Using a Combination of UML, C2RM, XML, and Metadata Registries to Support Long-Term Development/Engineering

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The original document contains color images.
Objective

• To facilitate C2 Architecture and Applications development in terms of a formal language for C2 based upon a C2RM

• To derive the rules for analyzing and parsing C2 Products from Natural Language to Machine Language for use by C2 Applications.

• To leverage commercial representation and modeling languages such as the Unified Modeling Language (UML) and Extensible Markup Language (XML and associated tools).
Why Reference Models

• “By creating compelling reference models of (domain) knowledge, we lead our organizations into the appropriate conclusions.”
• “Reference models are the patterns of the solution for transforming perception into real-world success.”
• “Reference models simplify problem solving, so that ordinary professionals can practice their discipline with world-class results”
• “Software professionals need reference models in order to understand abstractions”
• “20% of adults have the appropriate world-perspective to define abstractions.”
• “Reference models (and reference architectures) are necessity in the confusing, rapidly changing technology environment in which we practice”
• “Reference models are commonplace in fields of human endeavor”

Relationship of C2UML to C2RM C2RA, and C2XML
C2 Product Example: Operations Order (OPORD)

Five-Paragraph Meta-model based upon FM 101-5, Staff Organization and Operations

◆ Situation
  ◆ The Enemy Forces
    ◆ Who are they? What kind of unit is it? What kind of Equipment do they have?
    ◆ Where are they? How strong are they? Where are they effective?
    ◆ How capable are they? What are they likely to do?
  ◆ The Friendly Forces
    ◆ What is our higher echelon mission and Concept of Operation? What is the mission of adjacent units?

◆ Mission
  ◆ A clear concise, statement of what the unit is to do to include who, where, when, and why of the operation.

◆ Execution
  ◆ What is the Concept of Operation? How to maneuver, how to fire, how to deal with obstacles? In Offense: what unit formations, movement techniques, routes of advance? On Defense: what battle positions to establish, weapon orientation, engagement plan, +more.

◆ Service Support
  ◆ Where is refueling, How? Where is the collection point of damaged vehicles?

◆ Command and Signal
  ◆ How communications will be maintained?
  ◆ What is the command succession?
C2RM Generic Package Classes

- **Image**
  - Photons, Sounds, Scent, Touch, Electromagnetic, Radiation

- **Message**
  - Voice, Text, Alert, Electronic

- **Ordnance**
  - Bombs, Bullets, Shells, Missiles, Photons, Gas, Water, Stones

- **Cargo**
  - Crate, Pallet, Own Weight, Supply, Stowage
Fundamental types of Interactions

Legend:
- Friend (F)
- Foe (G)
- Inflictions/effects
- Identifications
- Communications
- Transportations

a) Infliction/Effects

b) Identification

c) Communication

d) Transportation
F27. Fundamental types of engagements

a) Direct

b) Direct Support/NLOS

c) BLOS

d) Coordinated

e) General Support/NLOS

f) Managed BLOS

g) Support Reinforcement/NLOS

Legend:
- Resource
  - Friend F
  - Foe G
- Inflictions/Effects
  - Identifications
  - Communications
  - Transportations
Nested/Aggregated C2RM Entities

- Vehicles
- Weapons
- C2
- Sensor
- Tcve
- Wpn
- Vcl
- Tranceivers
- Sensors
Network-Centric Sensors

Legend:
- Resource
- Friend F
- Foe G
- Inflictions/Effects
- Identifications
- Communications
- Transportations
Network-Centric Border

Legend:
- Resource
  - Friend F
  - Foe G
- Inflictions
- Identifications
- Communications
- Transportations
Building a Reference Force

Crew / Team

Sec / Sqd

Individual

Crew / Team C2, CS

Sec / Sqd C2 / CS
A Reference Platoon

Reference Platoon C2, CS, CSS

Crew / Team A

Crew / Team B

Crew / Team C
A Reference Battalion

Reference Battalion
C2, CS, & CSS

Reference Company
A Company

Reference Company
B Company

Reference Company
C Company
A Reference Brigade

1st Battalion

Brigade

C2, CS, & CSS

2nd Battalion

3rd Battalion
Armor Unit Representation

Platoon Example

Diagram showing a platoon example with positions for Plt Ldr, Wingman, and Plt Sgt.
Armor Unit Representation

Company Example
Armor Unit Representation

Battalion Example

C2

XO

BCV

S2

Bn Cdr

S3

CSS

X

CS

BSA

UMCP

CTCP

HHC Cdr

Support

S1/S4

Field Trains

HHC XO

Medical

HHC 1Sgt

ENG

FSE

ARTY

M106

M106

M106

M106

ADA

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C2 Systems are like Onions

Onions have layers
Regardless of whether one likes them or not
C2 Systems also have layers

Layers, therefore, are essential to describing onions
Similarly, Layered architectures are critical in representing C2 Systems

The world according to Shrek
Every Port Consists of 7 Logical Layers

(According / Analogous to the OSI Communication Layer Model)

Example
The Communication Port includes the following layers:

7. **Application Layer** – The GOAL of the C2 process enabled by the port.
6. **Presentation Layer** – translates formats between the port and the application.
5. **Session** – responsible for a complete sequence / dialog of actions necessary to complete a set of transactions.
4. **Transport** – a middle and supervising layer to provide transparency of the networking between any two port types/users.
3. **Network** – multi-connection between more than two assets of the same port type.
2. **Link** – single connection between two assets of the same port type.
1. **Physical** – the port’s electrical and physical interface to the environment.
F6. Layering the Problem/Solution domain

**PEER-TO-PEER LOGICAL RELATIONSHIPS**

**Problem Domain**
- Future
- Present
- Past

**Time Domain**
- Far-Term Course-of-Action (CoA)
- Near-Term CoA
- Established Precedent CoA

**Space Domain**
- Multi-Lateral
- Bilateral
- Unilateral

**Solution Domain**
- Combined Capability
- Relative Capability
- Unit Capability

**Environment/Interaction Media**
F5. Domains for developing C2 objects
Extending the ISO OSI RM to C2

An ISO OSI RM System

Application (Process) Layer

ISO OSI RM

BRG OSI RM

Communications Port

A C2RM Unit, Resource, Asset

C2 Application Layers

D

P

O

A

C2 Port Layers

Communications Port

Transportations Port

Identifications Port

Inflictions* Port

*Inflictions = Negative Effects / Impacts (lethal / non-lethal)
C2 applications Layers

PEER-TO-PEER
LOGICAL RELATIONSHIPS

Resource A

- C2 Conflict
- C2 Presentation
- C2 Operation
- C2 Procedure
- C2 Network
- C2 Link
- C2 Asset

Resource B

- C2 Conflict
- C2 Presentation
- C2 Operation
- C2 Procedure
- C2 Network
- C2 Link
- C2 Asset

Objectives/Guidance
Resources Selection
Courses-of-Action
Resources Deployment
Orders
Monitor Status
Rules of Reporting
Rules of Engaging
Id Data Fusion
Coordinated Engagement
Single Target
Id/Engagement
Sensor/Radar
Mover/Shooter

Environment/Interaction Media
Inflictions Layers

PEER-TO-PEER LOGICAL RELATIONSHIPS

Request Negative Effect / Impact Service
Impact Service Status
Feasible Negative Effect / Impact
Negative Effect / Impact Assessment
Delivery Readiness
Synchronize Deliveries
Delivery Flow Control
Delivery Logistics
Positioning Control
Delivery Coordination
Delivery Range
Delivery Error Control
Armament Load
Armament Range

Actual Path/Media for Inflictions
Transportations Layers

PEER-TO-PEER LOGICAL RELATIONSHIPS

Resource A

Application
Presentation
Session
Transport
Network
Link
Physical

Request Cargo Service
Cargo Service Status
Cargo Supply
Cargo Demand
Logistic Support
Synchronize User Tasks
Logistic Flow Control
Cargo Assembly/Disassembly
Route/Congestion Control
Multipath Navigation
Single Road Connection
Single Road Navigation
Mechanical Force
Wheels/Tracks/Wings

Resource B

Application
Presentation
Session
Transport
Network
Link
Physical

Actual Path/Media for Transportations
C2 and Port Layers Integration
F33. Technology base layers

Resource A
- Experience
- Knowledge
- Information
- Object
- Tool
- Equipment
- Supply

External Interface

Physical exchange object

Resource B
- Experience
- Knowledge
- Information
- Object
- Tool
- Equipment
- Supply

Motivation
Intentions
Causality
Practicality
Relevancy
Certainty
Admissibility
Accuracy
Flexibility
Portability
Capability
Supportability
Producibility
Consumability

PEER-TO-PEER LOGICAL RELATIONSHIPS

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Entity Domains

Problem-Solution Domain {Operational & Organizational}

- Missions
- Plans
- Tasks
- Jobs
- Assignments
- Transactions
- Packages

Technology-Implementation Domain {Technical & System}

- Experience
- Knowledge
- Information
- Object
- Tool
- Equipment
- Supply
A C2 perspective
F32b. Inserting C2 into existing technology

• A technology perspective

Recommendations
Conclusions
Understanding

Supply
Equipment
Tool

Object
Information
Knowledge
Experience

C2 Conflict
C2 Presentation
C2 Operation
C2 Procedure
C2 Network
C2 Link
C2 Asset

Presentation
Session
Transport
Network
Link
Physical

Environment/
Interaction Media

Understanding
Experience
Wisdom

Recommendations + Conclusions = Understanding

= Understanding

= Wisdom

+ Experience

= Wisdom

Energy
(Pulses)
(Codes)
(Bundles)
(Conclusions)
(Recommendations)
(Judgements)
### TAnB1. C2RM Key Words

- **Coherent, Consistent Taxonomy**

  **Port,** Physical, Link, Network, Transport, Session, Presentation, Application  
  **Interaction,** Communications, Transportations, Identifications, Inflictions  
  **Official,** Operator, Coordinator, Administrator, Agent, Controller, Planner, Commander  
  **Method,** Instruction, Technique, Discipline, Schema, Tactic, Strategy, Policy  
  **Leader/Commander,** Expert, Partner, Captain, Manager, Director, General, President  
  **Product/Requirement/Fact,** Package, Transaction, Assignment, Job, Task, Plan, Mission  
  **Conflict,** Armament, Engagement, Combat, Battle, Campaign, War, Peace  
  **Representation,** Energy, Pulse, Code, Bundle, Conclusion, Recommendation, Judgment  
  **Base,** Supply, Equipment, Tool, Object, Information, Knowledge, Experience  
  **C2 Application,** Asset, Link, Network, Procedure, Operation, Presentation, Conflict  
  **Organization Module,** Item, Component, Entity, Element, Resource, Unit, Enterprise  
  **C2 Service,** Environment, Friend, Foe, Relative, Requirement, Generation, Evaluation, Specification  
  **C2 Modes,** Assess, Develop, Monitor  
  **Package,** Ordnance, Image, Message, Cargo  
  **Problem/Solution (C2) Domain,** Command, Center, Staff, Application, Service, Utility, Facility  
  **Implementat'n/Technology Domain,** Setting, Session, Phase, Base, Service, Utility, Facility  
  **Services,** Display, Enter, Process, Store, Flow  
  **Scenario,** Scenario, Snapshot, Overlay, Cell, Cr_object  
  **Conflict Region (Cr) Object,** Unit, Coordination, Environment  
  **Statement elements:** Who(source), What(action), Whom/Which(target), When, Where, How, Why(outcome)
The **Massive amount** of Reconnaissance and Surveillance assets forces distributed control, distributed processing and semi-autonomous collaboration between the assets.

The goals are:

1. Only **Identified** and **Verified** objects emerge.
2. Efficient deployment of the Sensors.
3. Reduced number of errors and false alarms.
4. Saving bandwidth.
Identification Asset

Set Priorities, Plan Session, Create/End Session Multi-Entities Correlation

Inter-System Fusion Change angle/altitude

Physical Signal

Uniform Format of Instructions Joint Integrated Report

Multi-Entities Fusion, Target Allocation Improve Location

Single Detection
Unattended Ground Netted Sensors

- Fusion
- Processed Data
- Detection

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Layered Multi-Sensor Integration

Communication between Sensor systems and C2 Vehicle

Communication between Interoperable Sensor systems-RPC

Reconnaissance & Surveillance Application

Uniformity Of Report

Directing, Correlation

Entities Fusion

System Fusion

Detection

Raw Signal

Unattended Ground Netted Sensors

Unattended Ground Linked Sensors

Manned Netted Reconnaissance & Surveillance Sensor

UAV
Cr_object Layered_interaction

N_Da_Objects

N_Cr_Objects

Unit 123
Move 1st Inf Unit
Establish Convoy
Move Order
Vehicle Sec
Way Points
Velocity Acceleration
APC M113

Request Cargo/Mvr Service
Cargo/Mvr Service Status
Cargo/Mvr Supply
Cargo/Mvr Demand
Logistic/Mvr Support
Synchronize Mvr Tasks
Log./Mvr Flow Control
Cargo Assembly/Disassembly
Route/Congestion Control
Multipath Navigation
Single Road Connection
Single Road Navigation
Mechanical Force
Wheels/Tracks/Wings

Availability,
Trafficability,
Mobility
Weight
Sqm-Sec
Route1, Route2, Route3
Gradient Surface
Location

Action Flow
Event Flow

N_Cr_Objects

Region 456

Terrain Database

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There are four different types of ports, but there may be a few of each kind.

Use-cases Views per Use-Case.

Mission Level Views

Task Level Views

PortApp Level Views

PortLayer Level Views

C2App Level Views

System

Subsystem

Package of “use-cases views”
Use Case Name : Report Status
Preconditions: Previous Status Info.
Post Conditions: New Updated Status Info.
Description: The Commander initiated a status request, the Ranger can’t make contact with his Subordinates.

{repeat until either status report is received or 10 minutes have elapsed}
{1 minute}
Warfighter Ports Use Cases

(Example)

PLGR

Commander

Get Coordinates
Send/Get Image
Talk to Rescuee
Send/Get Data

Communication Port

Rescuee

Locate Rescuee
Watch Route
Track Targets
Look for Threats
BDA

Identification Port

C2

Infliction (Effects) Port

Camouflage Rescuee
hit Target

Transportation Port

Move
Transport Rescue
Supply / Cargo
Take Cover

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Zoom-in on a Typical Layer

A "Layer" Sub-Sub-System

Use-Case 1 (Service)
Use-Case 2 (Service)
Use-Case 3 (Service)

Layer N+1
Layer N
Layer N-1

User Layer
Provider Layer
Peer LSS Collaborator

Virtual Connection

LSS – Layer Subsystem
Communication Network Layer

Network Layer

- Set Priorities
- Control Traffic
- Monitor Route
- Create/End Route

Transport Layer

Link Layer

LSS – Layer Subsystem
# Layered Port Classes and Subclasses

<table>
<thead>
<tr>
<th>GENERAL PORT</th>
<th>Identification</th>
<th>Communication</th>
<th>Infliction</th>
<th>Transportation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint Integrated Report</td>
<td>ISR Data</td>
<td>Encryption</td>
<td>Effect Data</td>
<td>Supply Data</td>
</tr>
<tr>
<td>Synchronize user tasks</td>
<td>ICD/IFF</td>
<td>Compression</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Set Priorities / Plan Session</td>
<td>BD.A</td>
<td>Enable logon, Establish QoS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Control</td>
<td>Multi-Entities Fusion</td>
<td>Assemble/Disassemble Packets</td>
<td>Authorize Weapon Establish Possible Effect</td>
<td>Cargo Supply/Demand</td>
</tr>
<tr>
<td>Resource Allocation</td>
<td>Classify/Verify</td>
<td></td>
<td></td>
<td>Monitor Unit’s Location</td>
</tr>
<tr>
<td>Position Control</td>
<td>Multi-Sensor Correlation</td>
<td>Route Connection</td>
<td>Match Munitions to Desired Effects</td>
<td>Assemble/Disassemble Cargo</td>
</tr>
<tr>
<td>Route Connectivity</td>
<td>Single Detection</td>
<td>Traffic Control</td>
<td></td>
<td>Route Connection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Radio</td>
<td>Control Fire Tempo</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Arm Weapon</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Fuel Vehicle</td>
<td></td>
</tr>
</tbody>
</table>

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Formalizing C2 Products

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<th>W6H Elements and Templates</th>
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<td>C2 Conflict</td>
</tr>
<tr>
<td>C2 Presentation</td>
</tr>
<tr>
<td>C2 Operation</td>
</tr>
<tr>
<td>C2 Procedure</td>
</tr>
<tr>
<td>C2 Network</td>
</tr>
<tr>
<td>C2 Link</td>
</tr>
<tr>
<td>C2 Asset</td>
</tr>
</tbody>
</table>

C2 Layers

Port Layers

Communications | Presentations | Transportations | Inflections

Environment /Interaction Media

<table>
<thead>
<tr>
<th>Natural Language</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPORDER</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>W6H Instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>W6H Element Parser</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>W6H relationships</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Language</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>XML Instances</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2(X)ML</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sentences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statements</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Peace</th>
</tr>
</thead>
<tbody>
<tr>
<td>War</td>
</tr>
<tr>
<td>Campaign</td>
</tr>
<tr>
<td>Battle</td>
</tr>
<tr>
<td>Combat</td>
</tr>
<tr>
<td>Engagement</td>
</tr>
<tr>
<td>Armament</td>
</tr>
</tbody>
</table>

Elements and Templates
W6H Class Diagram

**when**

<table>
<thead>
<tr>
<th>Who</th>
<th>Whom/Which</th>
</tr>
</thead>
<tbody>
<tr>
<td># whose</td>
<td># whose</td>
</tr>
<tr>
<td>+ which</td>
<td>+ which</td>
</tr>
<tr>
<td>+ where</td>
<td>+ where</td>
</tr>
<tr>
<td>+ when</td>
<td>+ when</td>
</tr>
<tr>
<td># why</td>
<td># why</td>
</tr>
<tr>
<td>+ what</td>
<td>+ what</td>
</tr>
<tr>
<td>- how</td>
<td>- how</td>
</tr>
</tbody>
</table>

**where**

<table>
<thead>
<tr>
<th>Which</th>
</tr>
</thead>
<tbody>
<tr>
<td># whose</td>
</tr>
<tr>
<td>+ which</td>
</tr>
<tr>
<td>+ where</td>
</tr>
<tr>
<td>+ when</td>
</tr>
<tr>
<td># why</td>
</tr>
<tr>
<td>+ what</td>
</tr>
<tr>
<td>- how</td>
</tr>
</tbody>
</table>
The “Who” / “Whom” Class

- whose
- which
- where
- when
- why
- what
- how

Who/Whom

Unit

Resource

Individual

Asset
The “Which” Class

The Which Class
- how
- what
- when
- why
# whose
+ which
# why
+ what
- how

Platform

Environment

Coordination
The “Which” Platform Subclasses
The Other “Which” Subclasses

Environment Subclasses

- Space
- Air
- Water
- Ground

Coordination Subclasses

- Geometry
- Coordination
- Point
- Line
- Area
- Volume
Control Language for C2 Products

Control Language Definition

Control Language is made of simple sentences (associations) using 2 or more W6H Elements constructs. There are two types of constructs: Main and Supplemental.

* **Main Constructs** includes all W6H elements **at most one time**.

  Who (does) **what** (action) (to) whom (with) which, where, when, why and how.

* **Supplemental Constructs** are derived using UML-based Domain Object statements:

  Which W6H element is included in which other W6H element?
  Which W6H element is extended by which other W6H element?
  Which W6H element is a generalization/specialization of which other W6H element?
  Which W6H element is an aggregate (shared/composite) of which other W6H element?
  Which W6H element is equivalent to which other W6H element?

Commander’s Intent Example W6H Relationships

**Who**(1st Armored Brigade) **What**(destroy) **Whom**(enemy) **Which** (using minimum force)

**Where**(in objective area) **When**(on order)

**Why**(to ensure safe forward passage by 21st Infantry Division)

**How**(immediate, wedge formation,)
An XML Schema Using W6H Constructs

Main Construct

Supplemental Constructs

Color Schema

When
Who
Which
What
Whom
Which
Where
How
Why

When
Why
Where
How

Generated with XMLSpy Schema Editor www.xmlspy.com
### Singly-Nested Main Statement Elements Constructs Schemata

<table>
<thead>
<tr>
<th>When (for a given statement)</th>
<th>Who (for the given When)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where (for the given When)</td>
<td>When (for the given Who)</td>
</tr>
<tr>
<td>Who (is at the given When)</td>
<td>Where (is the Who)</td>
</tr>
<tr>
<td>What (occurs at the given When)</td>
<td>How (does the Who implements the What)</td>
</tr>
<tr>
<td>Whom (is at the given When)</td>
<td>Why (use this particular Who)</td>
</tr>
<tr>
<td>How (the When is bounded and subdivided)</td>
<td>Whom (for the given When)</td>
</tr>
<tr>
<td>Why (use the given When)</td>
<td>When (for the given Whom)</td>
</tr>
<tr>
<td></td>
<td>Where (is the Whom)</td>
</tr>
<tr>
<td></td>
<td>How (is the Whom affected by the What)</td>
</tr>
<tr>
<td></td>
<td>Why (use this particular Whom)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What (occurs for the given When)</th>
<th>Who (for at the given When)</th>
</tr>
</thead>
<tbody>
<tr>
<td>When (for the given What)</td>
<td>When (for the given Who)</td>
</tr>
<tr>
<td>Where (is the What)</td>
<td>Where (is the Who)</td>
</tr>
<tr>
<td>How (is the What affected by the Where)</td>
<td>How (does the Who implements the What)</td>
</tr>
<tr>
<td>Why (use this particular What)</td>
<td>Why (use this particular Who)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Where (for the given When/Who/What/Whom)</th>
<th>Why (use this particular When/Where/Who/What/Whom/How)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How (is the Where bounded and subdivided)</td>
<td>Which (reason is applicable for this Why)</td>
</tr>
<tr>
<td>Why (use this particular Where)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How (for the given When/Where/Who/What/Whom)</th>
<th>Why (use this particular When/Where/Who/What/Whom/How)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Which (parts are used for this particular How)</td>
<td></td>
</tr>
<tr>
<td>Why (use this particular How)</td>
<td></td>
</tr>
</tbody>
</table>

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## Identifying W6H Elements in OPORDER

### OPORDER Excerpt

On order IBCT deploys to MACRAN REPUBLIC and moves immediately to Kazar to secure the KACANIC CORRIDOR, PRISTINA Airfield, and PRISTINA, and to establish a US presence throughout the zone.

### W6H Elements for OPORDER Excerpt

<table>
<thead>
<tr>
<th>W6H Elements</th>
<th>W6H Metadata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who /whom/whose:</td>
<td>unit, resource, asset, individual</td>
</tr>
<tr>
<td>What (do):</td>
<td>action, plan, operation, task, mission, results, status, outcome</td>
</tr>
<tr>
<td>Which (object/product):</td>
<td>platform, equipment, supply, system, package(messages, images, cargo, ordnance)</td>
</tr>
<tr>
<td>Where (at):</td>
<td>place, vicinity, coordinates, region, location, position</td>
</tr>
<tr>
<td>When (on):</td>
<td>datetime, event, before, after, during, parallel, sequential, o/o</td>
</tr>
<tr>
<td>Why (to):</td>
<td>purpose, goal, objective</td>
</tr>
<tr>
<td>How (by):</td>
<td>organization, formation (arrangements of forces for specific purposes), command relationship (degree of control responsibility), timing</td>
</tr>
</tbody>
</table>
W6H Elements for OPORDER Excerpt

On order IBCT deploys to MACRAN REPUBLIC and moves immediately to Kazar to secure the KACANIC CORRIDOR, PRISTINA Airfield, and PRISTINA, and to establish a US presence throughout the zone.

W6H General rules:
Each sentence is composed of a set of W6H elements. Each complex W6H element may be decomposed into W6H sub-elements. Iterate W6H rules for each complex W6H element. Apply template/logic to relate between W6H elements and sub-elements. Apply template/logic to relate between abstract references and concrete context.

W6H Element rules:
Find conjunctions and separate complex sentences into simple sentences. Find pronouns and substitute names from context. Identify non-essential background information. Find noun phrases to identify who and whom. Find verb phrases to identify what actions are taken. Look for the temporal phraseology (time) to extract when. Look for spatial phraseology (places) to extract where. Identify how for each what if any. Find goal phrases by looking for “to” “for” “because” and other “rationale” phraseology to identify why.

W6H Association Rules:

W6H Relationships for OPORDER Excerpt (Control Language)

IBCT is a US unit

On order IBCT deploys to MACRAN REPUBLIC

On order IBCT moves immediately to zone

IBCT secures zone. IBCT establishes presence throughout zone

Zone is in Kazar. IBCT is in zone

Kacanic Corridor is in zone. Pristina Airfield is in zone. Pristina is in zone
<table>
<thead>
<tr>
<th>Control Language Constructs</th>
<th>XML tagging applied to Control Language Constructs</th>
</tr>
</thead>
</table>
| IBCT is a US unit          | `<unit type="tactical" name="IBCT" id="1st" role="Combat" size="Bde
Team" aff="US" cmps="(+)"/>` |
| On order IBCT deploys      | `<on type="order"/>` |
| to MACRAN REPUBLIC          | `<do type="task">deploy</do>` |
| On order IBCT moves immediately to zone | `<do type="task">move</do>` |
| IBCT secures zone          | `<to><do type="task">secure</do>` |
| IBCT establishes presence throughout zone | `<to><do type="task">establish presence</do>` |
| zone is in Kazar           | `<include><at type="zone" name=""/> <at type="region" name="Kazar"/></include>` |
| KACANIC CORRIDOR is in zone | `<include><at type="corridor" name="KACANIC"/> <at type="zone" name=""/></include>` |
| PRISTINA Airfield is in zone | `<include><at type="airfield" name="PRISTINA"/> <at type="zone" name=""/></include>` |
| PRISTINA is in zone        | `<include><at type="city" name="PRISTINA"/> <at type="zone" name=""/></include>` |
Conclusions

• UML is a viable and robust meta-model for all Object-Oriented models
• UML can be represented effectively in XML
• The C2 domain is inherently Object-Oriented
• UML is a viable and robust meta-model for C2 architectures and applications
• C2 Applications and architectures can be represented effectively in XML
• C2RM is needed as viable and robust meta-model for all C2 UML models and applications and all C2 XML representations
• C2 metadata registries will be more effectively utilized if they are designed to correspond to a robust C2 meta-model such as the C2RM
For More Information

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Inter-relating ISO 11179 Concepts and Domains

<table>
<thead>
<tr>
<th>DE Concepts:</th>
<th>Concept Domains:</th>
<th>DEs:</th>
<th>Value Domains:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone</td>
<td>Drop Zone</td>
<td>DZ</td>
<td>[Point]</td>
</tr>
<tr>
<td>Location</td>
<td>Ground Location</td>
<td>GL</td>
<td>[Lat/Lon]</td>
</tr>
<tr>
<td>Coordinate</td>
<td>Geographic Coordinate</td>
<td>GC</td>
<td>[Lat]</td>
</tr>
</tbody>
</table>

DE Concept: The Data Field / Variable, eg: Zone
Concept Domain: The Data Use / Context, eg: Drop Zone
DE: the Data Field Identifier / Name / Symbol, eg: “DZ”
Value Domain: [Point]

DE Concept: The Data Field / Variable, eg: Location
Concept Domain: The Data Use / Context, eg: Ground Location
DE: the Data Field Identifier / Name / Symbol / Label, eg: “GL”
Value Domain: [Lat/Lon]

DE Concept: The Data Field / Variable, eg: Coordinate
Concept Domain: The Data Use / Context, eg: Geographic Coordinate
DE: the Data Field Identifier / Name / Symbol, eg: “GC”
Value Domain: [Latitude]
Information Architecture for Unit Status

<status>

<strength>
  <troops>
  <equipment>

<capability>
  <lethality>
  <mobility>
  <SA>
  <survivability>
  <interoperability>

<disposition>
  <location>
  <formation>
  <posture>
  <activity>

<readiness>
  <training>
  <maintenance>
  <supply>