

# **Joint Doctrine Ontology as Benchmark for Military Information Systems Interoperability**

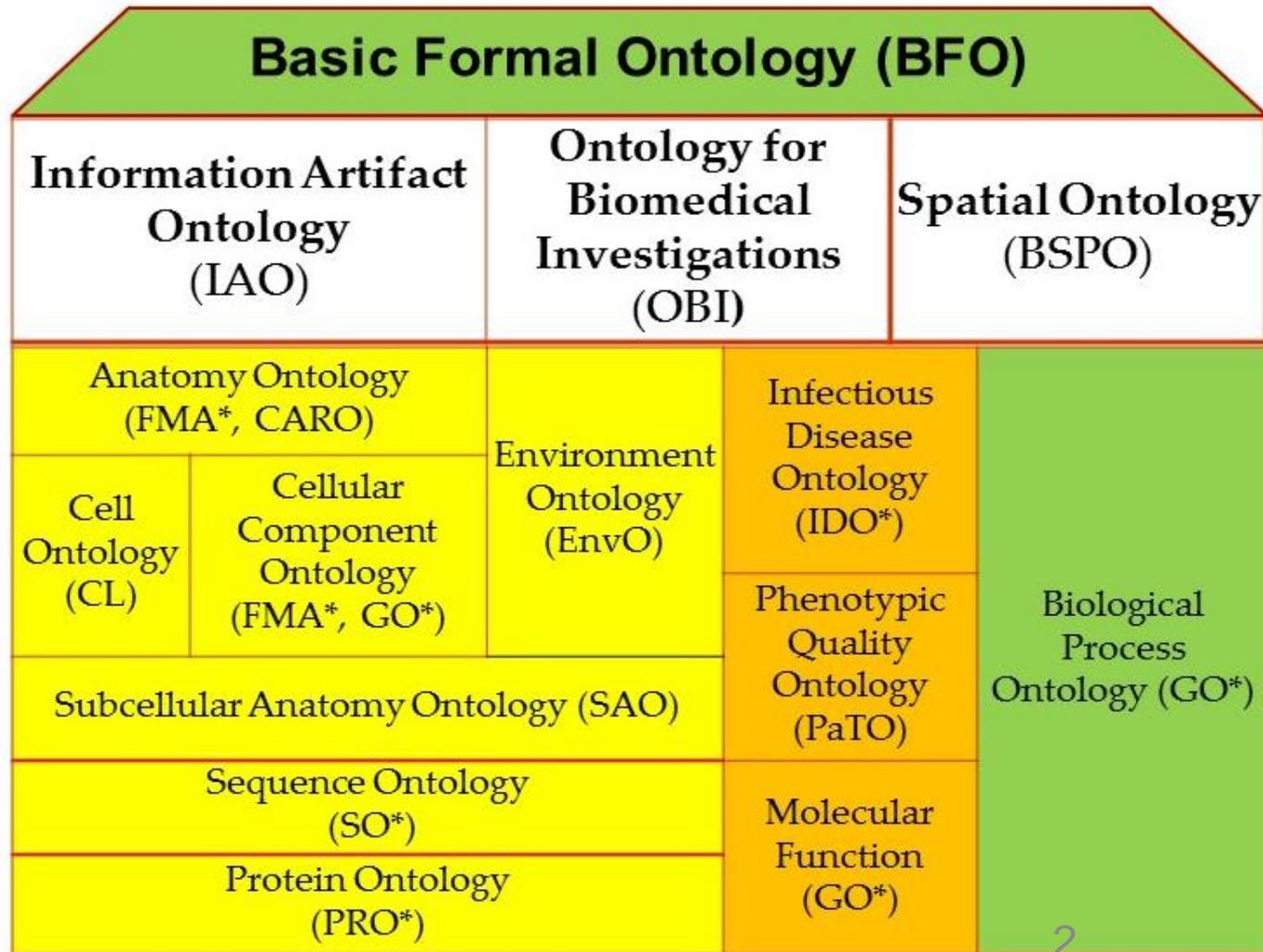
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University at Buffalo, NY**

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**Electronic Mapping Systems, Inc., Fairfax, VA**

# OBO Foundry hub and spokes strategy for developing interoperable ontology modules



This strategy now being used in many areas to ensure interoperability by providing common domain neutral starting point for distributed ontology creation

OBO Foundry	Open Biomedical Ontologies Foundry
CROPS / Planteome	Common Reference Ontologies for Plant Science
UNEP Ontology Framework	United Nations Environment Programme
TRIP Ontologies	Federal Highway Administration (FHWA) Transportation Research Informatics Platform (TRIP)
Common Core Ontologies (CCO)	US Army / I2WD and ARL, IARPA, JIDO, ONR, AFRL

CUBRC / National Center for Ontological  
Research (NCOR)

United Nations Environment Programme (UNEP)

United States Geological Survey (USGS)

Office of Naval Research (ONR)

Central Intelligence Agency (CIA)

US Army

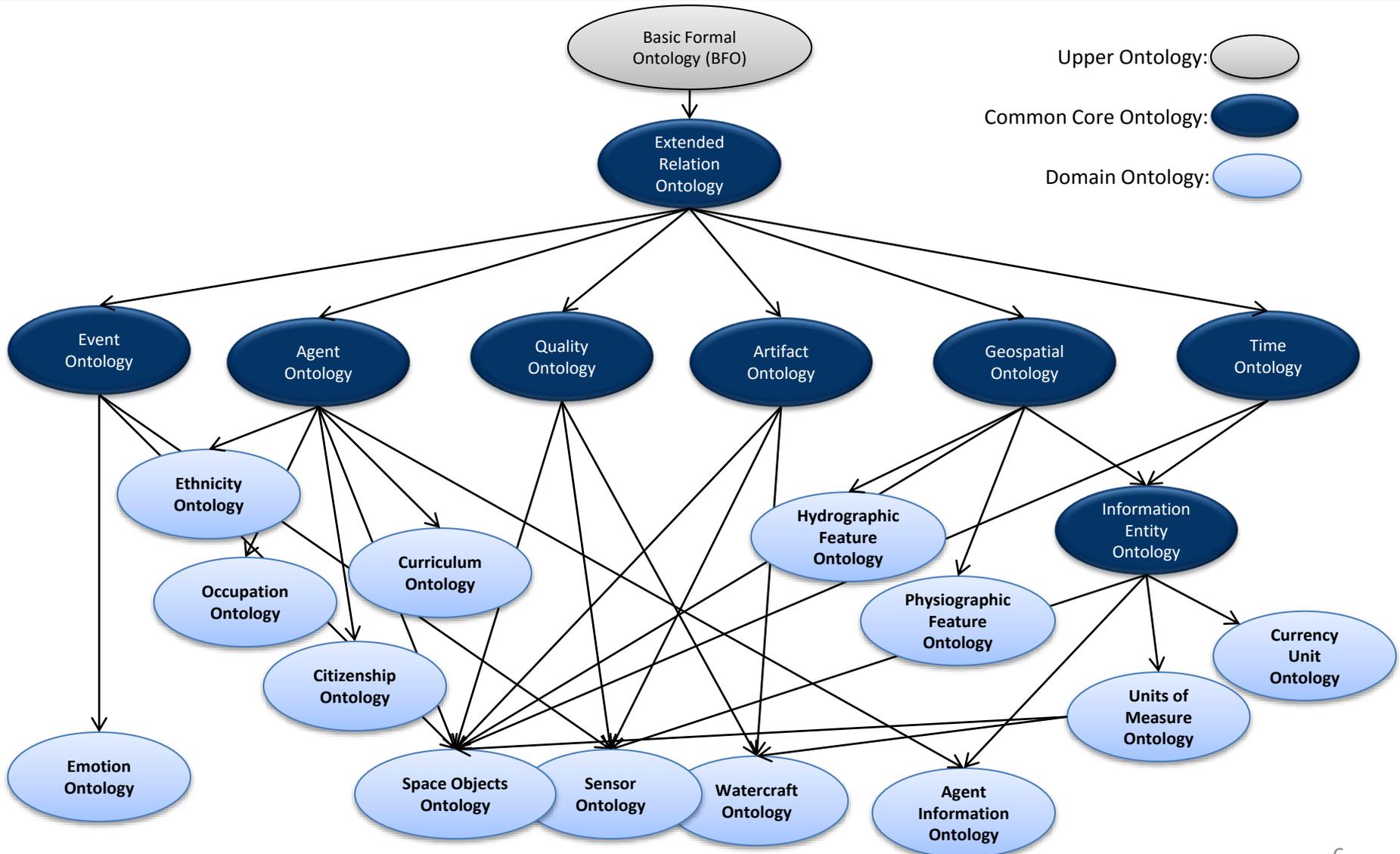
Intelligence and Information Warfare Directorate (I2WD)

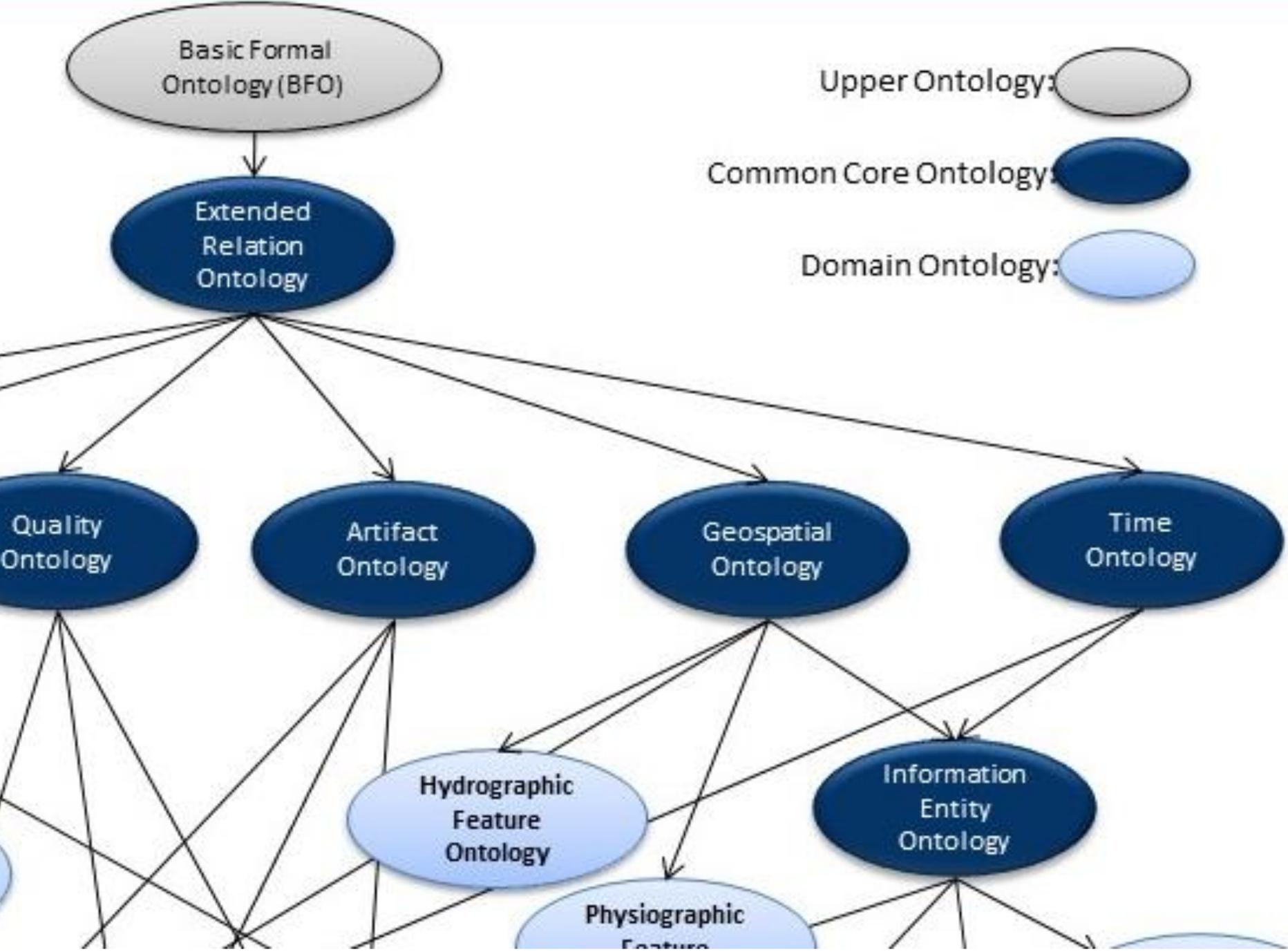
Army Net-Centric Data Strategy Center of Excellence

Air Force Research Laboratory (AFRL)

- 2014 – The Common Core Ontologies
  - Initiated through IARPA KDD Program
  - Sponsor: Intelligence and Information Warfare Directorate (I2WD)
  - Client: Distributed Common Ground System-Army (DCGS-A)
  - Objective: To develop a common vocabulary that can be used and extended to integrate any data source

# Hub and Spokes Structure of Common Core and Domain Ontologies





# AFRL Mission Awareness for Mission Assurance (MAMA) Initiative

**Goal:** enhance cyber-situational awareness through an automated assessment of mission execution based on analysis of network traffic flows relating to *Air Mobility Operations* and *Space Operations*

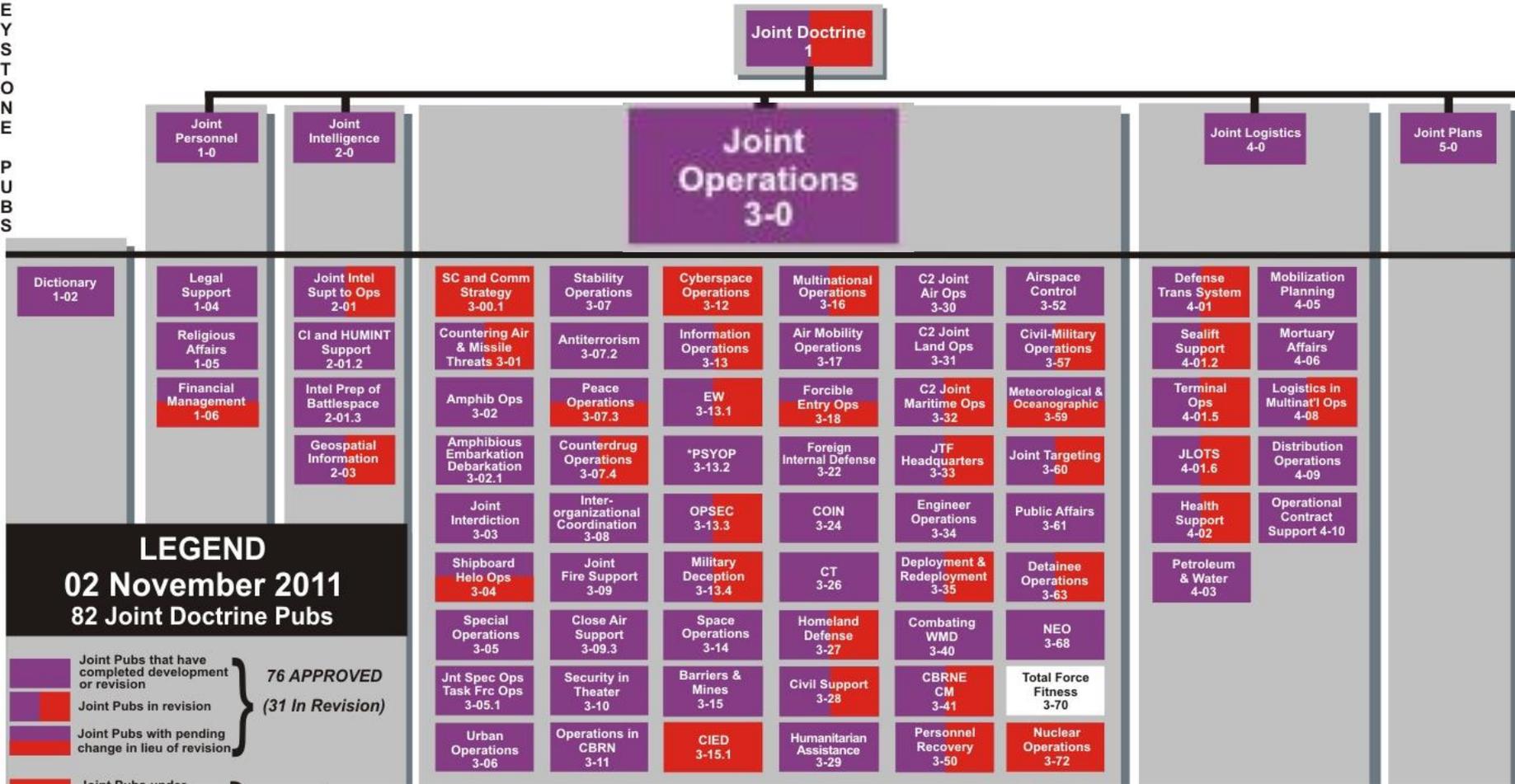
**Problem:** Different network traffic flows will refer in different ways to the same action, force, aircraft, target, report, information system

**Need:** Controlled vocabulary for Air Mobility Operations and Space Operations

# JOINT DOCTRINE HIERARCHY

KEY CAPSTONE PUBLIS

DOCTRINE PUBLICATIONS



# Joint Operations 3-0

SC and Comm Strategy 3-00.1	Stability Operations 3-07	Cyberspace Operations 3-12	Multinational Operations 3-16	C2 Joint Air Ops 3-30	Airspace Control 3-52
Countering Air & Missile Threats 3-01	Antiterrorism 3-07.2	Information Operations 3-13	<b>Air Mobility Operations 3-17</b>	C2 Joint Land Ops 3-31	Civil-Military Operations 3-57
Amphib Ops 3-02	Peace Operations 3-07.3	EW 3-13.1	Forcible Entry Ops 3-18	C2 Joint Maritime Ops 3-32	Meteorological & Oceanographic 3-59
Amphibious Embarkation Debarcation 3-02.1	Counterdrug Operations 3-07.4	*PSYOP 3-13.2	Foreign Internal Defense 3-22	JTF Headquarters 3-33	Joint Targeting 3-60
Joint Interdiction 3-03	Inter-organizational Coordination 3-08	OPSEC 3-13.3	COIN 3-24	Engineer Operations 3-34	Public Affairs 3-61
Shipboard Helo Ops 3-04	Joint Fire Support 3-09	Military Deception 3-13.4	CT 3-26	Deployment & Redeployment 3-35	Detainee Operations 3-63
Special Operations 3-05	Close Air Support 3-09.3	<b>Space Operations 3-14</b>	Homeland Defense 3-27	Combating WMD 3-40	NEO 3-68

# JOINT DOCTRINE HIERARCHY

Joint Doctrine  
1

Joint  
Operations  
3-0

SC and Comm  
Strategy  
3-00.1

Stability  
Operations  
3-07

Cyberspace  
Operations  
3-12

Multinational  
Operations  
3-16

C2 Joint  
Air Ops  
3-30

Airspace  
Control  
3-52

Countering Air  
& Missile  
Threats 3-01

Antiterrorism  
3-07.2

Information  
Operations  
3-13

Air Mobility  
Operations  
3-17

C2 Joint  
Land Ops  
3-31

Civil-Military  
Operations  
3-57

Amphib Ops  
3-02

Peace  
Operations  
3-07.3

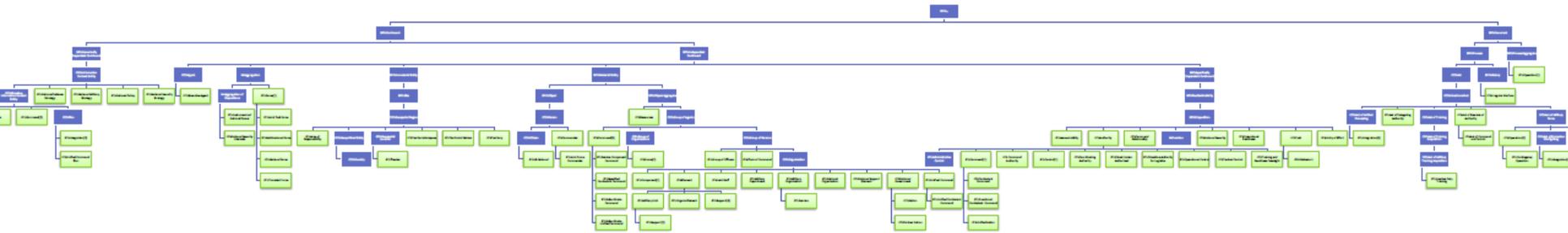
EW  
3-13.1

Forcible  
Entry Ops  
3-18

C2 Joint  
Maritime Ops  
3-32

Meteorological &  
Oceanographic  
3-59

# First draft of JDO *is\_a* hierarchy for JP 1 (Capstone Pub)



Sources:

Basic Formal Ontology (BFO)

Common Core Ontologies (CCO)

Joint Publication (JP)

# Beyond MAMA

Distributed Living Planning within  
Contested Environments (Living Plan)  
(AFRL Rome) – **JOINT PLANNING**

Digital Thread / Digital Twin (DT/DTw)  
(AFRL Dayton) – **JOINT LOGISTICS**

Joint action requires interoperability of people and information systems

**Interoperability** = def. The ability of systems, units, or forces to provide data, information, materiel, and services to, and accept the same from, other systems, units, or forces, and to use the data, information, materiel, and services exchanged to enable them to operate effectively together.

DoD Instruction 8330.01

How is IT interoperability to be achieved?

By adherence to standards listed in the DoD IT Standards Registry (DISR).

DoD Instruction (DoDI) 8330.01

# An Example

DISR:



**Sample Terms (from**

<https://acc.dau.mil/CommunityBrowser.aspx?id=220108&lang=en-US>)

**Architecture**

**Integrated Architecture**

**Enterprise Architecture**

**Naval Open Architecture**

**Open Architecture (twice)**

**Open System Architecture**

**Software Architecture**

**System Architecture**

How to do it right?

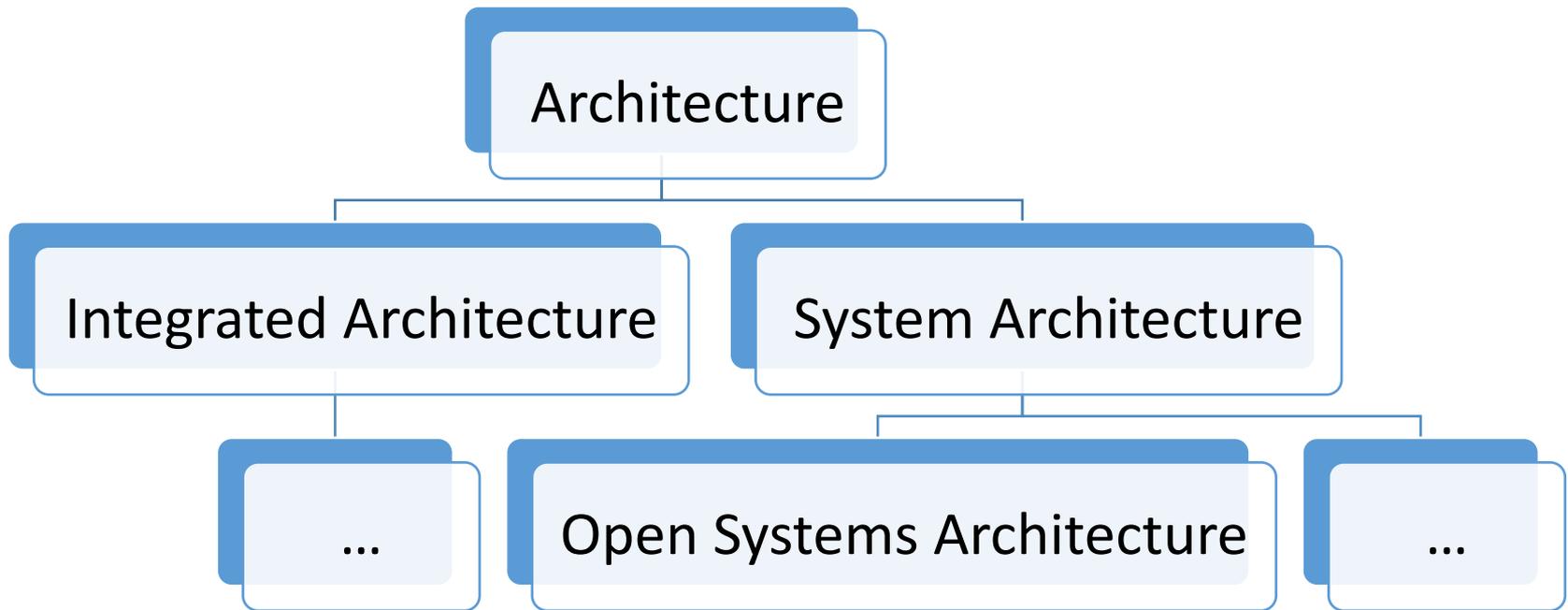
## Define **Architecture**

Define **Integrated Architecture** as: An **Architecture** which [is integrated ...]

Define **System Architecture** as: An **Architecture** of a System

Define **Open System Architecture** as: A **System Architecture** which [is open ...]

... thereby yielding the taxonomical part of an ontology as a true hierarchy



How does



do it?

**Architecture** [IEEE 1471-2000]

**Integrated Architecture** [DoDAF]

**Enterprise Architecture** [Virginia Information Technologies Agency]

**Naval Open Architecture** [*RhumbLines*, December 12, 2006, Naval Office of Information]

**Open Architecture** [ITtoolbox].

**Open System Architecture** [*A Modular Open Systems Approach (MOSA) to Acquisition, OSJTF*]

How does



do it?

**Architecture** =Def. the fundamental organization of a system embodied in its components ... [IEEE 1471-2000]

**Integrated Architecture** =Def. multiple views or perspectives ... [DoDAF]

**System Architecture** =Def. the composite of the design architectures for products and their life cycle processes ... [IEEE 1220-1998]

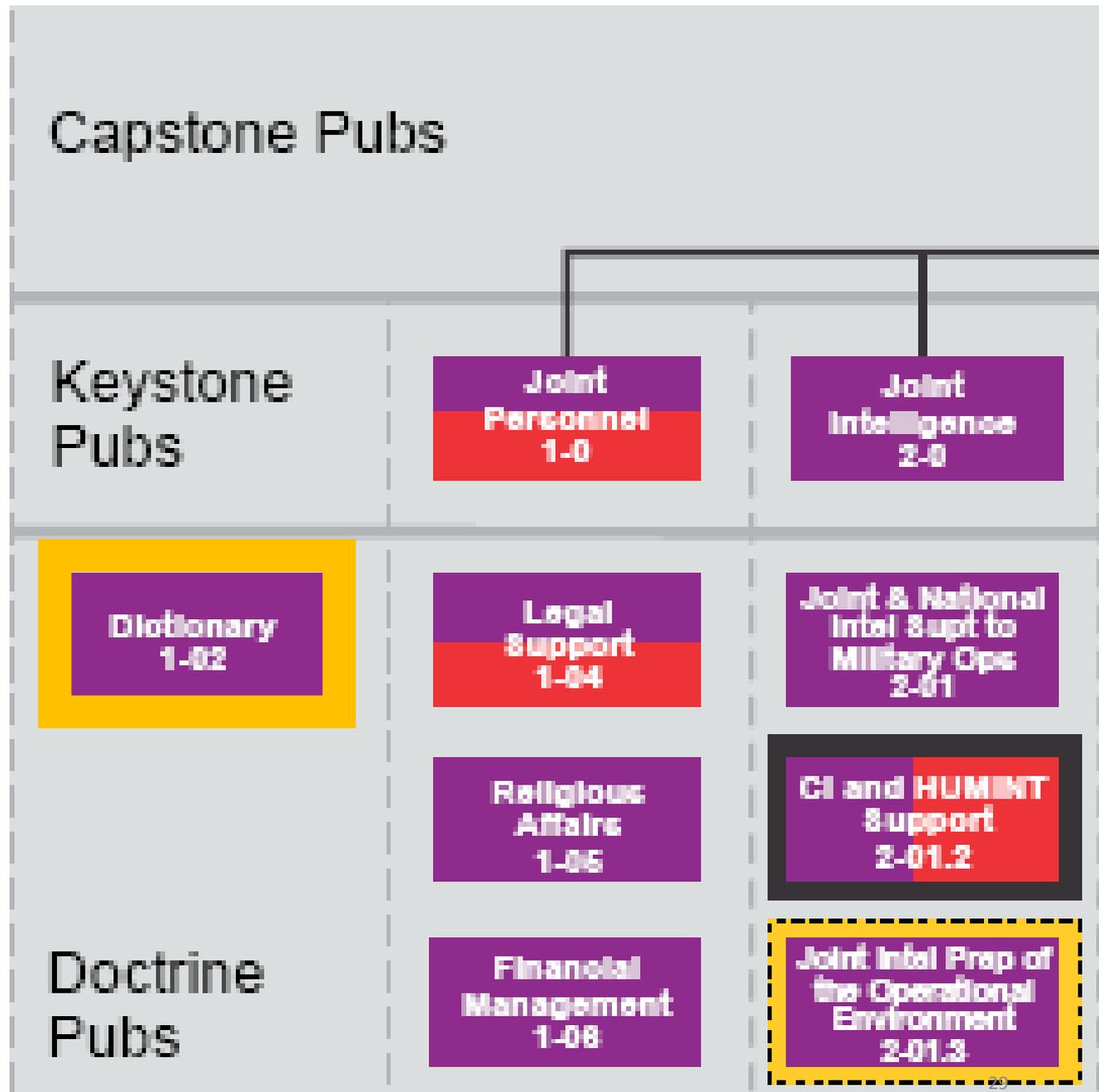
**Open System Architecture** =Def. a system that employs modular design, ... [OSJTF]

So much for acquisitions

What about real warfighting?

Where can we find an authoritative, coherently and diligently authored dictionary of terms and definitions covering all aspects of military endeavor, organization and (increasingly) IT system?

# JP 1-02



# JP 1-02 (fragment)

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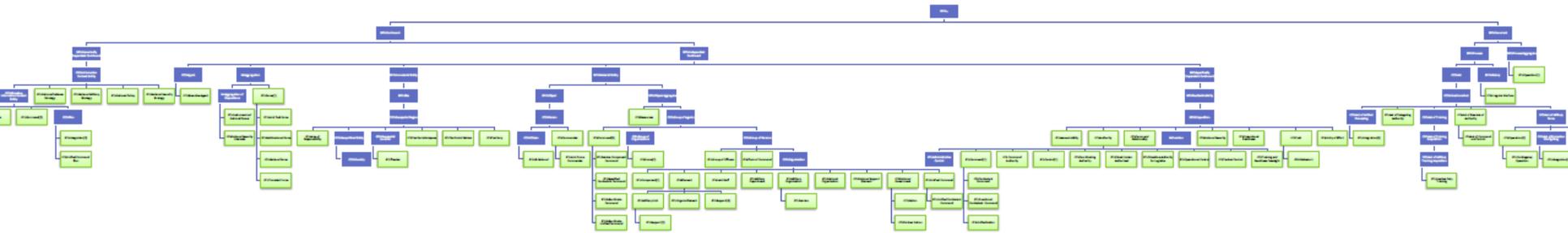
**intratheater airlift** — Airlift conducted within a theater with assets assigned to a geographic combatant commander or attached to a subordinate joint force commander. See also **intertheater airlift**. (JP 3-17)

**intratheater patient movement** — Moving patients within the theater of a combatant command or in the continental United States. See also **en route care; evacuation; intertheater patient movement**. (JP 4-02)

**inventory control** — That phase of military logistics that includes managing, cataloging, requirements determinations, procurement, distribution, overhaul, and disposal of materiel. Also called **inventory management; materiel control; materiel management; supply management**. (JP 4-09)

**inventory control point** — An organizational unit or activity within a Department of Defense supply system that is assigned the primary responsibility for the materiel inventory management of a group of items either for a particular Service or for the Defense Department as a whole. Also called **ICP**. (JP 4-09)

# First draft of JDO *is\_a* hierarchy for JP 1 (Capstone Pub)



Sources:

Basic Formal Ontology (BFO)

Common Core Ontologies (CCO)

Joint Publication (JP)

# JDO as computational shadow of JP 1-02

## Built for humans

**intratheater airlift** — Airlift conducted within a theater of operations, under the command of a combatant commander or attached to a subordinate command. Also called **intertheater airlift**. (JP 3-17)

**intratheater patient movement** — Moving patients within a theater of operations, under a command or in the continental United States. Also called **intertheater patient movement**. (JP 4-02)

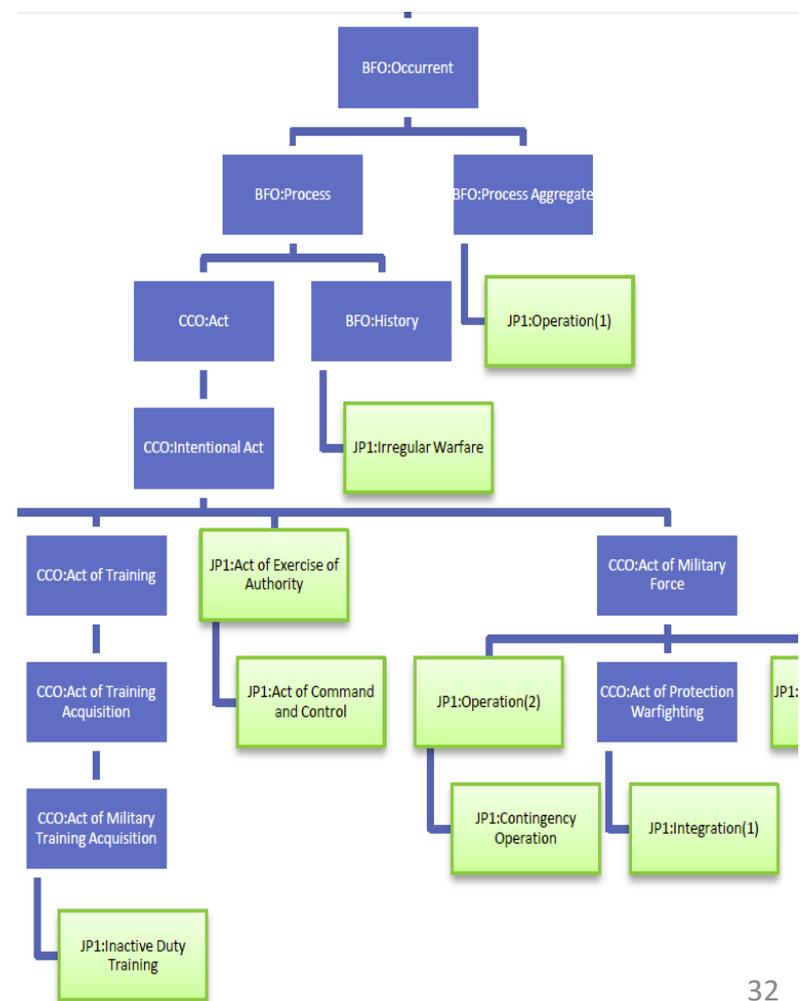
**inventory control** — That phase of military logistics that involves the determination of requirements, procurement, and management of materiel. Also called **inventory management; supply management**. (JP 4-09)

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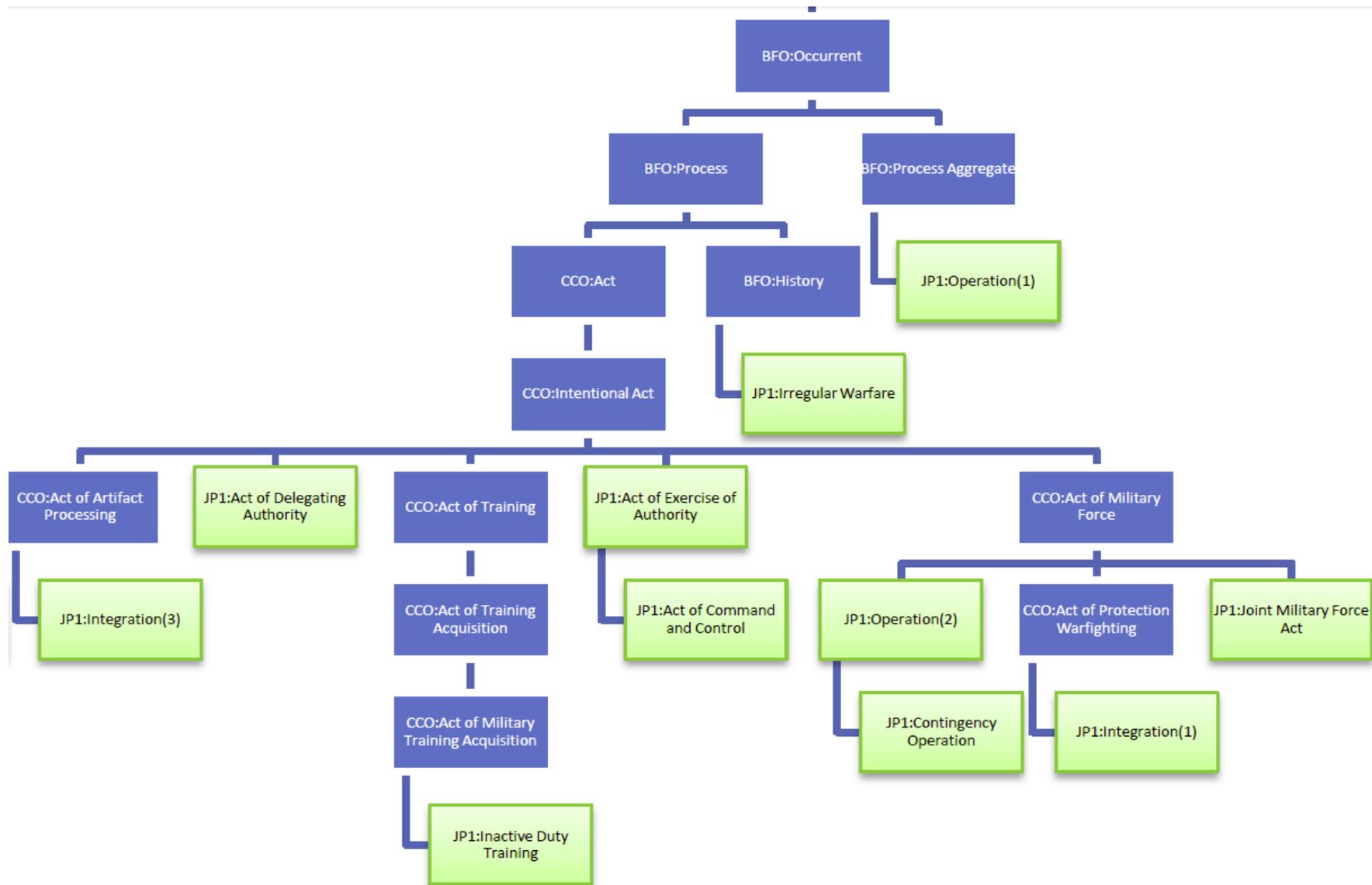
**ionizing radiation** — Particulate (alpha, beta, and gamma) radiation of sufficient energy to displace electrons from atoms. (JP 3-11)

**irregular warfare** — A violent struggle among state and nonstate actors, waged primarily through irregular and asymmetric means, that includes terrorism, sabotage, guerrilla warfare, and other subconventional activities. Also

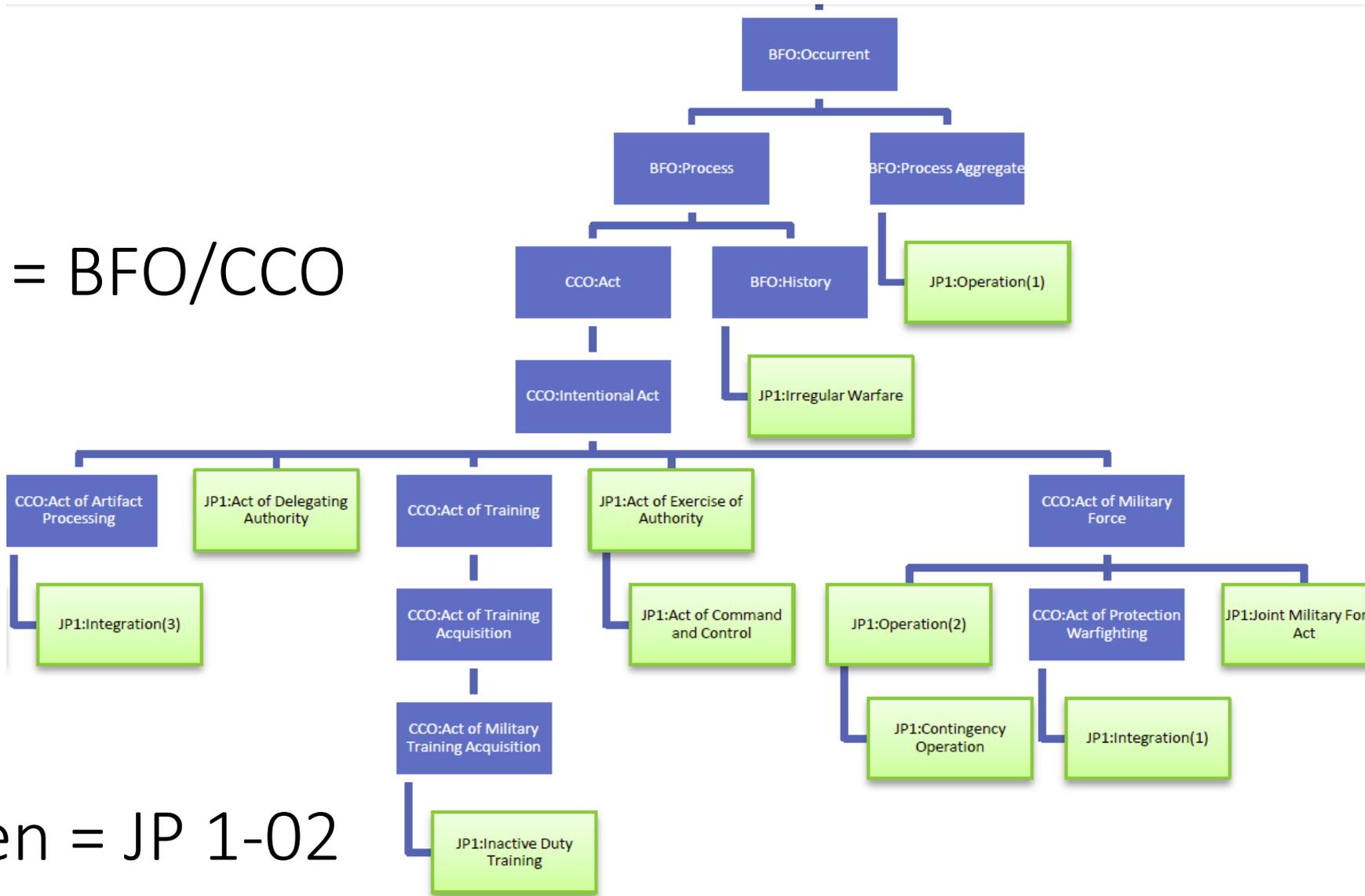
## Built for computers



# Joint Doctrine Ontology (fragment)



Blue = BFO/CCO



Green = JP 1-02

# Joint Doctrine Ontology: A Benchmark for Military Information Systems Interoperability

DoD and Chairman of the Joint Chiefs of Staff instructions require that all warfighters and warfighting organizations should use a common terminology.

In addition, instructions state that all IT intended for use in military operations should be designed from the beginning to be interoperable (paragraph 9b of Chapter 2, “Doctrine Governing Unified Direction of Armed Forces,” JP 1 ).

Proposal: Require that all DoD IT efforts, insofar as they are intended for use in military operations, be developed in such a way as to be interoperable with JDO.

# The DoD Manual (DoDM) 5120.01, “Joint Doctrine Development Process”,

provides the guidance that steers DoD to consistent terminology across the joint publications governing different types of operational domains.

This same guidance should be extended to IT developers.

Those engaged in developing IT systems for military operations should be required to take the terminology and definitions of joint doctrine as their starting point.

# JP 1-02 Definition Writing Guide

## Types of errors

- a definition should not be *over-restrictive*;
- it should not be *circular*;
- it should be *positive* (state what is covered by a term rather than what is not covered);
- and it should contain no *hidden definitions* (where the definition of one term is embedded inside another).

**U N C H**

<p><b>operational area</b> =def. An overarching term encompassing more descriptive terms (such as area of responsibility and joint operations area) for geographic areas in which military operations are conducted.</p>	X	X		X
<p><b>contingency operation</b> =def. A military operation that is either designated by the Secretary of Defense as a contingency operation or becomes a contingency operation as a matter of law (Title 10, United States Code, Section 101[a][13])</p>			X	
<p><b>subordinate command</b> =def. A command consisting of the commander and all those individuals, units, detachments, organizations, or installations that have been placed under the command by the authority establishing the subordinate command.</p>		X	X	

Table 1: Examples of errors in JP 1-02

U = **unclear**, N = **not concise**, C = **circular**, H = **hidden definitions**

# using JDO to maintain coansistency when JPs are revised

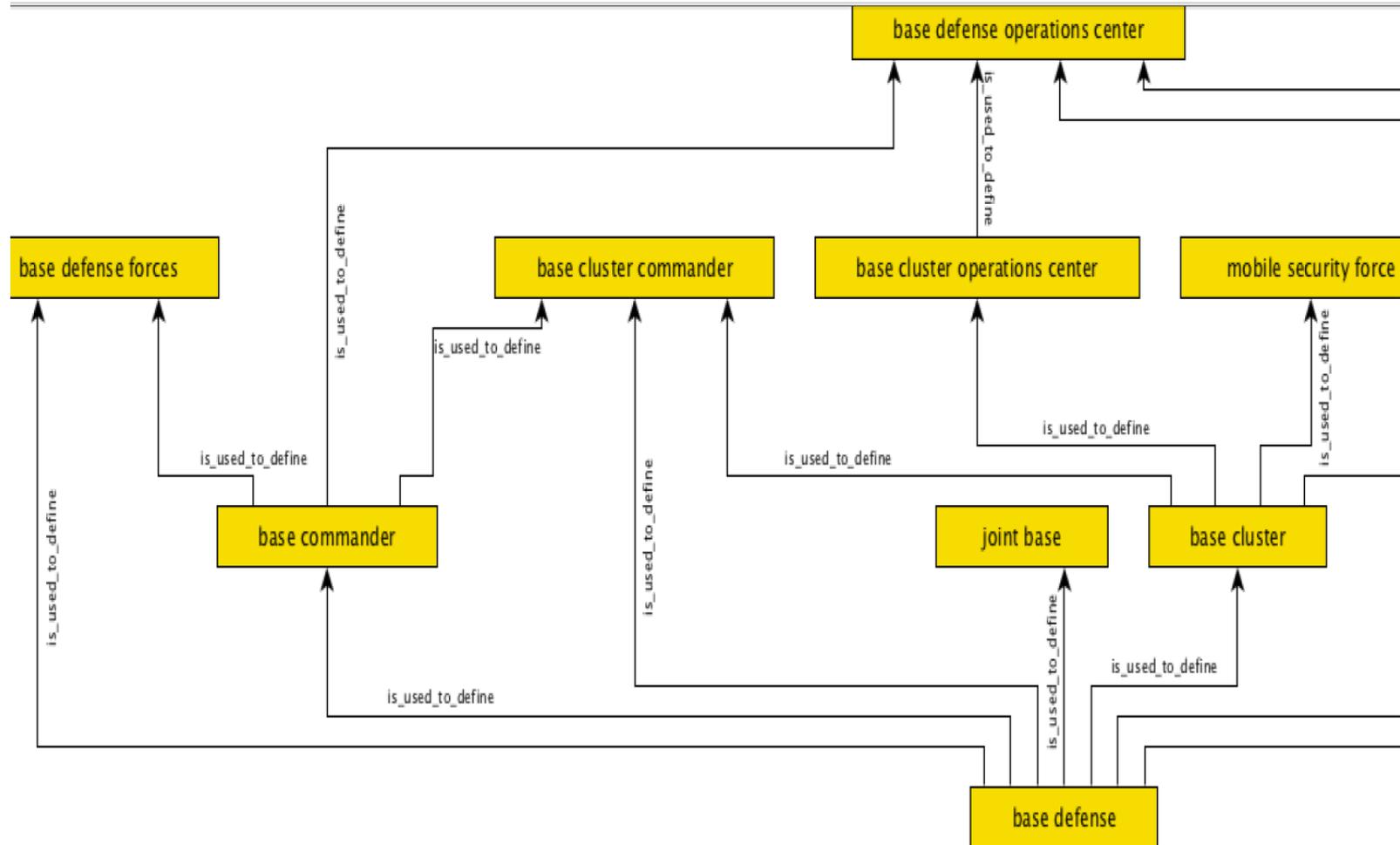


Figure : Fragment of the JP 1-02 network generated by the relation *is used to define*.



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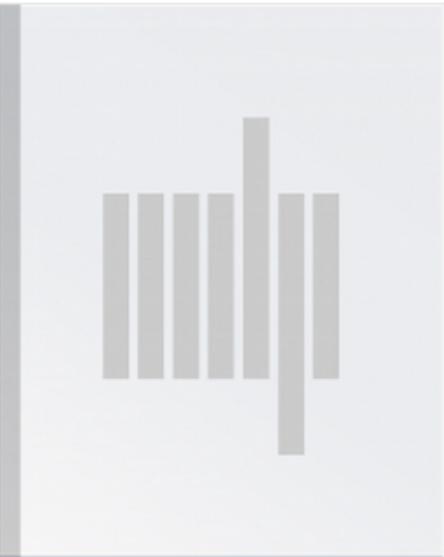
# Building Ontologies with Basic Formal Ontology

By [Robert Arp](#), [Barry Smith](#) and [Andrew D. Spear](#)

## Overview

In the era of “big data,” science is increasingly information driven, and the potential for computers to store, manage, and integrate massive amounts of data has given rise to such new disciplinary fields as biomedical informatics. Applied ontology offers a strategy for the organization of scientific information in computer-tractable form, drawing on concepts not only from computer and information science but also from linguistics, logic, and philosophy. This book provides an introduction to the field of applied ontology that is of particular relevance to biomedicine, covering theoretical components of ontologies, best practices for ontology design, and examples of biomedical ontologies in use.

After defining an ontology as a representation of the types of entities in a given domain, the book distinguishes between different kinds of ontologies and taxonomies, and shows how applied ontology



Paperback | \$30.00 | £20.95 | ISBN: 9780262527811 | 248 pp. | 7 x 9 in | 32 b&w illus. | August 2015

<https://mitpress.mit.edu/building-ontologies>

## JP 1-02 Definition Writing Guide

### Definition of 'definition'

definition = Def. a formal statement of the exact meaning of a term that enables it to be distinguished from any other.

A definition is distinguished from a description by the fact that the latter 'is a narrative containing information about the term that is not constrained in format or content.'

# There are not only errors but also gaps

action	nation
agent	national organization
authority	order
commander	organization
geographical area	territory
geopolitical entity	training

Examples of terms which are used in JP 1-02, but not defined in JP 1-02

# Current rule: use Webster's dictionary

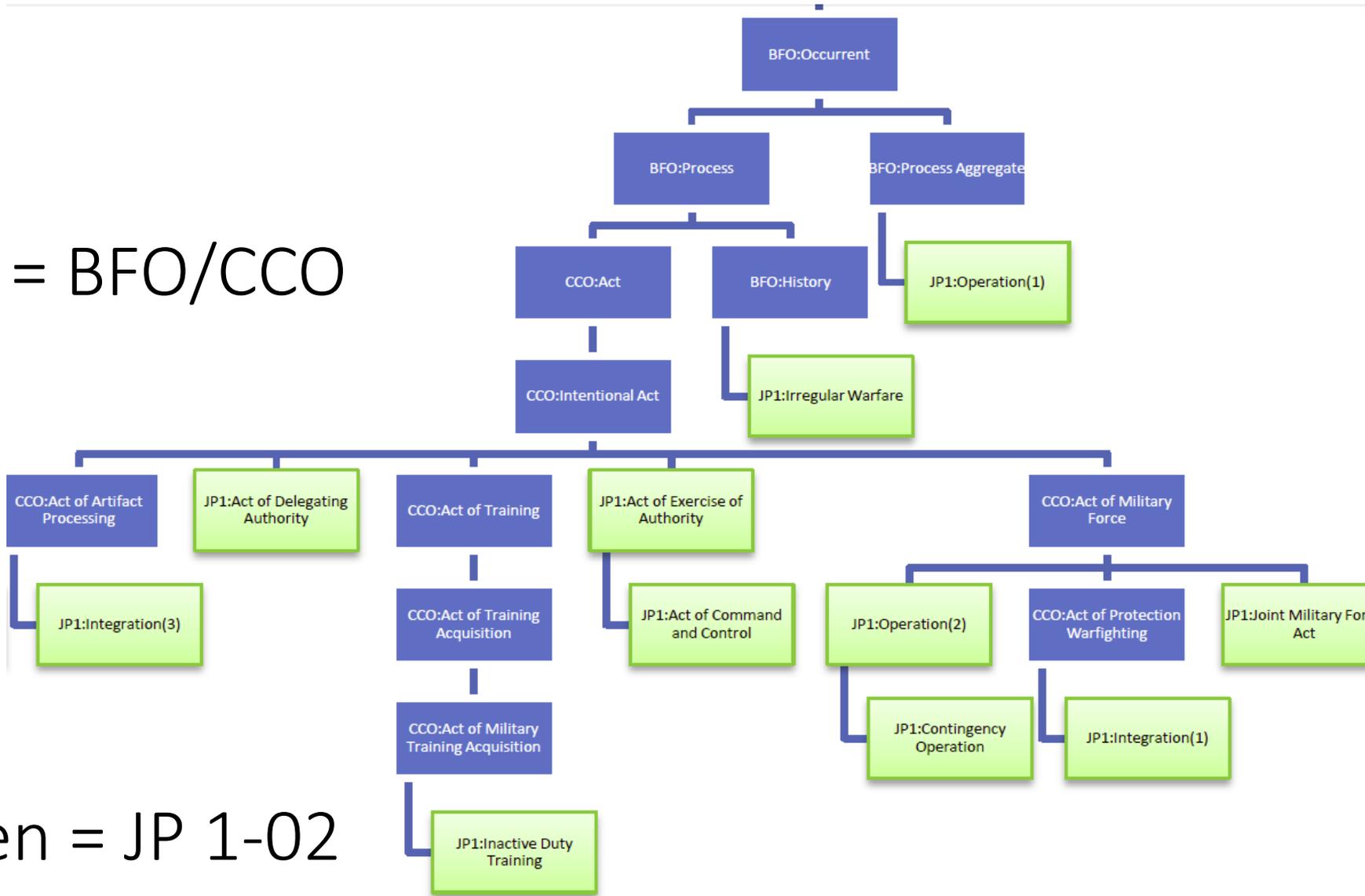
Webster's yields circularity among definitions of related terms

- 1) The Webster's def. of 'authority' employs the term 'command'; the definition of 'command' employs the term 'order'; and the definition of 'order' employs the term 'authority' for a tight little circle.
- 2) An even tighter circle: the definition of 'command' employs 'order', and the definition of 'order' employs 'command'.
- 3) Finally, the definition of 'nation' employs 'territory', and the definition of 'territory' employs 'nation'.

Replacement rule: Use CCO instead of Webster's

Identify gaps in JP 1-02 and add the corresponding terms together with logically well-formed definitions to CCO

Blue = BFO/CCO



Green = JP 1-02

**Rule 1: Do not confuse the entity you are defining with the term used to represent that entity.**

- Example: an operational area is not a ‘kind of overarching term’.

**Rule 2: Distinguish between general terms and proper names.**

- Almost every JP 1-02 term refers to something general – a kind or type (as in all the cases listed in Table 1) – having multiple specific instances. A small number of JP 1-02 terms are proper names, which is to say, they refer to exactly one specific instance. Examples include the Universal Joint Task List and Joint Doctrine Development System.

Rules 3–5 apply only to general terms, and are satisfied already by the definitions of many such terms in JP 1-02

## Rules 3-4

**Rule 3: All general terms should be singular in number.**

**Rule 4: Each general term should have at most one single parent term.**

**Rule 5: A definition of a general term A should have the two-part form:**

- **An A =Def. a B which Cs.**

**where B is the parent term of A in the hierarchy of the ontology**

For example:

- artillery vehicle =def. A vehicle which is designed for the transport of one or more artillery weapons.
- artillery weapon = def. A device which is designed for projection of munitions beyond the effective range of personal weapons.

# Scope of JDO

Work on JDO is funded by 3 AFRL initiatives described below.

Funding is being applied

1. to create those branches of JDO whose content corresponds to Joint Pubs specifically related to these initiatives and to the Capstone and Keystone Pubs from which they descend
2. to explore the role that can be played by JDO in subordinate terminologies, including Service manuals, TTP specifications, and other authoritative sources