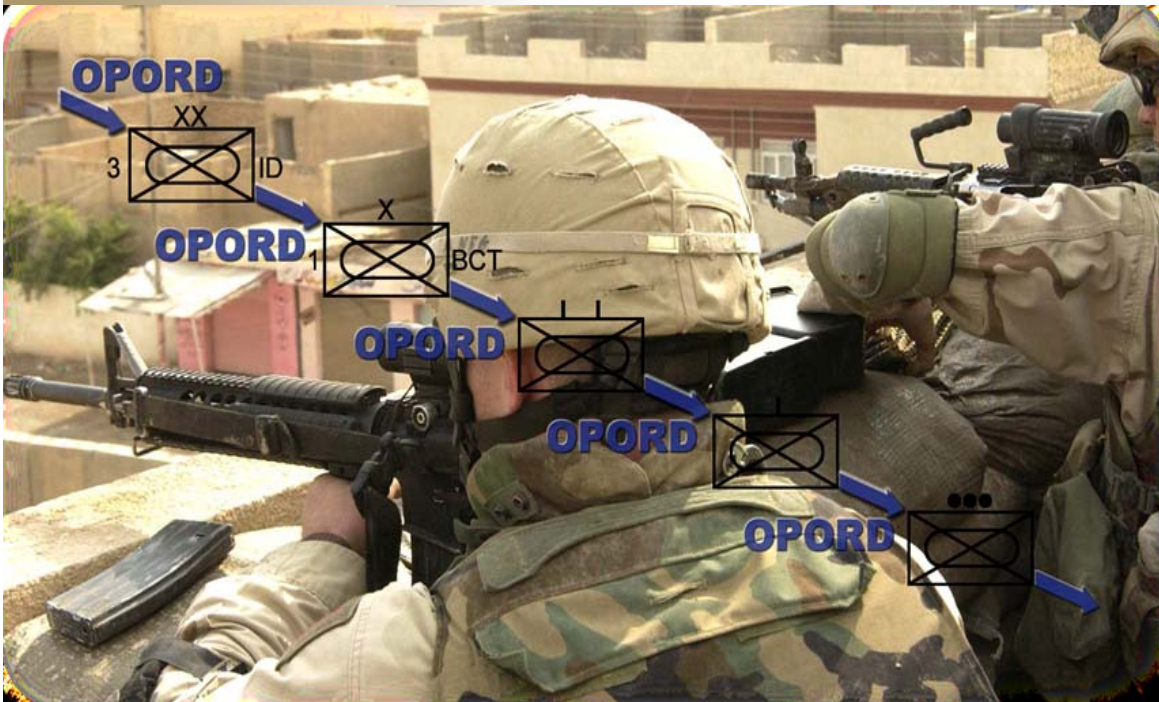
prdC2
Order

tpcHdr		**tpcSit**	**tpcMsn**		**tpcExe**
		Para 1	Para 2		Para 3

tpcSS	**tpcC3**	**tpcTO**	**tpcInt**	**tpcOps**
Para 4	Para 5	Annex A	Annex B	Annex C

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OPORD

XX
3 | ID

OPORD
X
1 | BCT

OPORD

OPORD

OPORD

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

$OPORD_0(n+!)$

$OPORD_0(n)$

$OPORD_1(n+!)$

$OPORD_1(n)$

$OPORD_2(n+!)$

$OPORD_2(n)$

0 - Previous
1 - Current
2 - Next

Plan
Prepare
Execute
Assess

$OPORD_1 (n)$

Mission Received | OPORD Issued | H-hour | WARNO For New Mission | Current Mission Accomplished

FM 6-0

$OPORD_1(n+1)$ $OPORD_1(n)$ $WARNO_2(n+1)$ $OPORD_2(n)$
Mission(n+1)   Mission (n)   Mission(n+1)   Mission (n)
Tasks (n)   Tasks (n-1)   Tasks (n)   Tasks (n-1)
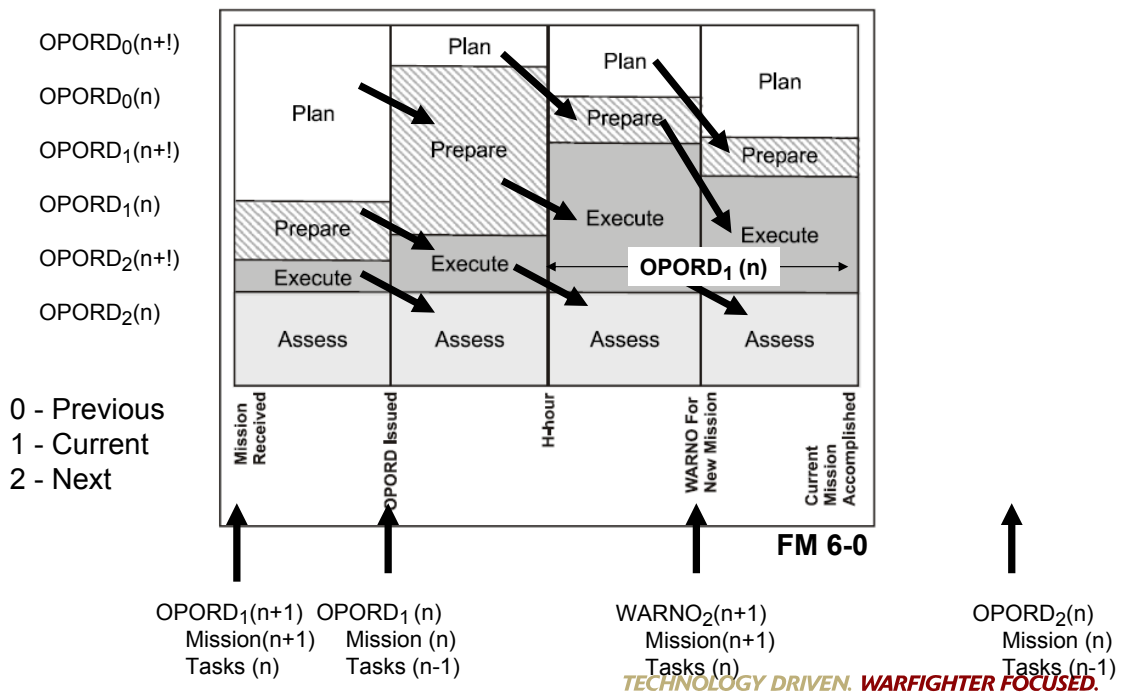
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
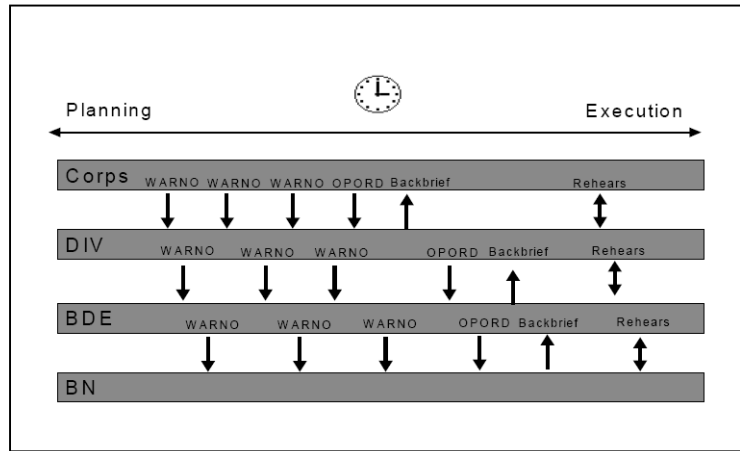
FM 6-0

Information Dissemination & Management (ID&M)

ORDER ISSUED TO YOU

MDMP

TLP

SMEAC

METT-TC
OAKOC
ASCOPE

ORDER YOU ISSUE

ORDER ISSUED TO YOU

I. SITUATION
  A. Enemy Forces
  B. Friendly Forces
    1. Higher
      (a.) Mission
      (b.) Intent
    2. Adjacent
    3. Supporting
  C. Attach/Detach
II. MISSION
III. EXECUTION
  A. Cmdr's Intent
  B. Concept of the Op
    (a.) Scheme of Maneuver
    (b.) Fire Support Plan
  C. Tasks
  D. Coordinating Instructions
IV. ADMIN/LOGISTICS
V. COMMAND/SIGNAL

ORDER YOU ISSUE

I. SITUATION
  A. Enemy Forces
  B. Friendly Forces
    1. Higher
      (a.) Mission
      (b.) Intent
    2. Adjacent
    3. Supporting
  C. Attach/Detach
II. MISSION
III. EXECUTION
  A. Cmdr's Intent
  B. Concept of the Op
    (a.) Scheme of Maneuver
    (b.) Fire Support Plan
  C. Tasks
  D. Coordinating Instructions
IV. ADMIN/LOGISTICS
V. COMMAND/SIGNAL

*TECHNOLOGY DRIVEN. **WARFIGHTER FOCUSED.***

UNT(O)

| UNT(P) | WRN(O) | PLN(O) | OPS(O) | FRG(O) | UNT(D) |

WPOF(P)

wrnPln

opsOrd — collaborate

runEstimate

WARNO(O)

opsPln

opsOrd — collaborate

runEstimate

wrnPln

opsOrd — collaborate

runEstimate

OPLAN(O)

opsOrd

opsPln

runEstimate — collaborate

WARNO(O)

OPORD(O)

opsOrd

runEstimate — frgPln

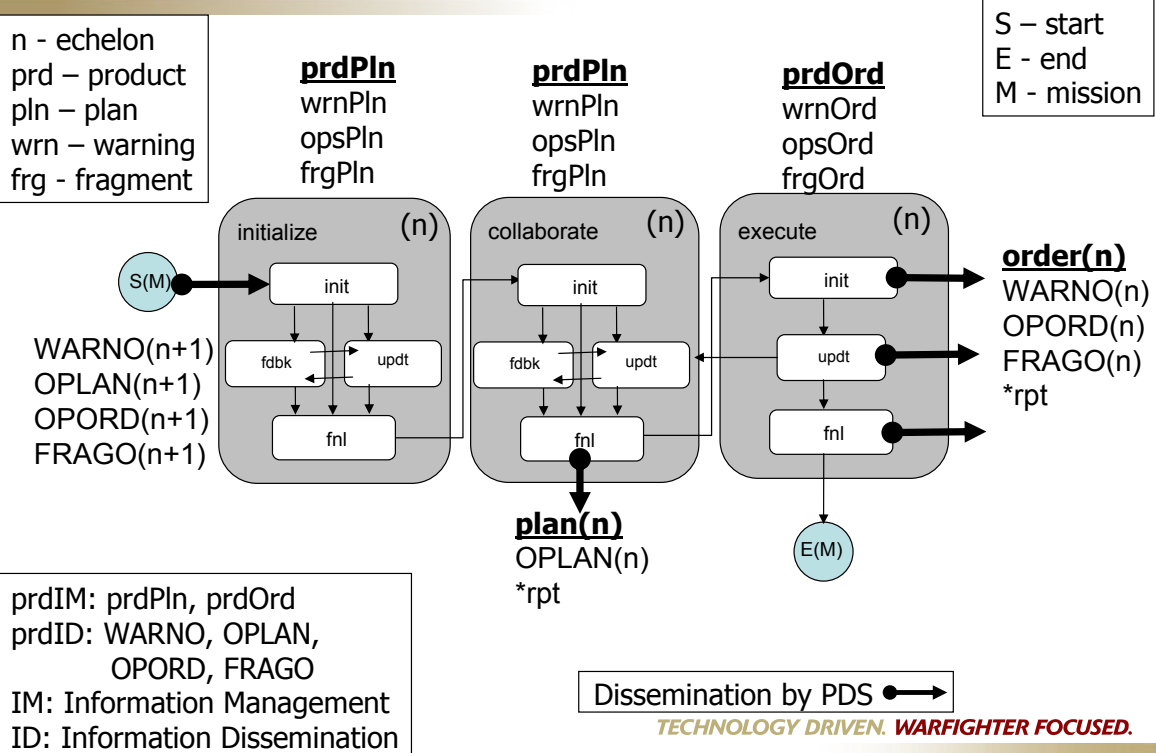collaborate

FRAGO(O)

*TECHNOLOGY DRIVEN. **WARFIGHTER FOCUSED.***

- UNT – Unit system
- P – Parent
- D – Dissemination / Distribution (parent, subordinates, adjacent, supported units)
- O – Own
- WRN – WARNO prdC2 subsystem
- PLN – OPLAN prdC2 subsystem
- OPS – OPORD prdC2 subsystem
- FRG - FRAGO prdC2 subsystem
- WPOF – WARNO | OPLAN | OPORD | FRAGO
- WARNO – Warning Order
- OPLAN – Operations Plan
- OPORD – Operations Order
- FRAGO – Fragmentary Order
- runEstimate is based upon current opsOrd
- opsOrd – imports current OPORD updated with current COP and all FRAGOs issued since OPORD was issues.
- wrnPln – Planned WARNO
- opsPln – Planned OPORD including assumption and relative times (H-Hour / D-Day)
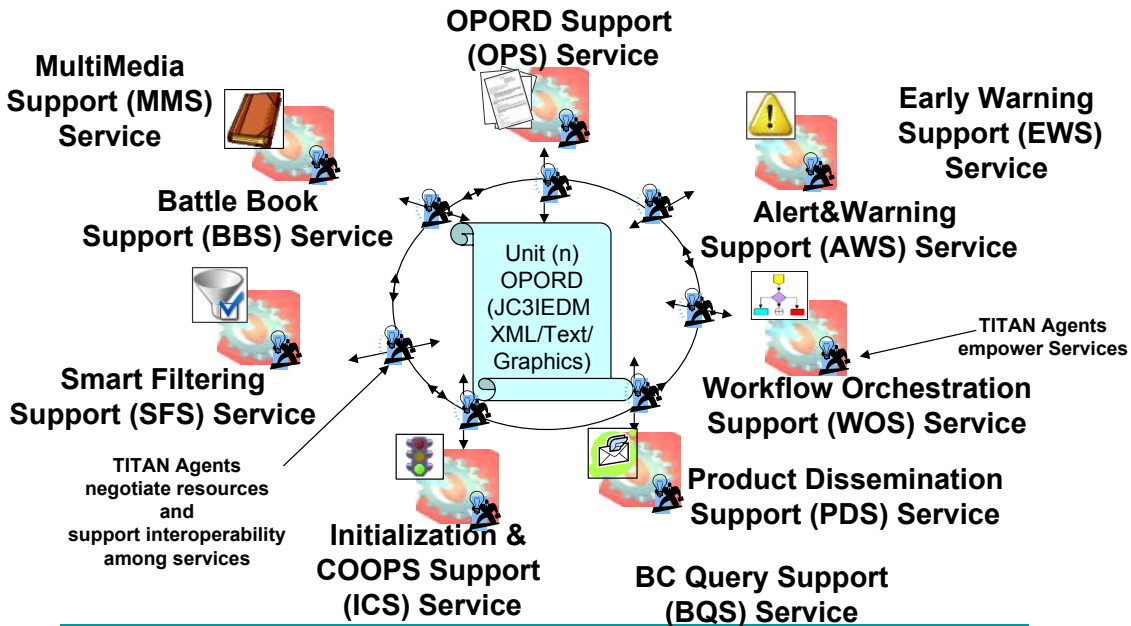- frgPln – Planned FRAGO

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n - echelon
prd – product
pln – plan
wrn – warning
frg - fragment

S – start
E - end
M - mission

prdPln
wrnPln
opsPln
frgPln

prdPln
wrnPln
opsPln
frgPln

prdOrd
wrnOrd
opsOrd
frgOrd

initialize (n)   collaborate (n)   execute (n)

S(M)

init   init   init

fdbk   updt   fdbk   updt   updt

fnl   fnl   fnl

WARNO(n+1)
OPLAN(n+1)
OPORD(n+1)
FRAGO(n+1)

order(n)
WARNO(n)
OPORD(n)
FRAGO(n)
*rpt

plan(n)
OPLAN(n)
*rpt

E(M)

prdIM: prdPln, prdOrd
prdID: WARNO, OPLAN,
    OPORD, FRAGO
IM: Information Management
ID: Information Dissemination

Dissemination by PDS ●—▶

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- Publishing and disseminating prdID
  - WARNO(n) – wrnOrd (execute, fnl,n) updated by running estimates as required
  - OPLAN(n) – opsPln (collaborate,fnl,n) updated by running estimates as required
  - OPORD(n) – opsOrd (execute, fnl,n) updated by running estimates as required
  - FRAGO(n) – frgOrd (execute, fnl,n) updated by running estimates as required
- Transitioning and publishing prdIM
  - WARNO(n+1) $\rightarrow$ wrnPln (initialize, *, n), opsPln (initialize, *, n), frgPln(initialize, *, n)
  - OPLAN(n+1) $\rightarrow$ wrnPln (initialize, *, n), opsPln (initialize, *, n), frgPln(initialize, *, n)
  - OPORD(n+1) $\rightarrow$ wrnPln (initialize, *, n), opsPln (initialize, *, n), frgPln(initialize, *, n)
  - FRAGO(n+1) $\rightarrow$ wrnPln (initialize, *, n), opsPln (initialize, *, n), frgPln(initialize, *, n)
- * prdC2:status:init will be used if this is the first time that any prdID(n+1) has been received,
- prdC2:status:updt will be used if prdC2:status:init has been previously published,
- prdC2status:fnl will be used if prdC2:status:init/updt has been previously published
- wrnPln (initialize, fnl, n) $\rightarrow$ wrnPln (collaborate, init, n)
- opsPln (initialize, fnl, n) $\rightarrow$ opsPln (collaborate, init, n)
- frgPln (initialize, fnl, n) $\rightarrow$ frgPln (collaborate, init, n)
- wrnPln (collaborate, fnl, n) $\rightarrow$ wrnOrd (execute, init, n)
- opsPln (collaborate, fnl, n) $\rightarrow$ opsOrd (execute, init, n)
- frgPln (collaborate, fnl, n) $\rightarrow$ frgOrd (execute, init, n)
- wrnOrd (execute, *, n) $\rightarrow$ WARNO(n)
- opsOrd (execute, *, n) $\rightarrow$ OPORD(n)
- frgOrd (execute, *, n) $\rightarrow$ FRAGO(n)

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Battle Command Support Services Concept

OPORD Support (OPS) Service

MultiMedia Support (MMS) Service

Early Warning Support (EWS) Service

Battle Book Support (BBS) Service

Alert&Warning Support (AWS) Service

Unit (n) OPORD (JC3IEDM XML/Text/ Graphics)

TITAN Agents empower Services

Smart Filtering Support (SFS) Service

Workflow Orchestration Support (WOS) Service

TITAN Agents negotiate resources and support interoperability among services

Initialization & COOPS Support (ICS) Service
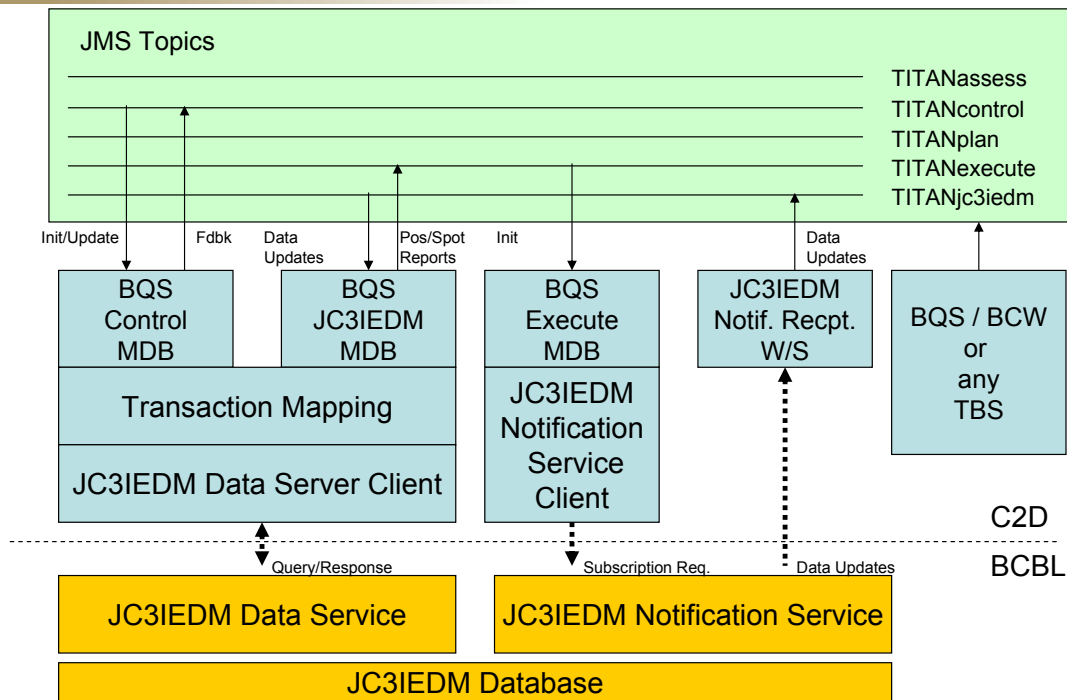
Product Dissemination Support (PDS) Service

BC Query Support (BQS) Service

TITAN Services will be SOAF-A compliant and utilize BCCS Infrastructure

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

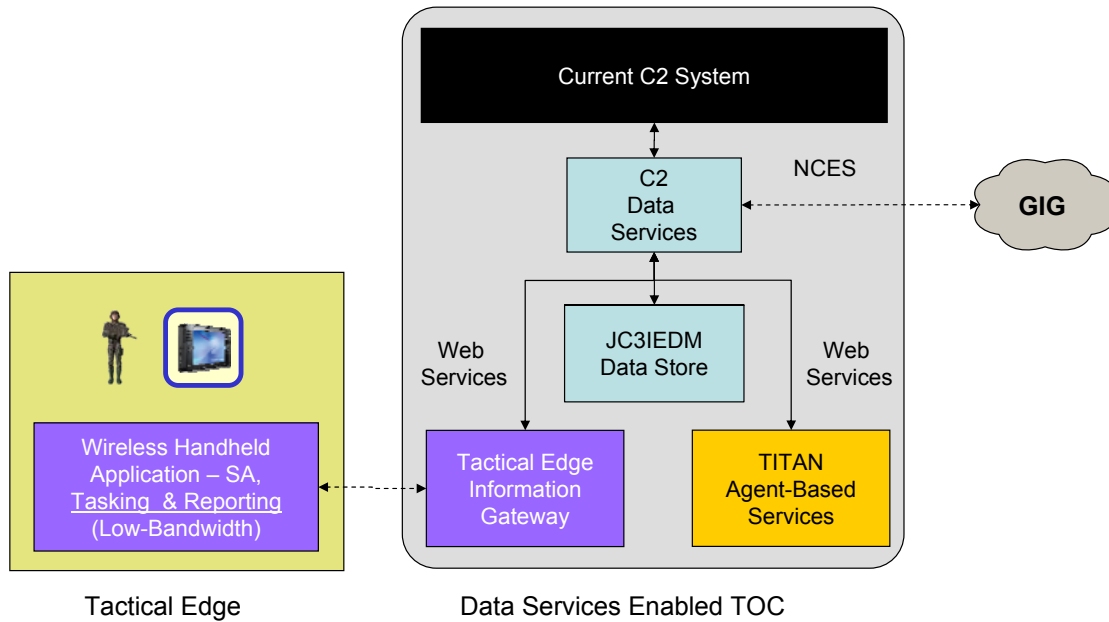TITAN BC Support Services & Agents

ICS

BBS

BCW

OPS

SFS

JMS

AWS

TITAN

PDS

WOS

SOAF-A

BQS

JDS — JC3SOA

VMF*

ABCS — DDS | DMS

NFFI*

CDS

MIP — DEM | Coalition

* proposed

JMS Topics

TITANassess
TITANcontrol
TITANplan
TITANexecute
TITANjc3iedm

| Init/Update | Fdbk | Data Updates | Pos/Spot Reports | Init | | Data Updates | |

| BQS Control MDB | BQS JC3IEDM MDB | BQS Execute MDB | JC3IEDM Notif. Recpt. W/S | BQS / BCW or any TBS |

| Transaction Mapping | | JC3IEDM Notification Service Client | | |
| JC3IEDM Data Server Client | | | | |

C2D

Query/Response   Subscription Req.   Data Updates

BCBL

JC3IEDM Data Service | JC3IEDM Notification Service

JC3IEDM Database

```
┌──────────────────────────────────────────────┐
│           Current C2 System                    │
│                                                │
│              ┌─────────────┐      NCES          │
│              │     C2      │              ┌─────┐│
│              │    Data     │ ‹----------›│ GIG ││
│              │  Services   │              └─────┘│
│              └─────────────┘                     │
│                     │                            │
│   Web        ┌─────────────┐      Web           │
│  Services    │   JC3IEDM   │    Services        │
│              │  Data Store │                    │
│              └─────────────┘                    │
│         │                        │              │
│  ┌──────────────┐         ┌──────────────┐      │
│  │Tactical Edge │         │    TITAN     │      │
│  │ Information   │         │ Agent-Based  │      │
│  │  Gateway     │         │  Services    │      │
│  └──────────────┘         └──────────────┘      │
└──────────────────────────────────────────────┘
```

┌──────────────────────────┐
│   │
│ Wireless Handheld   │
│ Application – SA,   │
│ Tasking & Reporting   │
│ (Low-Bandwidth)   │
└──────────────────────────┘

Tactical Edge   Data Services Enabled TOC

• OPORD Support (OPS) Service

– *Provides BFAs with access to an authoritative source of a distributed, updateable linkable, highly structured XML managed plans and orders organized by units available for collaboration or dissemination.*

– *Includes relevant Mission Products such as COP, Missions, Commanders intent, COO / COA / Tasks, Coordinating Instructions (CCIRs), Task Organization, Overlays, and other available Annexes.*

  • *Managed Plan/order update Agent*

  • *Aggregated Disposition Agent*

  • *AoR / CM Agent*

  • *Activity Tracking Agent*

• Battle Book Support (BBS) Service

– *Provides Commanders and Staff with access to data base of Order of Battle (based on TO&E, MTO&E, Consumables for Friendly, Neutral, and Enemy). Asset Capabilities including weapons, sensors, communications and mobility*

– *Provides Decision Support Tools (Services and Intelligent Agents) with computational parameters needed for CCIR / COA analyses*

  • *Capability update Agent*

  • *Capability Aggregation Agent*

  • *TOE Agent*

• Alert&Warning Support (AWS) Service

– *Supports the generation of warnings and alerts relevant to CCIRs and other coordinating instructions to include Space and Missile Defense sources*

– *Provides predictive assessments and indications of imminent and evolving situations*

– *Support CCIR-driven re-planning and Execution*

  • *Area Protection Agent*

  • *Route Protection Agent*

  • *Route Deviation Agent*

  • *Space-Time Event Cluster Agent*

  • *Readiness Agent*

  • *Strength Agent*

• **Smart Filtering Support (SFS) Service**

  – *Enables the extraction of structured data (graphics, numeric, tabular) from free text reports and messages*

  – *Identifies reports with relevant content for further analyses*

    • *Significant Fact Agent*

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• **Workflow Orchestration Support (WOS) Service**

  – *Provide a SoA Foundation - Army Point of Presence gateway to and from associated TITAN BC services from and to external SoA clients*

  – *Synchronize requests and responses by organizing the workflow of Services across the enterprise by recommending the sequencing coordination activities, tasks and events*

    • *Access Policy Agent*

    • *Service Notification Agent*

    • *Client Posting Agent*

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- **Product Dissemination Support (PDS) Service**

  – *Use OPORD Task Organization and Friendly Situation to determine the addressees to be entered for Dissemination of OPORDs and associated Reports*

  – *Use NETOPS C2 Registry to determine IP addresses for communications over the Tactical Internet invoking QoS, CoS and appropriate policies*

    - *QOS Agent*
    - *COS Agent*
    - *Contact Management Agent*

- **Initialization & COOPS Support (ICS) Service**

  – *Use Parent unit WARNO / OPORD to initialize Own unit OPLAN*

  – *Use Task organization to Support collaboration with Session, Presentation and Application levels of Data Initialization*

  – *Ensure that common relevant data is available to each mission and task work group*

    - *Order Initialization Agent*
    - *Service Connectivity Agent (Using DDS, C2R)*
    - *Service Federation Agent*

- svcToolBar - select and access TBSsvc

- prdC2menu - select prdC2:Type, pull down latest available instances, select instances)

- svcNavPanel – expandable outline, directory-like structure, selectable leaf objects (e.g. unit:, env:, crd:, txt:) highlighted in svcVisPanel and BCWdisPanel

- svcCntrlPanel – set conditions, constraints, & options for behaviors to assess & monitor

- svcStatusPanel – KNW / UNK info, activities indicator, IWA and recommendations

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

- Svc – Service such as OPSsvc, AWSsvc, BBSsvc, SFSsvc, ICSsvc, WOSsvc, PDSsvc

- TBS – TITAN Battle Command Support

- prdC2 – a managed C2 Product for dissemination

- Nav – Navigation

- Env: – Environment Object element

- Crd: – Coordination Object element

- Vis – Visualization

- Cntrl – Control

- Dis – Display

- KNW – Known

- UNK – Unknown

- IWA – Indications, Warnings and Alerts

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

svcToolBar - Select TBSsvc, Access TBSsvc

svcNavPanel –

•expandable outline,
•directory-like
        structure
•selectable leaf
        objects
    •unit:,
        • crd:,
    •env:,
        • txt:
•Highlighted
    •in svcVisPanel
        and
    •BCWdisPanel

prdC2menu
•select prdC2:Type:,
•pull down latest
    available instances,
•select instances

svcCntrlPanel –

•set conditions,

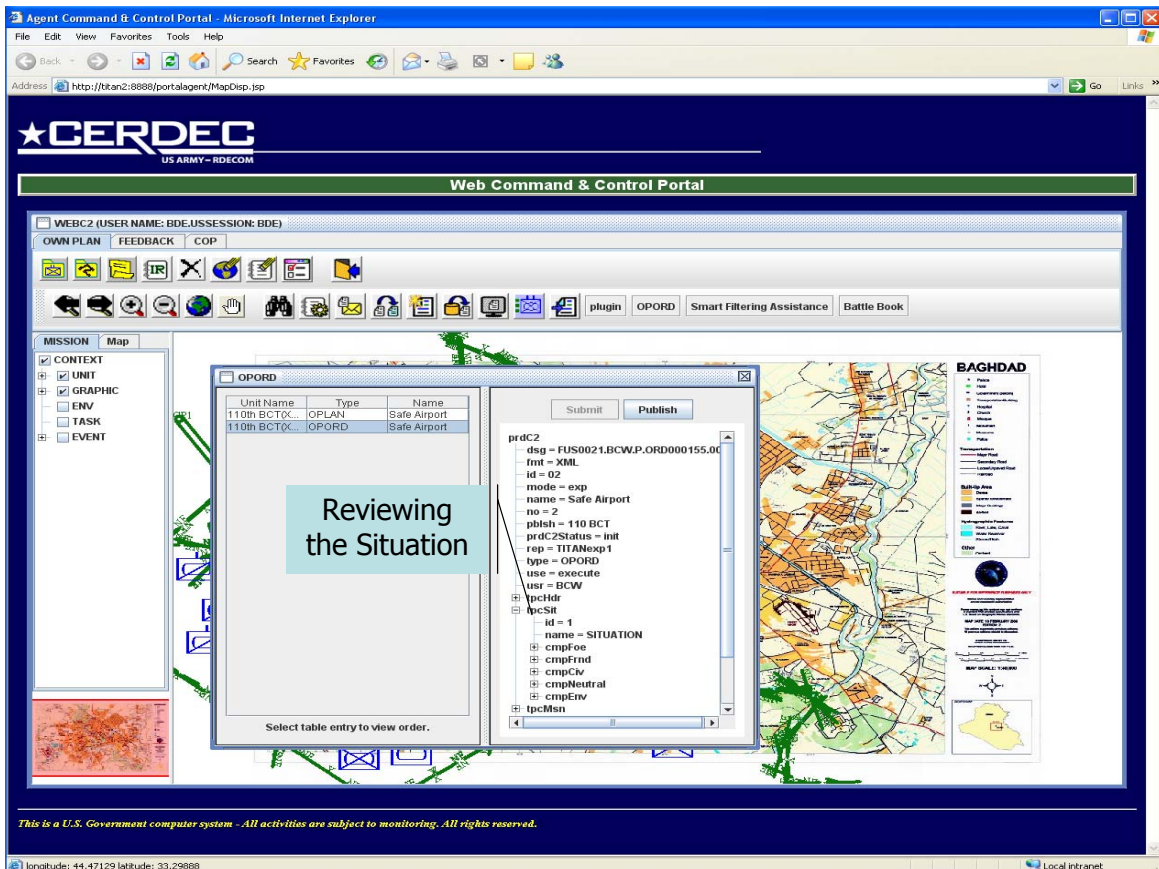•constraints, &

•options

•for behaviors

•to assess & monitor

svcStatusPanel –

• KNW info
• UNK info

• Activities indicatosr,
• Progress statistics

    • IWAs

        • &

            • Conclusions

• Recommendations

- **svcVisPanel** is controlled by **svcNavPanel**,
- **svcVisPanel** is uses the **BCWdisPanel**.
- **BCWdisPanel** is controlled by **BCWnavPanel**

TECHNOLOGY DRIVEN. ***WARFIGHTER FOCUSED.***

AWS Service

- NAI, TAI for Decision Points based upon Event Hotspot

- Threat Indications Warnings and Alerts based upon Enemy Location and Capability