



Maritime Information Exchange Model (MIEM)

September 29, 2008

Rick Hayes-Roth
hayes-roth@nps.edu

David Reading
reading@kingcrab.nrl.navy.mil



Sections

- What is MIEM and why?
- Model technical description
- How to use it
- Program overview & status



How do we...

...share actionable intelligence in the maritime domain (or air, or ground, ...)

- across agencies, services and nations
- so we can
 - Quickly exchange and update intelligence products
 - Detect threats and take quick appropriate actions
 - Detect anomalies and investigate them
 - Support and improve collaboration
 - Document and justify inferences and actions

?



Effective Sharing Requirements

- Humans and machines will read, edit & write data
- Over the next decade, data volumes will soar, so machines will play increasingly important roles
- Threats will come from people, vessels, cargo, organizations & facilities that can act over long times with complex histories and interactions
- Actors, events & linkages among them accumulate, as inferences, hypotheses & evidence support them
- Partners exchange much of this information
- Recipients understand this information
 - How it's represented & what it means



Best Practices in Industry



- Several industry consortia have established effective sharing efforts
 - E.g, electronics (RosettaNet) & mortgage banking (MISMO)
- They focus on value delivery chains
 - End-to-end transactions that deliver significant value to customers
 - They require information sharing models that enable “straight-through processing”
 - A series of “services” or “process steps” mediated by “documents” that convey the information required
- Information modeling focuses on **the right meaning (semantics)** to accomplish **the intended purpose (pragmatics)**
- XML schemas define semantic grammars (conceptual frames) that describe important states
- Partners validate the schemas by implementing transactions



What Kinds of Transactions?

Describing **dynamic situations**
so collaborators
can intervene or interdict
in a timely way

Hence, we need a “language” of situations
that warrant intervention



The Pragmatics of *Track*: Mobile Entity **M**



1. Observe, detect, identify, classify and monitor **M**
2. Locate **M**
3. Infer **M**'s intent
4. Determine **M**'s threats $T_{M,D}$ against domain **D**
5. Predict **M**'s future location and behavior
6. Alert agent A about **M** and threats $T_{M,D}$
7. Determine countermeasures $CM(T_{M,D})$ to threats $T_{M,D}$
8. Inform agent A about countermeasures $CM(T_{M,D})$



Intelligence = *Beliefs* of 10 Types



- (1) A **fact**
- (2) An **assumption**, less certain than a fact
- (3) A credible eye witness report, *viz.*, **ground truth**
- (4) Summary or aggregation of other beliefs, *viz.*, **implication**
- (5) Association and fusion of observations that support a simplifying inductive inference, interpretation or **abduction**
- (6) A **composition** (AND) of other beliefs
- (7) A probable inference or **confirming prediction** from another belief
- (8) An improbable inference from another belief, *viz.*, a **disconfirming expectation**
- (9) An analyst **judgment**, intuition, opinion, or concern, based on some other beliefs as well as some inference
- (10) A pattern-based or rule-based **assessment**, where a set of beliefs about an entity instantiates a pattern template above some threshold level indicating that the pattern's interpretation applies



Track

Top-Level Conceptual Hierarchy



Track

Beliefs

Identity

Characteristics

Dynamic State at Time T

History of States (past “track”)

Predicted States (future “track”)

Meta-Information

Evidence

Inferences

Error and uncertainty estimates

Temporal qualifications

Spatial qualifications



CMA JCTD identified MDA High-Value Transactions

- MDA partners assembled from USCG, NMIC, NORTHCOM, PACOM, EUCOM, NRL, SPAWAR, NPS
- High-value “scenarios” identified for CMA users
- Detailed vignettes collected for information sharing
- Available information sources and models surveyed
- Industry and government best practices reviewed
- Multiple levels of valued information sharing identified
- MIEM addresses, ultimately, all of these levels

CMA = Comprehensive Maritime Awareness

JCTD = Joint Capability Technology Demonstration

MDA = Maritime Domain Awareness

MIEM = Maritime Information Exchange Model

Levels of Value Added Information

Level	Type	Example	Value added
1 (lowest)	Sensor system reports	AIS (<i>Automatic Information System</i>)	Reduced development costs for consumers
2	Caveats & simple meta-data	Sensor type, classification	Implicit quality assessment
3	Fused data & inferred beliefs	Position, crew	Synergistic improvement in SA
4	Degree of belief & pedigree	Evidence, quality	Explicit information about quality
5	Multiple alternatives & analysis	Ambiguity, uncertainty	Explicit assertions of certainty
6	History, behavior & future projections	Voyages & predicted courses	Enables basic predictive analysis
7	“Of interest” conditions & watch lists	Suspicious cargo on board	Increased analytical efficiency
8	Threats & anomalies	Dangerous undeclared cargo	Increased pre-emptive threat reduction
9 (highest)	Case files for key entities	Histories, highlights, comprehensive details	Enables in-depth predictive analysis



What is the MIEM?

- An XML-based data sharing language standard-in-progress
- Applicable across the maritime domain both civil and military
- Modular, reusable, and extensible
- Non-proprietary

The MIEM will accelerate the creation
(among collaborating enterprises)
of actionable intelligence about maritime threats
and straight-through processing of that intelligence
into appropriate interdictions & other related interventions



What MIEM is not



- Database technology
- Just XML – it is a set of conceptual entities and their definitions
- Only DoD
- A programming language
- A silver bullet
- A replacement for exchanges and interagency agreements
- A definition of interoperability (messages, etc.)



MIEM Quality Attributes

- Expressiveness
 - Express details about maritime entities
 - Qualify, amplify, and annotate data with Metadata
 - Describe relationships between maritime objects.
 - Degrees of “belief”, inequalities, and relative values.
 - Ability to express the pedigree and line of reasoning supporting a belief
 - Allow multiple alternatives & analysis assertions (conclusions, opinions)
 - Multiple object states & behaviors (history)
 - Characterize behaviors
 - Associate multiple entities, history, analysis, prediction etc (case file)



MIEM Quality Attributes

- Flexibility
 - Specialized sub-schemas will align
 - Managing schema evolution will be easy
 - Applications can enrich semantics easily
 - Configuration management will be easy
 - Different lines of evolution supported
- Understandability
 - Ability of users to interpret the model correctly
 - Meaning and intent well documented
 - Style of use defined & well documented
 - User can read/understand documents



MIEM Quality Attributes

- Correctness
 - No redundancies within the model
 - Definitions are consistent across maritime community
- Efficiency
 - Does not result in excessively verbose messages (Message brevity)
- Interoperability
 - Path to NIEM harmonization prepared via NDR
 - Path to UCore 2.0 harmonization prepared
 - Model incorporates a focal object for the purposes of providing context for the reader.



Principal Features of MIEM

- **Key Domain Entities**
 - Conveyance/Vessel
 - Person/Crew/Passenger
 - Cargo & Facilities
 - Measurements: Time, Position, Length, Weight, ...
- **Key Secondary Concepts**
 - Life-cycle: States, Transitions, Voyages, Epochs
 - Events
 - Anomalies & Threats
- **Extensive & Universally Applicable Meta-data**
 - Source, Confidence, Alternatives, Pedigree, Caveats, ...
 - Past, Present & Future
- **Universal Extensibility & Restriction**
 - All classes can be augmented or simplified
- **Conceptual model in modular XML schemas**



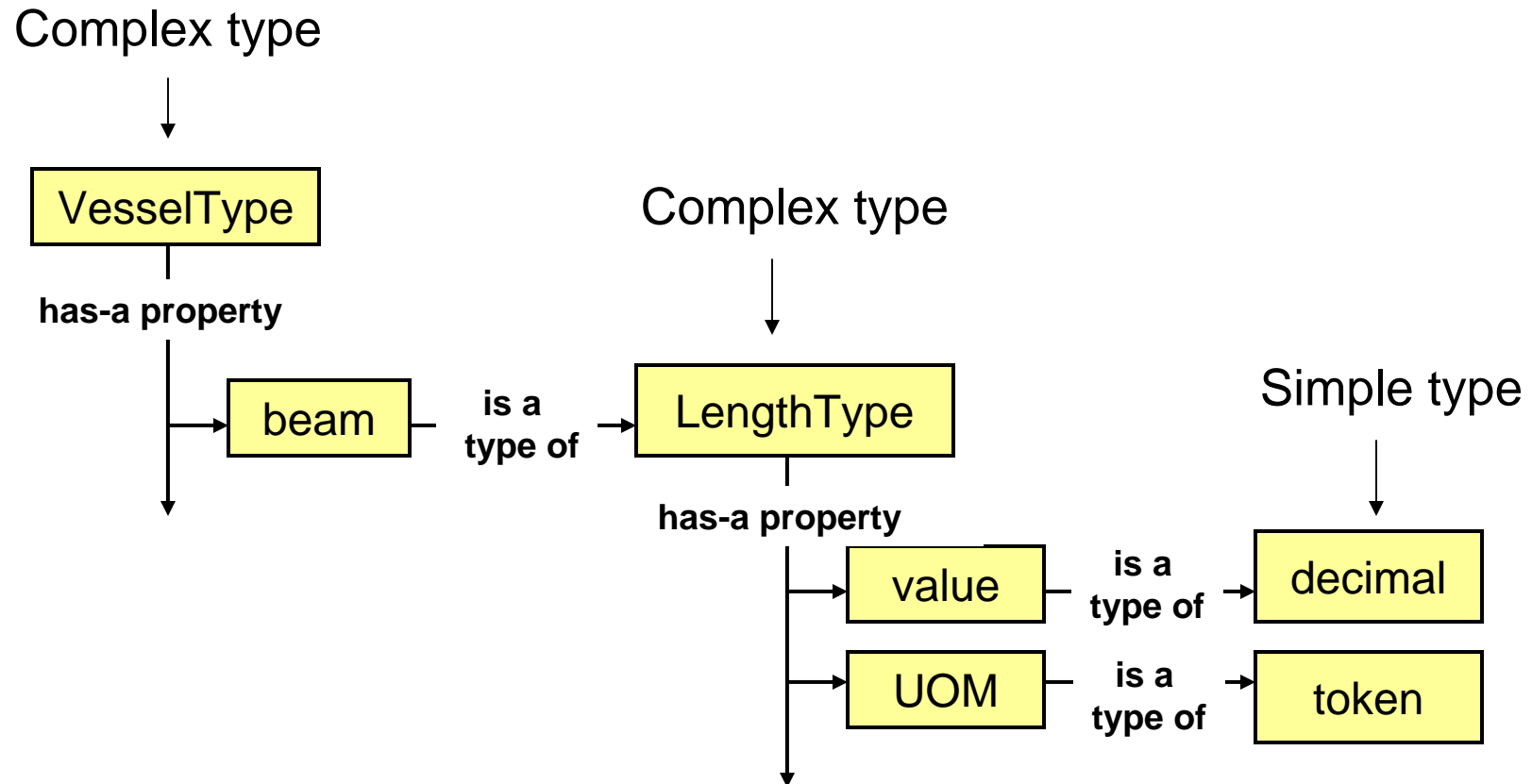
Conclusions: What MIEM Is & Why

- To make intelligence actionable, we should employ best industry practices for sharing information to accomplish high-value work quickly & effectively
- This will require the definition of “documents” that carry information among partners & processes
- The rich semantic **Track** is an obvious first focus
- The MIEM aims to define these **Track** semantics for shared MDA intelligence documents

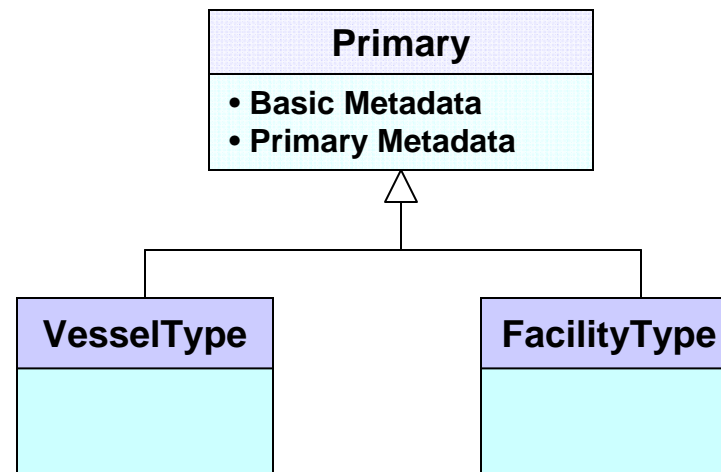


MIEM Technical Details

Conceptual Model Structure



Type inheritance



- Complex types can be extended
- Permits common properties
- Object Oriented “inheritance”
- Uses XML “extension base”



XML Schema



```
<xs:complexType name="LengthType">
  <xs:complexContent>
    <xs:attribute name="value" type="xs:decimal">
    <xs:attribute name="UOM" type="xs:token">
    </xs:attribute>
  </xs:complexContent>
</xs:complexType>
```

```
<xs:complexType name="VesselType">
  <xs:annotation>
    <xs:documentation>A description of a maritime domain vessel</xs:documentation>
  </xs:annotation>
  <xs:complexContent>
    <xs:extension base="md:PrimaryType">
      <xs:sequence>
        . . .
        <xs:element name="beam" type="md:LengthType" minOccurs="0" maxOccurs="unbounded">
          <xs:annotation>
            <xs:documentation>The maximum width of the vessel.</xs:documentation>
          </xs:annotation>
        </xs:element>
        . . .
      </xs:sequence>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>
```



XML Instance



```
<vessel md:id="Vessel001">  
  <md:beam value="14.7" UOM="ft"/>  
</vessel>
```

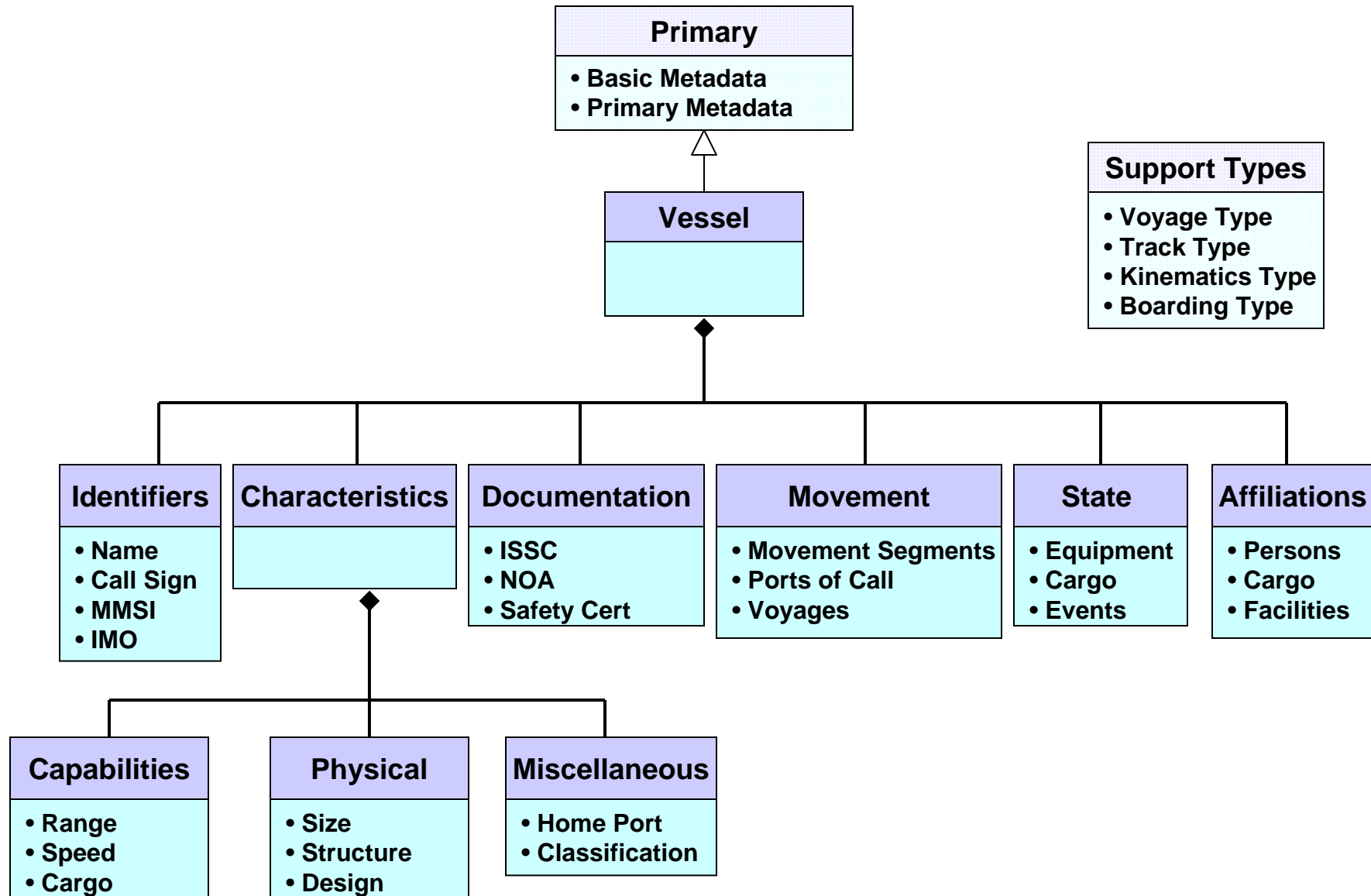


Primary Object Types

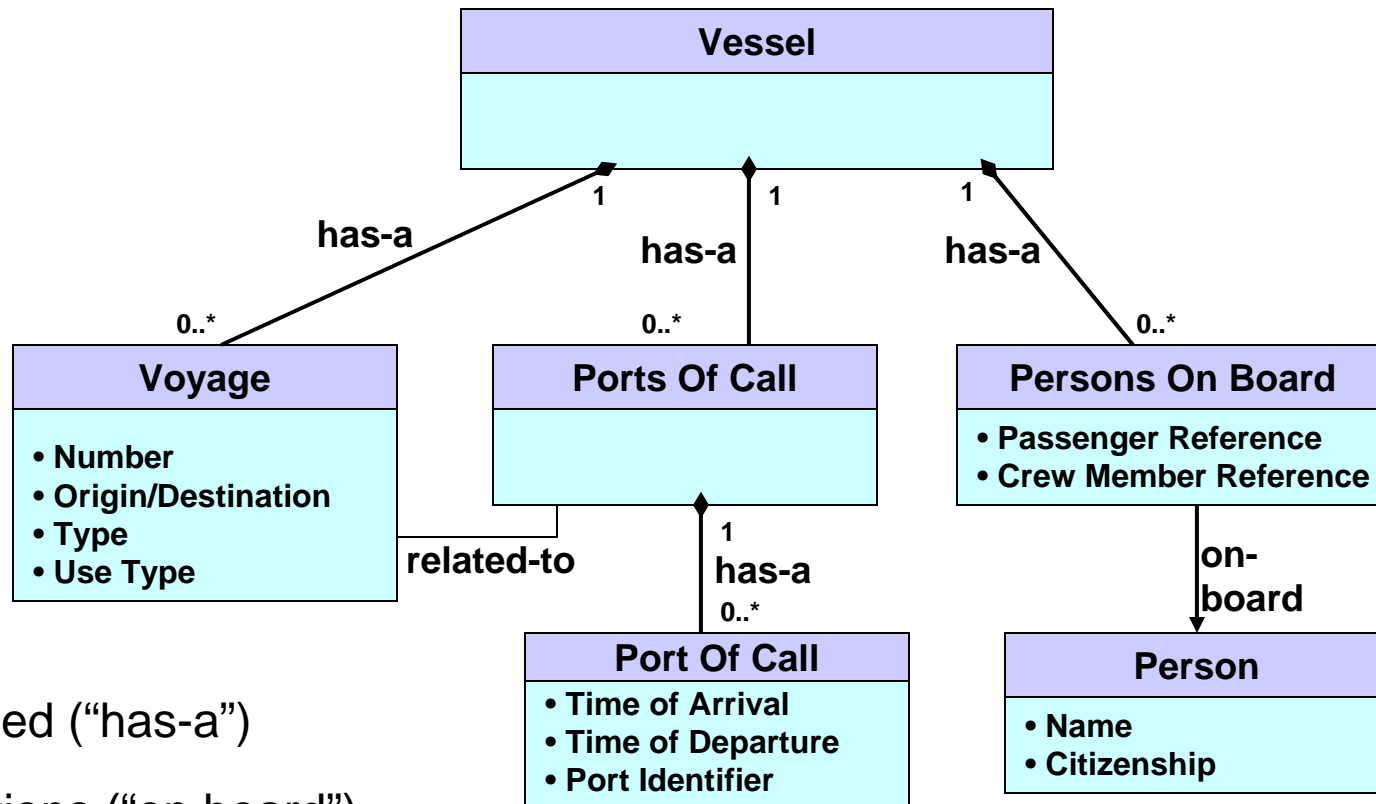


- **Vessels** - Characteristics, capabilities, dynamic state, and relationships
- **Persons** - Identification, description, whereabouts, relationships
- **Cargo** - Shipments, equipment, manifest, and goods
- **Facilities** - Ports, organizations, and governments
- **Events** - Relates entities with associated causes and effects
- **Threats** - Capability, opportunity, level, threatening entity, and target
- **Of Interest Lists** - Heterogeneous lists of MIEM objects

Vessel Model Details

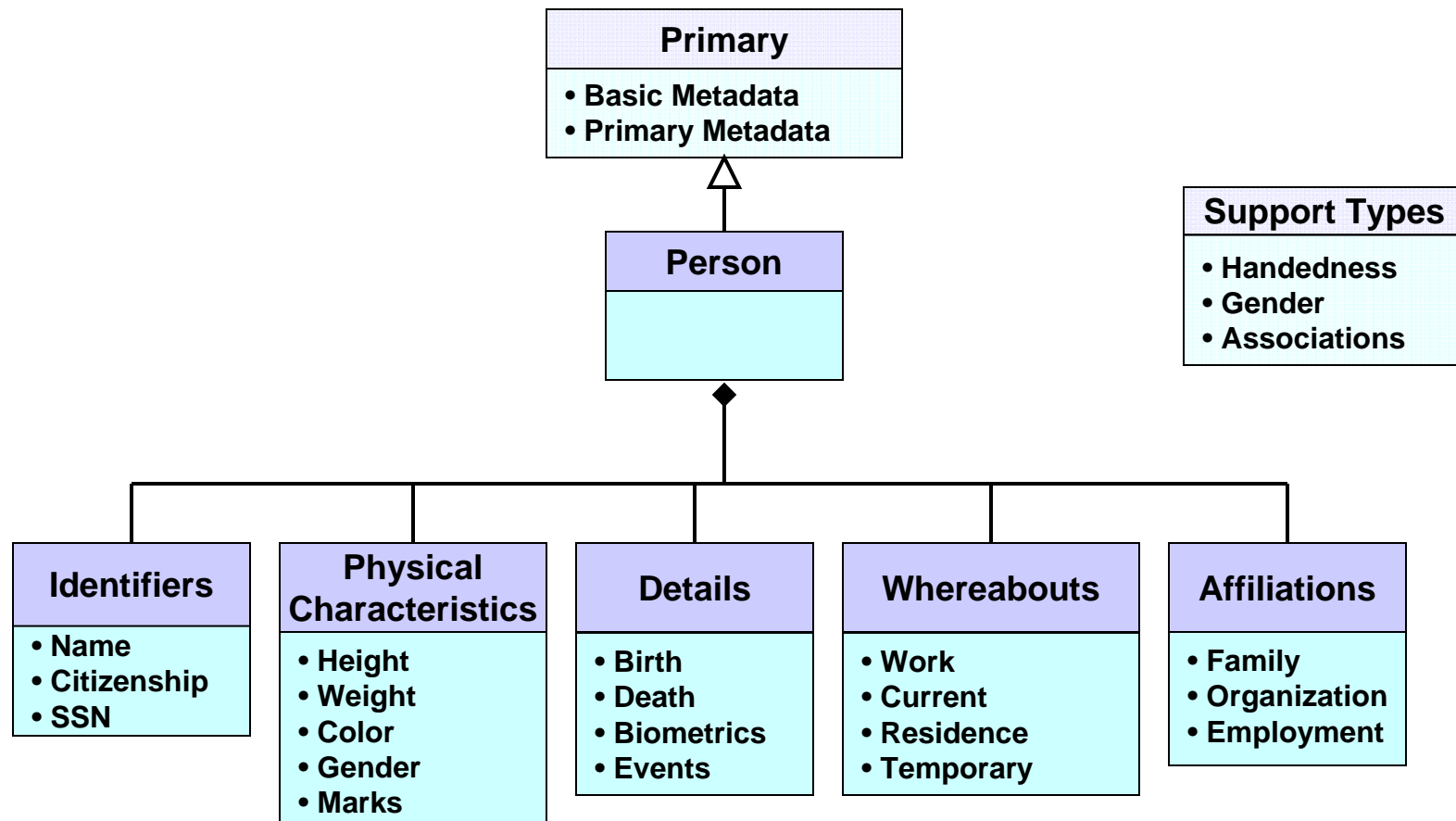


Typical Vessel Relationships

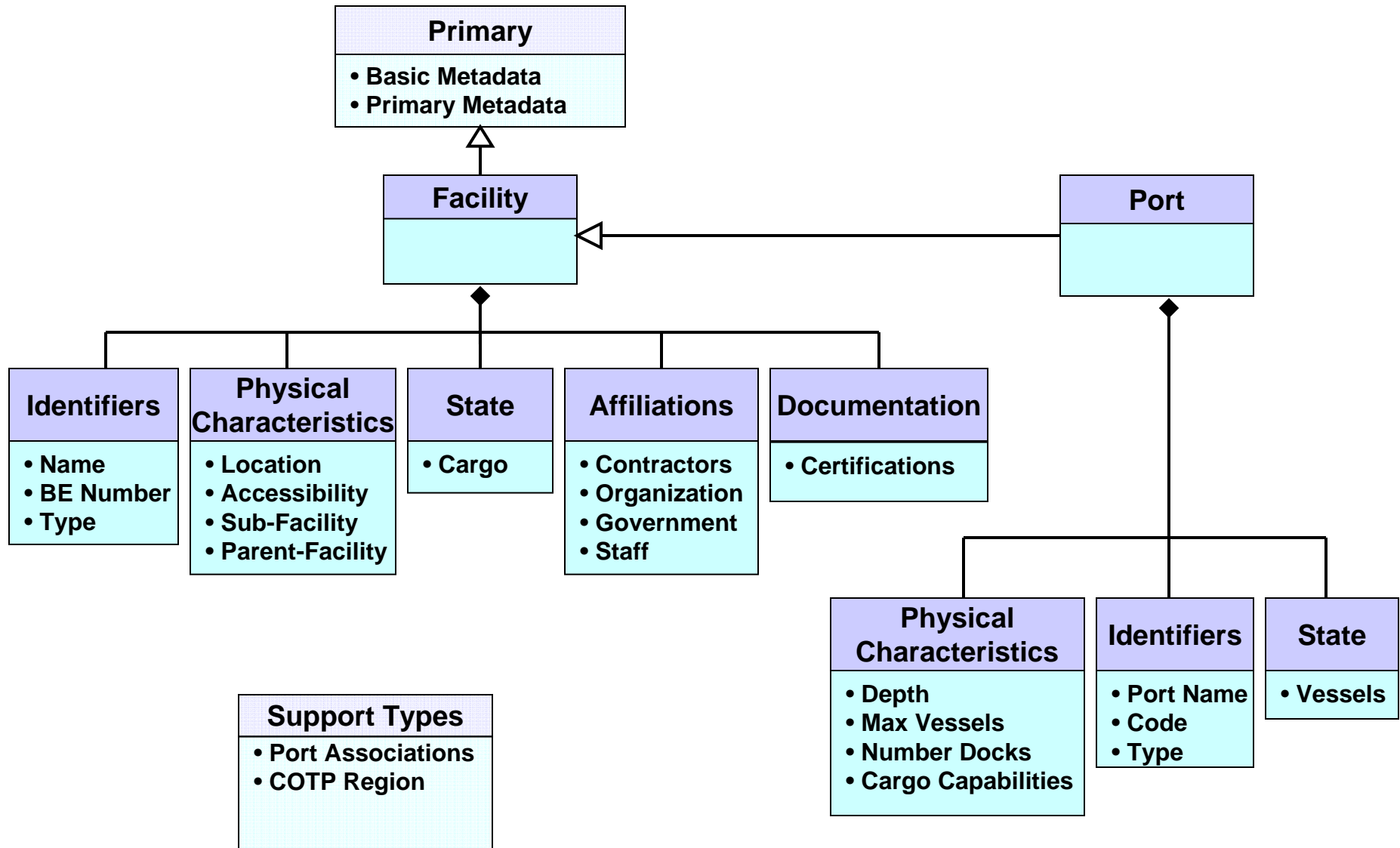


- Embedded (“has-a”)
- Associations (“on board”)
 - Strong, explicit relationships
 - Defined Association Types
- Affiliations (“related-to”)
 - Weak relationships between entities
 - ID/IDREFS references

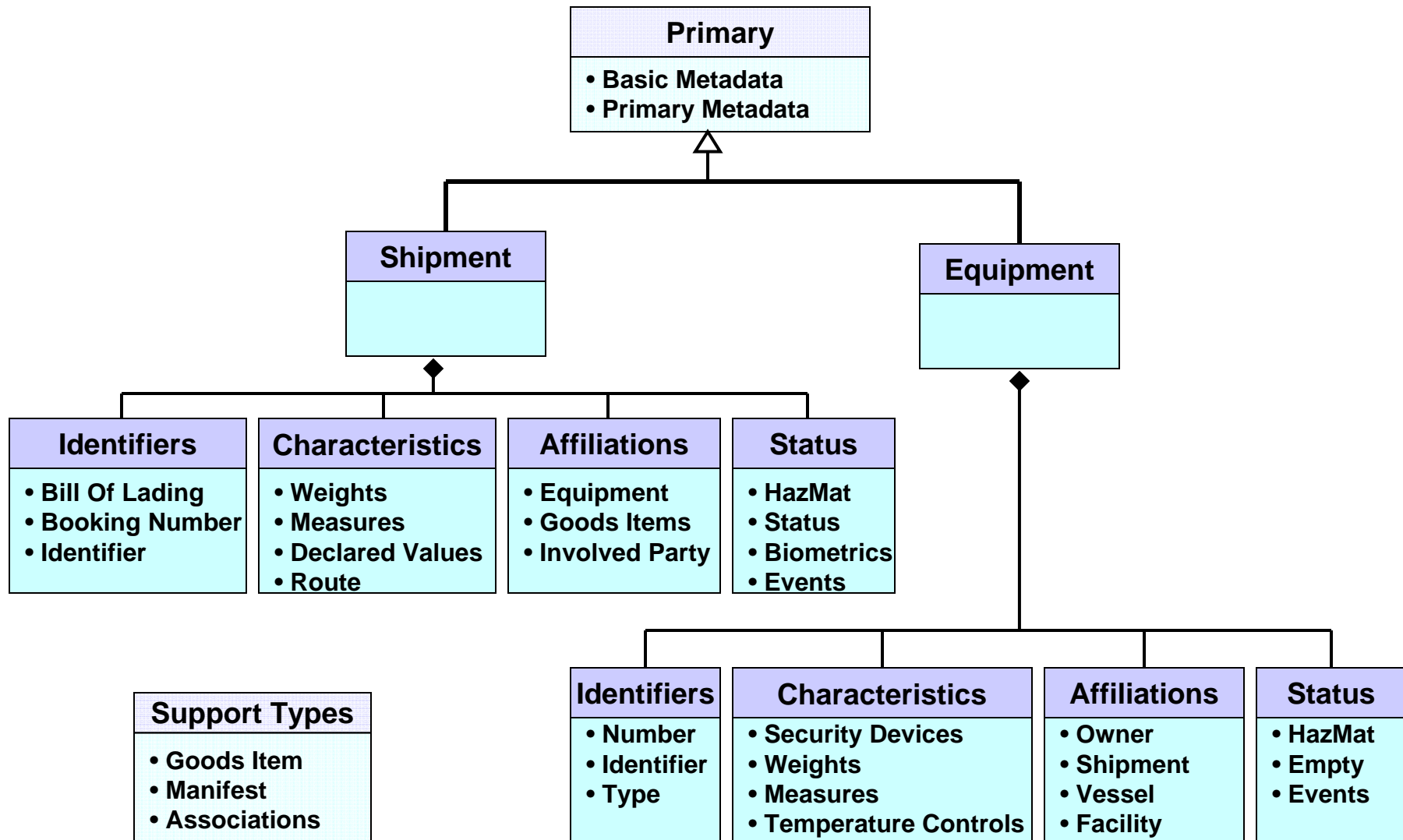
Person Model Details



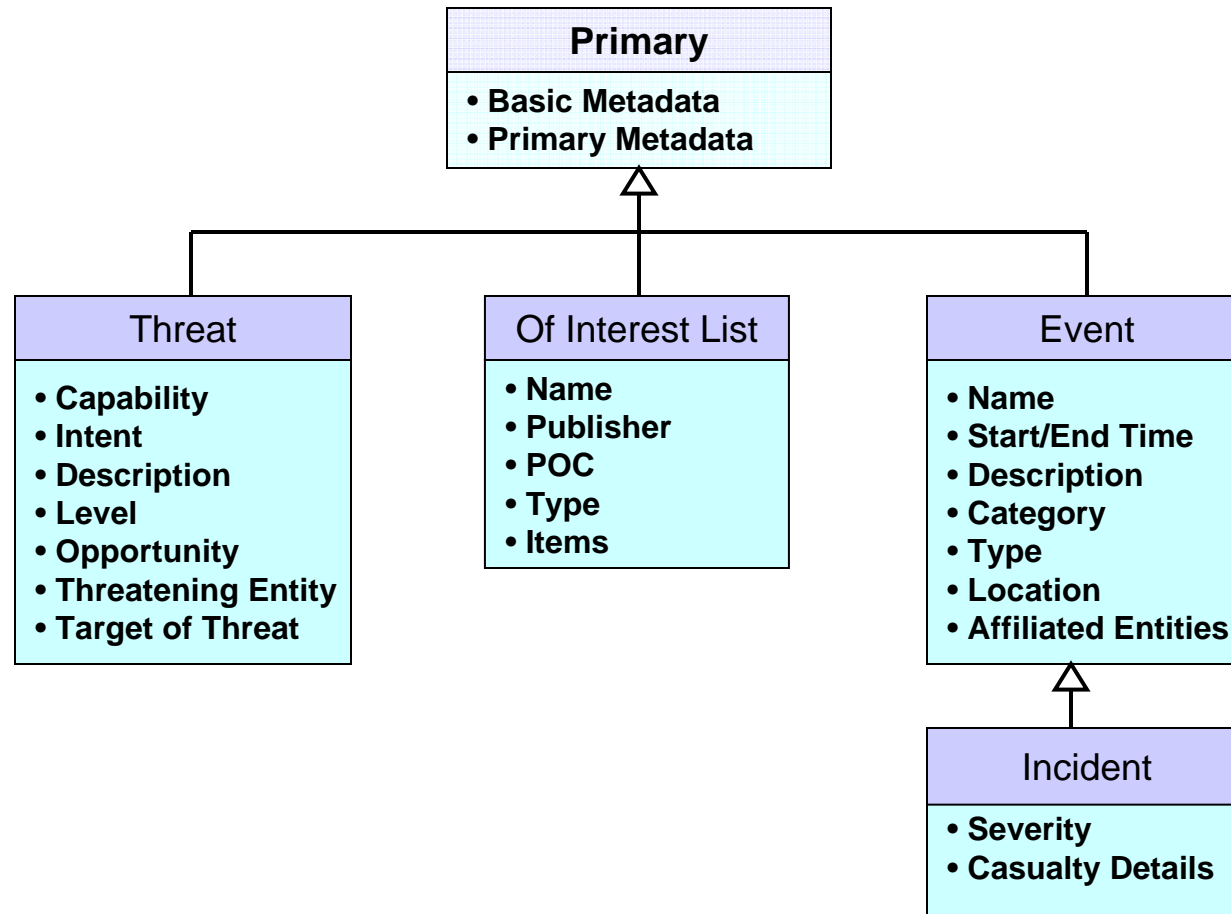
Facility Model Details



Cargo Model Details

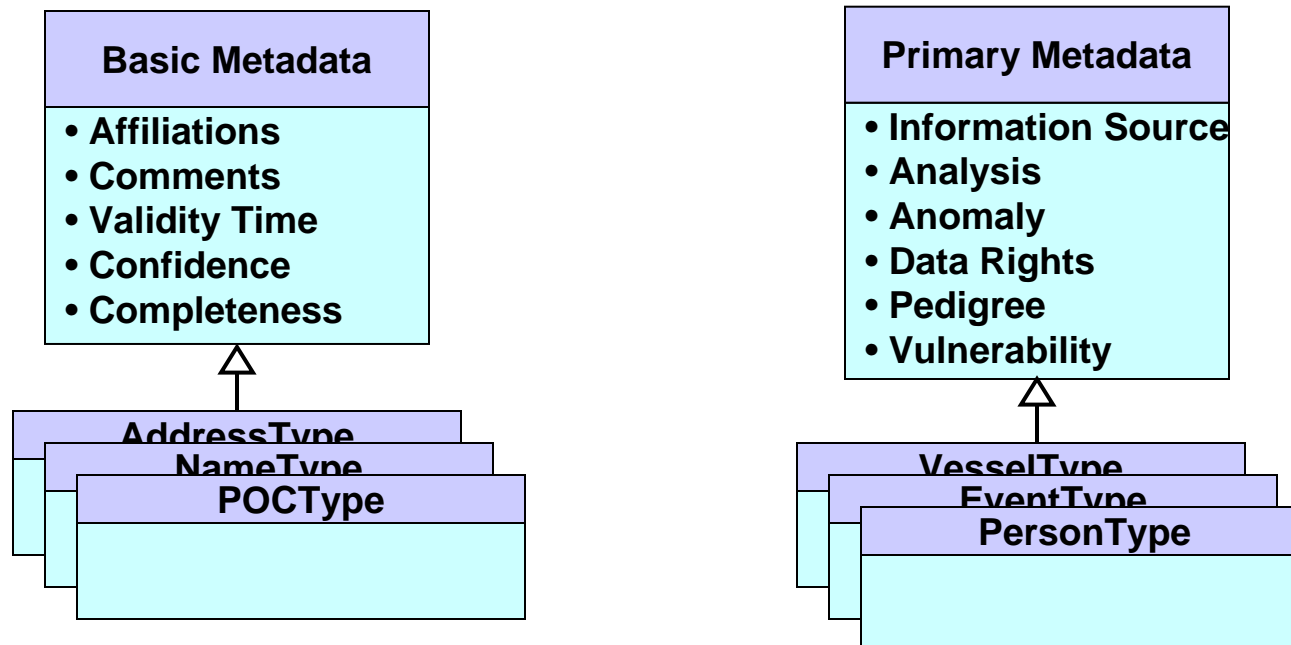


Abstract Types: Threats, Of Interest Lists & Events

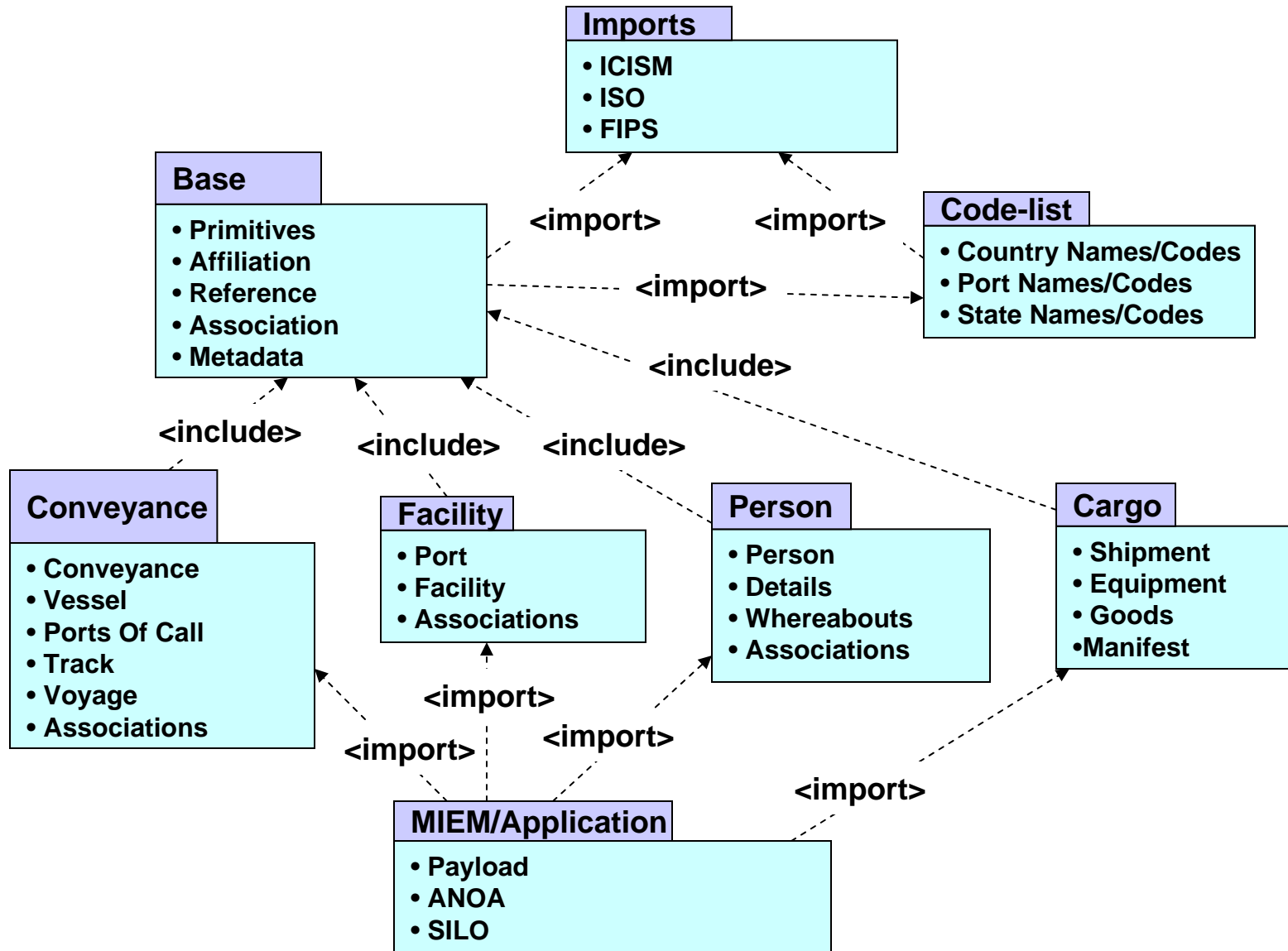


Basic Types with Metadata

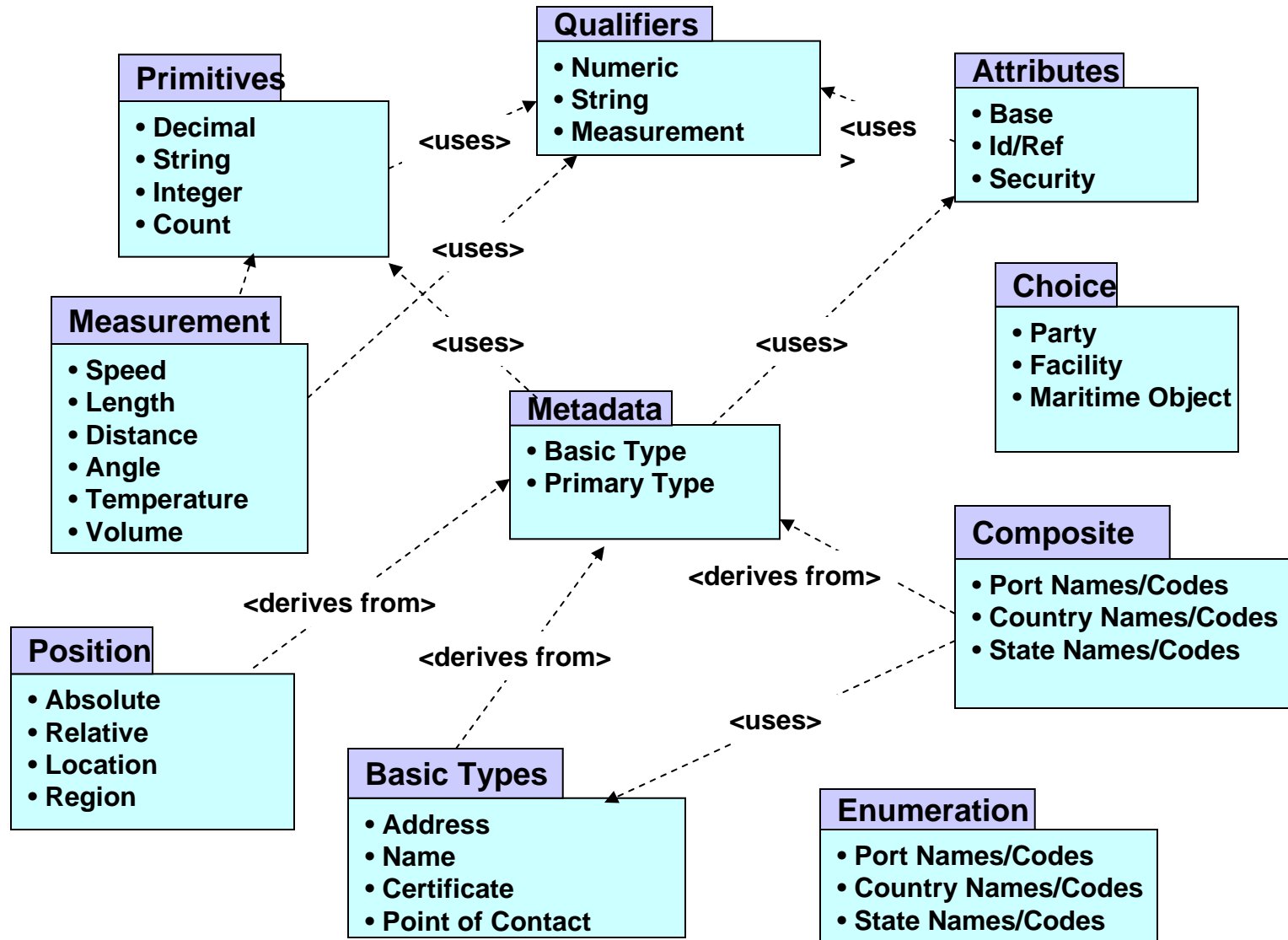
- All beliefs carry Metadata
- Simple beliefs carry Basic Metadata
 - MIEM Support Types carry Basic Metadata
- Complex beliefs carry Primary Metadata
 - MIEM Primary Types carry Primary Metadata



Model Packaging



Base Package



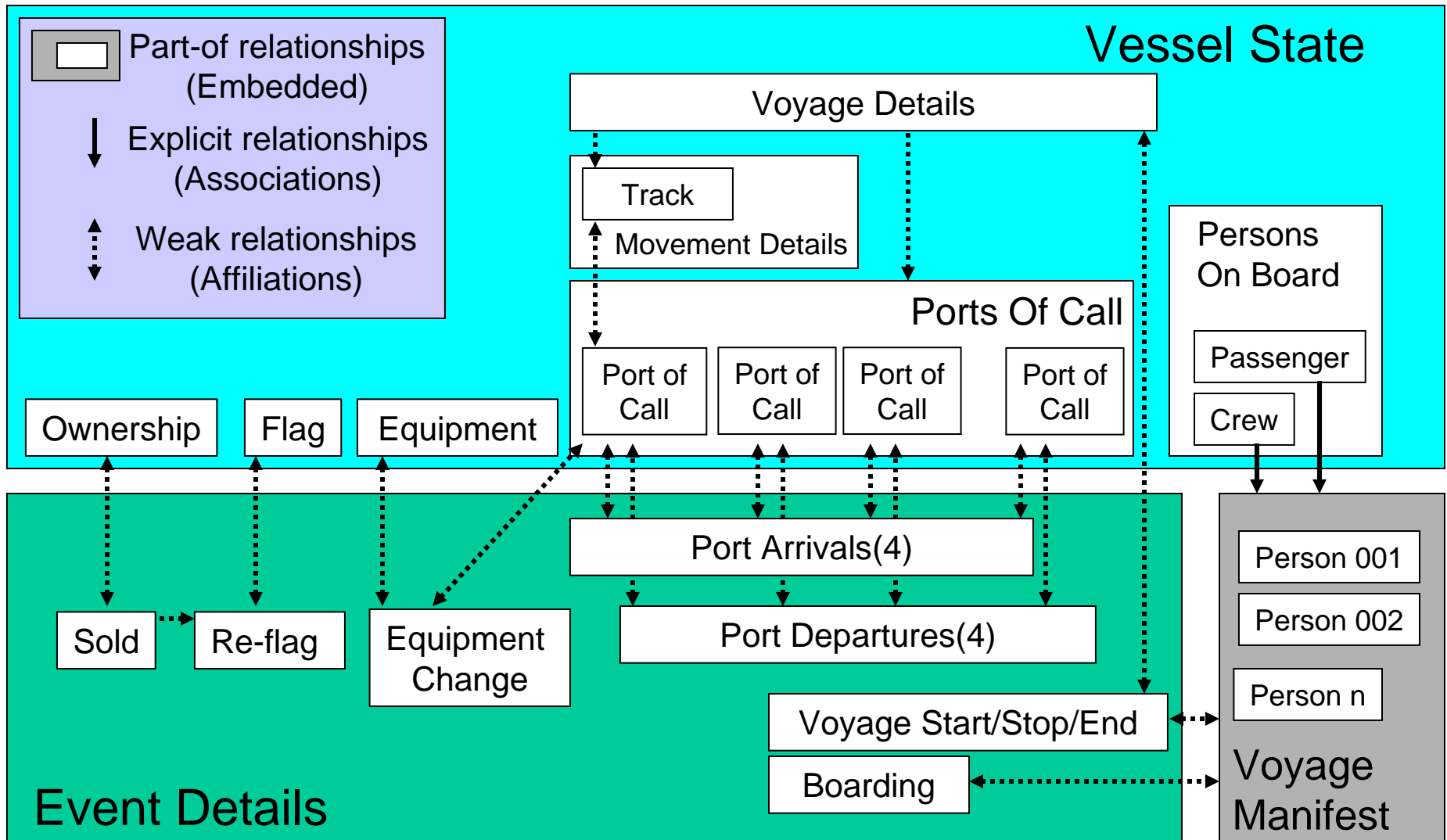


How do we Use the MIEM to Describe Situations?

An Illustration of Vessel State and Entity Relationships

As of February 2008, the ship was sold to an Iranian company, IC2, and was reflagged as a Panamanian. It sailed from Portland, ME to Abu Dhabi where it had some new equipment EQ1, EQ2 added to it by organization ORG3. Then it made a new voyage to South Africa, with stops at Djibouti and Dar es Salaam before arriving at Cape Town with a filed crew and passenger manifest. We have good track observations on the first leg of this voyage only.

Example Vessel State and Event Relationships



Example Vessel State and Event Relationships (XML)

```
9 <vessel md:id="VESSEL001">
```

The Port with id "PORT0001" is defined as being the port of "Portland, ME" in the country "USA" with a defined set of properties.

John Doe and has an affiliation to a vessel with id "VESSEL001" which he boarded at the port with id "PORT0001"

```
17 <md:countryIdentifier alpha3Code="USA"/>
18 <md:portIdentifier value="Portland, ME" name="Portland"/>
19 </md:identification>
20 <md:affiliation>
31 </md:affiliation>
32 <md:capability/>
33 <md:characteristic>
34 <md:depth value="18.1" UOM="m"/>
35 </md:characteristic>
36 <md:documentation/>
37 </port>
38 <port md:id="PORT0002">
39 <md:identification>
```

```
40 <md:boardingDetails>
41 <md:vessel>
42 </md:affiliations>
43 </person>
```

```
44 </md:owner>
45 <md:personsOnBoard>
46 <md:crewMember>
47 <md:embarkInformation>
48 <md:where>
49 <md:referenceObject xsi:type="md:PortRefType" md:mRef="PORT0001"/>
50 </md:where>
51 </md:embarkInformation>
52 <md:person md:ref="PERSON0001"/>
53 <md:crewRole role="Captain"/>
```



Final Technical Observations

- Powerful language for expressing actionable intelligence documents
- Extensible – Model can be extended to produce application-specific schemas

Next section will illustrate some
real-world examples



Using the MIEM



How do we use the MIEM...

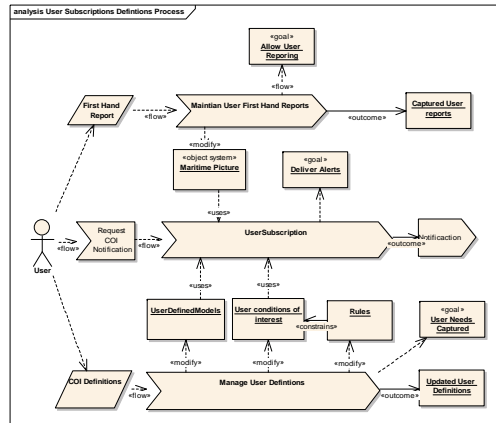
...as the basis of **information sharing** via **interoperable Web Services** in a Maritime Domain Service Oriented Architecture (**SOA**)?

...as a **payload** in an existing message exchange (e.g., UCore)?

...as the basis of a **case management** tool?

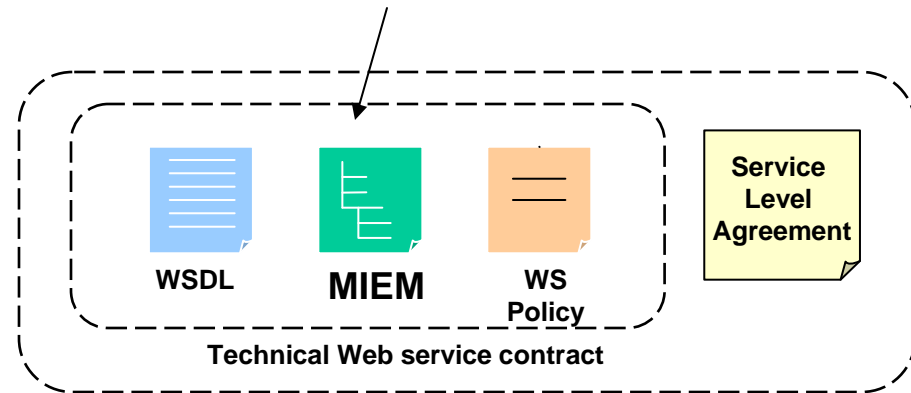
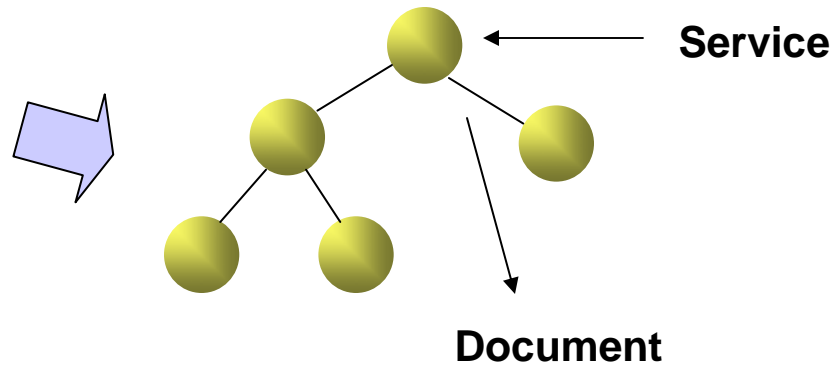
...to shape the **R&D** direction for other exchange models (e.g., NIEM Core)?

SOA Delivery Process



Business modeling

Service oriented analysis



Service Design



Advance Notice of Arrival (ANOA)

- Title 33, Code of Federal Regulation (CFR) requires foreign-flagged vessels and all commercial vessels (foreign or domestic) entering a U.S. port or place from a foreign port to give a 96-hour Advance Notice of Arrival (ANOA)
- Form is filed with the National Vessel Movement Center (NVMC) and can be filed online, faxed or emailed
- Frequent changes and updates:
 - ~ 12,000 vessels
 - ~ 138,000 ANOAs filed in 2007
- MDA DS COI Data Management WG reconciled to MIEM representation of ANOA



Single Integrated Lookout List



- SILO is part of the Global Maritime Intelligence Integration (GMII) Plan
- SILO will provide:
 - Access to a single integrated lookout list of all vessels of domestic and global intelligence interest, in coordination with cognizant authorities and centers.
- ONI and Coast Guard directed as co-leads
- Initial release per MIEM 0.90
- Will migrate to MIEM 1.0.



What is the Universal Core (UCore)?

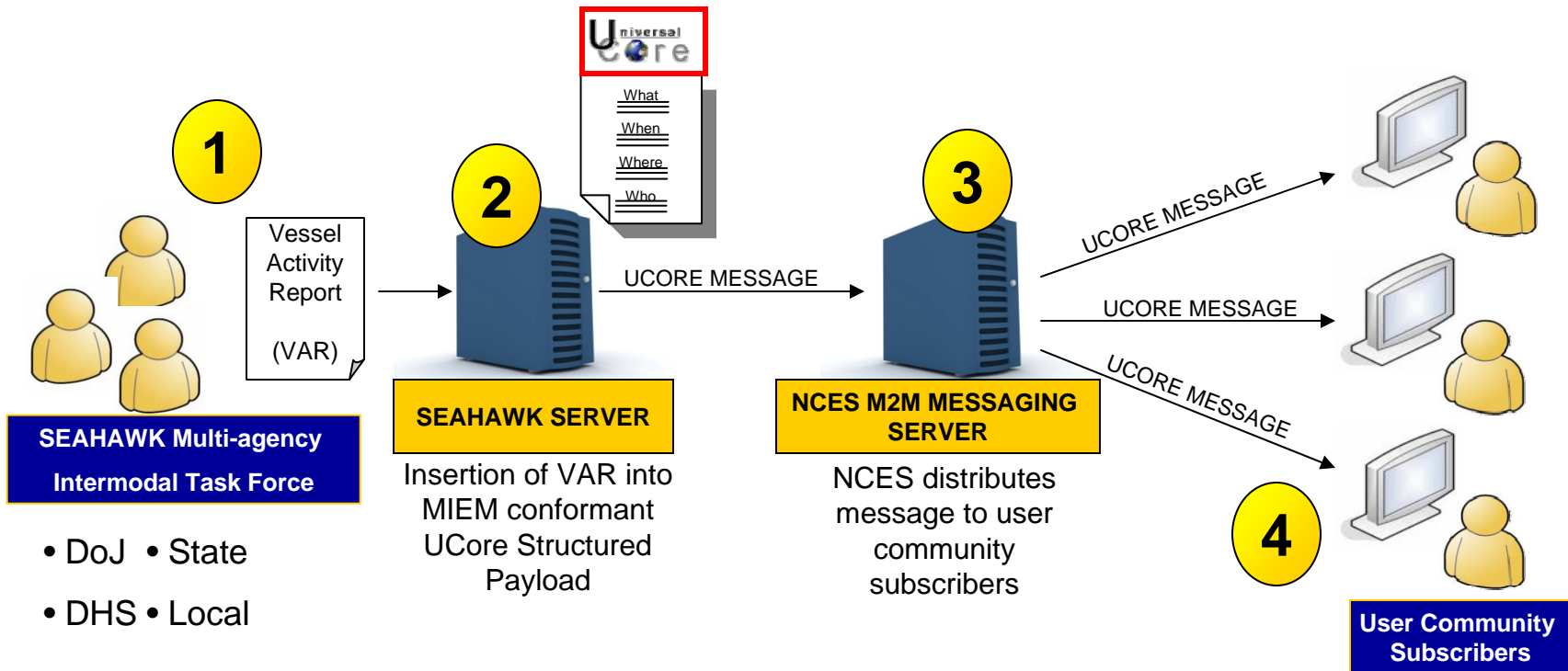
- A strategy for lightweight semantic tagging for a wide variety of documents
- Tagging provides a simple way to express “coordinates”: **Who, What, When, Where**
- Documents can be semantically rich domain specific intelligence reports
- For example, MDA actionable intelligence fully encoded using the MIEM



UCore & MIEM: SeaHawk

- SeaHawk multi-agency intermodal task force develops Vessel Activity Report through inputs received from Port of Charleston; VAR is sent to the SeaHawk server for publication
- SeaHawk server transforms VAR into a UCore-compliant message with **Maritime Information Exchange Model (MIEM) extensions**
- SeaHawk publishes the resulting message over NCES Messaging Service
- NCES messaging service distributes **UCore message** to authorized subscribers

SEAHAWK Data Flow Diagram





Case Management Tool

- Best practices in “tracking” require comprehensive “case” histories
 - E.g., USCG MIFCPAC & CBP AMOC
 - These practices are mostly manual today
- MIEM supports this vision of best business practice
 1. The analyst receives a case of interest
 2. Opens the “document” & sees a “top sheet” with highlighted entities, events, relationships
 3. Drills down where needed to assess beliefs
 4. Adds evidence, modifies beliefs, changes highlights
 5. Shares the “monotonically updated” document with others
- MIEM provides the foundation for **document-centered collaborative intelligence**



R&D Course Setting for Info Sharing

MIEM addresses more levels of value

- **Level 3, Fused data & inferred beliefs**
- **Level 4, Degree of belief & pedigree**
- **Level 5, Multiple alternatives & analysis**
- **Level 6, History, behavior & future projections**
- **Level 7, “Of interest” conditions & watch lists**
- **Level 8, Threats & anomalies**
- **Level 9, Case files for key entities**

These information requirements are ubiquitous

- Other intelligence programs will need similar capabilities
- NIEM will address & exploit these in its Core R&D



MIEM Program Status



MIEM Program Overview

Developed in partnership by

Comprehensive Maritime Awareness
Joint Concept Technology
Demonstration (CMA JCTD)

and

Maritime Domain Awareness
Data Sharing Community of Interest
Data Management Working Group
(MDA DS COI DMWG)



Status

- Beta test version released February 8, 2008
- Incremental Design review held June 10-11, 2008
- Version 1.0 product release scheduled September 19, 2008
 - XML Schema
 - User Guide
 - Training guide



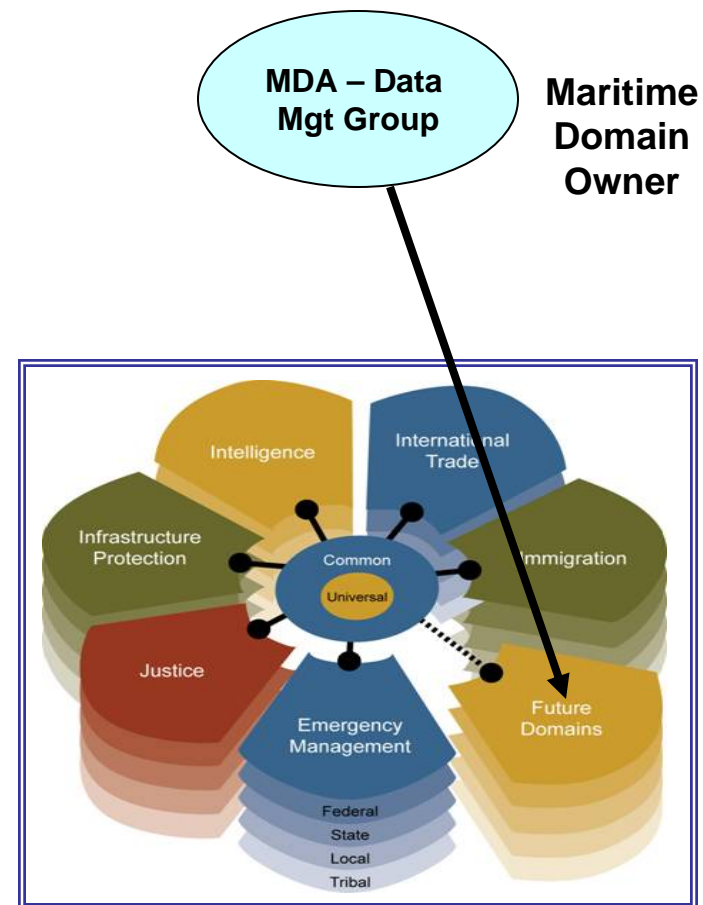
Beta Testers

- CMA JCTD -Cargo
- MASTER JCTD
- MDA DS COI
- MAGNET/MIFCPAC
- CMA – Singapore
- Seahawk
- NSA - RTRG
- NAVAIR - Tampa Bay Maritime Domain Awareness System (MDAS)
- TTCP – Maritime AG 8 International MDA
- SPAWAR Charleston - MDA Non Classified Enclave

Transition to MDA-NIEM

Planned FY09

- Transition the MIEM to the DHS/DOJ National Information Exchange Model (NIEM) as a new Maritime Domain
- Transition the MDA DS COI DMWG to an MDA Data Management Group
 - The MDA-DMG becomes the Maritime Domain owner





Summary & Conclusion

- MIEM provides a language for expressing actionable intelligence
 - Rich semantics for pragmatics of “tracking”
 - Supports higher-levels of analysis
 - Directly supports resource cueing & interdiction
- MIEM’s focus on document sharing supports a vital vision of collaborative intelligence
- The NIEM will incorporate the MIEM directly & as a guide for higher-levels of Core value
- MIEM elements and approach should benefit many intelligence suppliers and consumers