A Semantic Web Application for the Air Tasking Order (ATO)

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Agenda

- Semantic Web Technologies
  - Limitations with current WWW
  - Semantic Web Vision
  - Web Ontology Languages (OWL, RDF, RDFS SWRL)
  - Semantic Web Services
- Our Air Tasking Order Time Sensitive Target Application
  - ATO Ontology
  - Demo

Limitations of the WWW

limitations of the WWW and technologies:

- HTML mixes content with presentation
  - Primarily display and it is human updated
  - Poor for dynamic content (databases)
- Keyword search – great but information overload
  - Search engines locate information, we search
- XML eXtensible Markup Language – tree based

eXtensible Markup Language (XML)

- XML approach is to “wrap” each data item in start/end tags

```
<Aircraft>
        <wingspan> 14.8 meters </wingspan>
        <cruise-speed> 70 knots </cruise-speed>
        <description> UAV </description>
</Aircraft>
```

- Limited machine processing: knows it’s an aircraft but, doesn’t know the meaning of aircraft
- Semantic Web languages are based on XML

The Semantic Web Vision

- Semantic Web: “The first step is putting data on the Web in a form that machines can naturally understand, or converting it to that form. This creates what I call a Semantic Web and web of data that can be processed directly or indirectly by machines." Sir Tim Berners-Lee
- Semantics – is the meaning of words or symbols
- Two parts of Vision:
  1. Make the web a collaborative medium
  2. Machine understandable or processable
- Potential: Query, Electronic Commerce/Business, Scheduling, Biotechnology

Semantic Web Languages

OWL - Web Ontology Language

RDF, RDFS - Resource Description Framework (Schema)

SWRL –Semantic Web Rule Language

- **A standard way for understanding the semantics (meaning)**
- **Enables applications (computers) to use the data**

  subClassOf **: states one class is a subset of another class of items. Example: Fighter is a *subClassOf* CombatAircraft.**

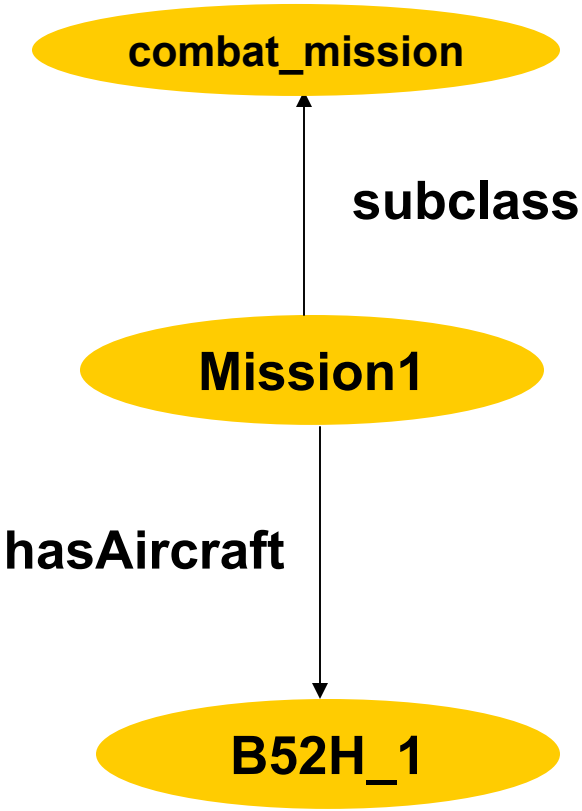
  properties**: properties are relations between classes, individuals and data Example: Mission1 *hasAircraft* B52H-1**

  equivalentClass**: one class is equivalent to another class. Example: Platform is an *equivalentClass* to Aircraft.**

Semantic Web Languages

- Web Ontology Language – OWL (W3C Recommendation) - son of DAML
- OWL Lite, DL (Description Logic), Full
- Adds property restrictions, logic, rules and expressiveness for the Semantic Web

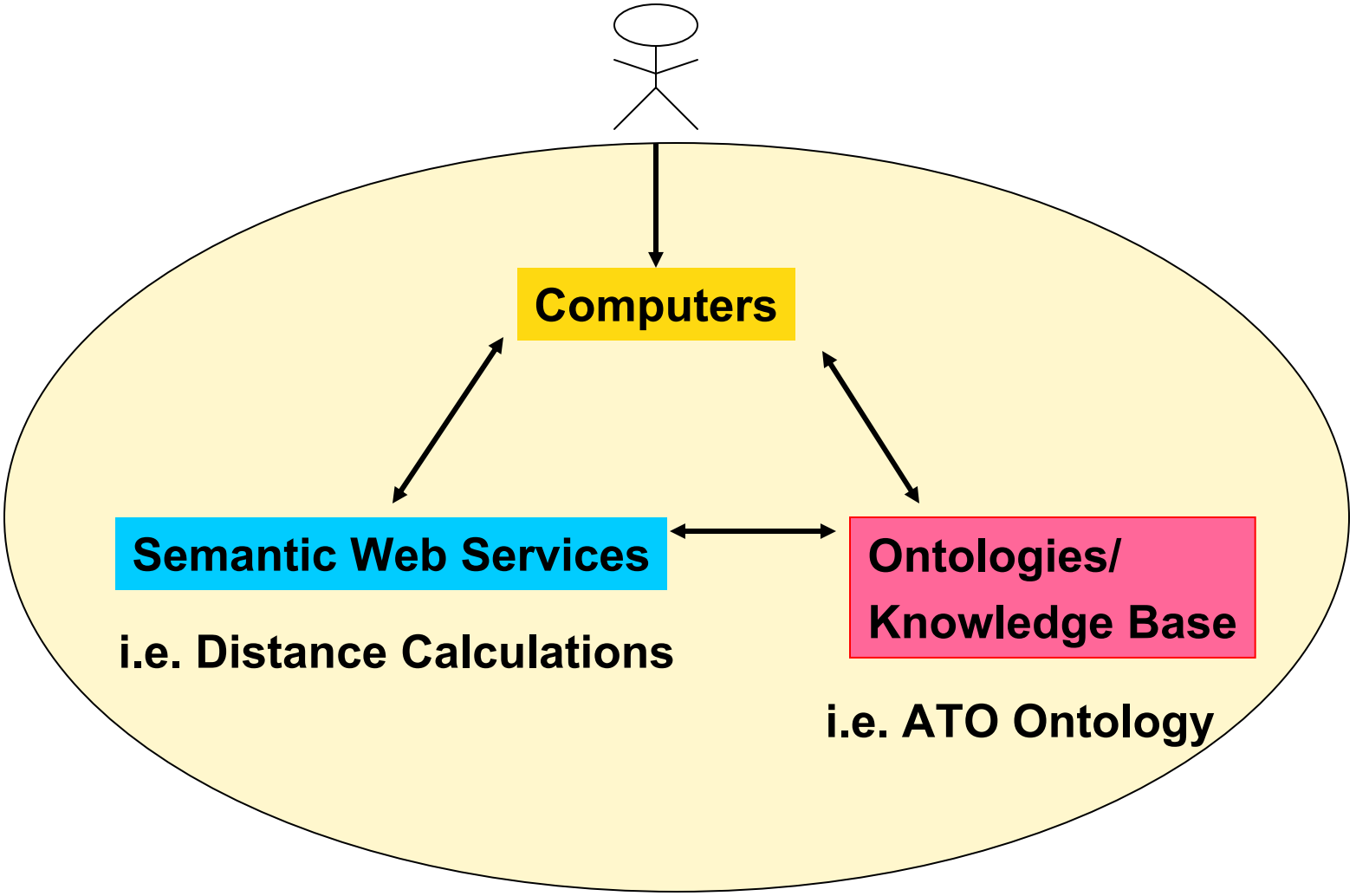
```
<owl:Class rdf:ID="Mission1">
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:someValuesFrom>
                <owl:Class rdf:ID="B52H_1"/>
            </owl:someValuesFrom>
            <owl:onProperty>
                <owl:ObjectPropertyrdf:
                    about="#has_aircraft"/>
            </owl:onProperty>
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Class rdf:about="#combat_mission"/>
    </rdfs:subClassOf>
</owl:Class>
```



Semantic Web Services

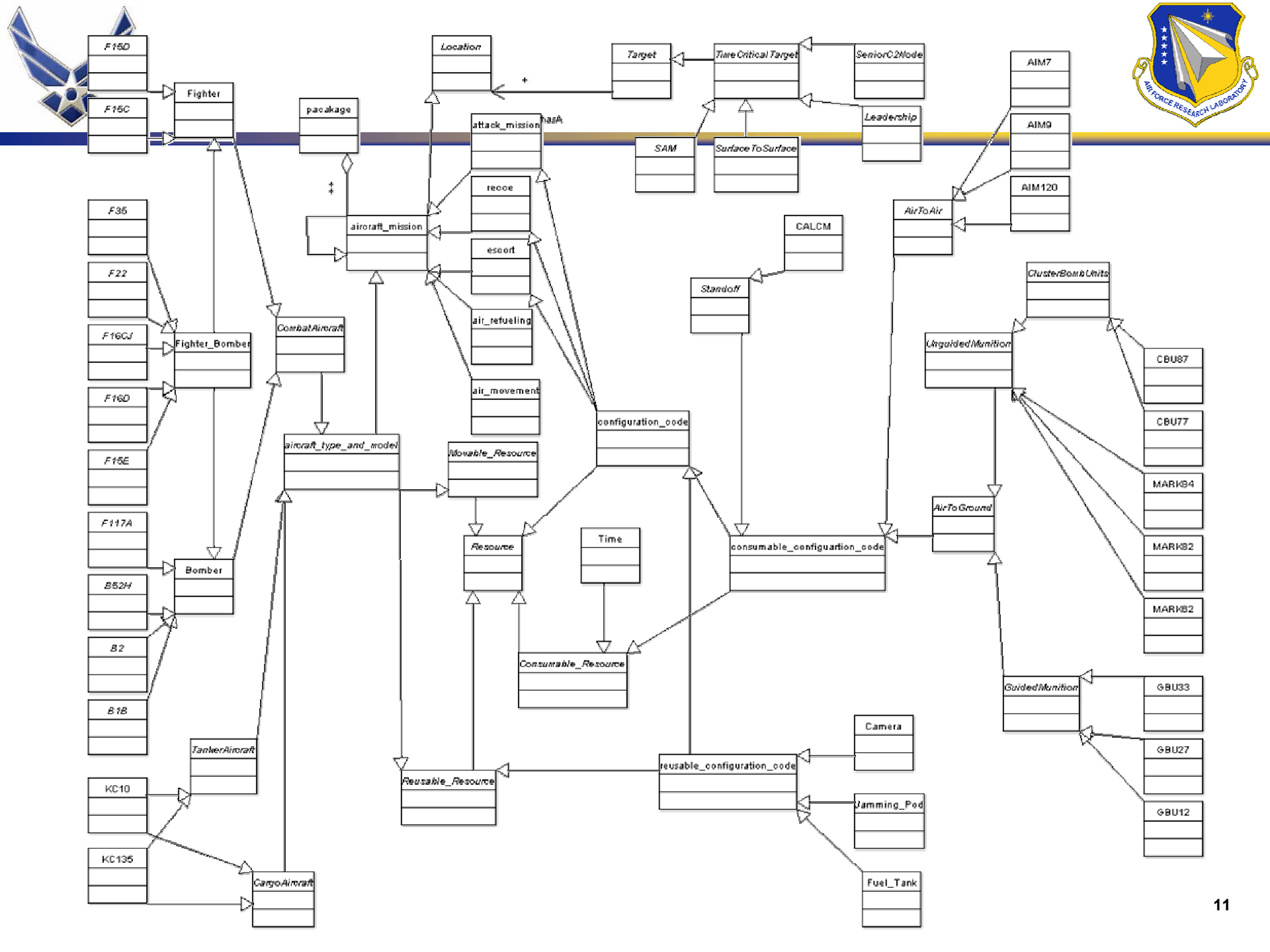
- **"Web services are software applications that can be discovered, described, and accessed based on XML and standard Web protocols over intranets, extranets and the internet"** **"The Semantic Web", Michael C. Daconta, Leo J. Orbst and Kevin T. Smith**
- **Semantic web services are web services that can accessed and understood by computers.**
- **Based on the OWL-S (Web ontology language for Semantic Web services).**

Semantic Web illustration

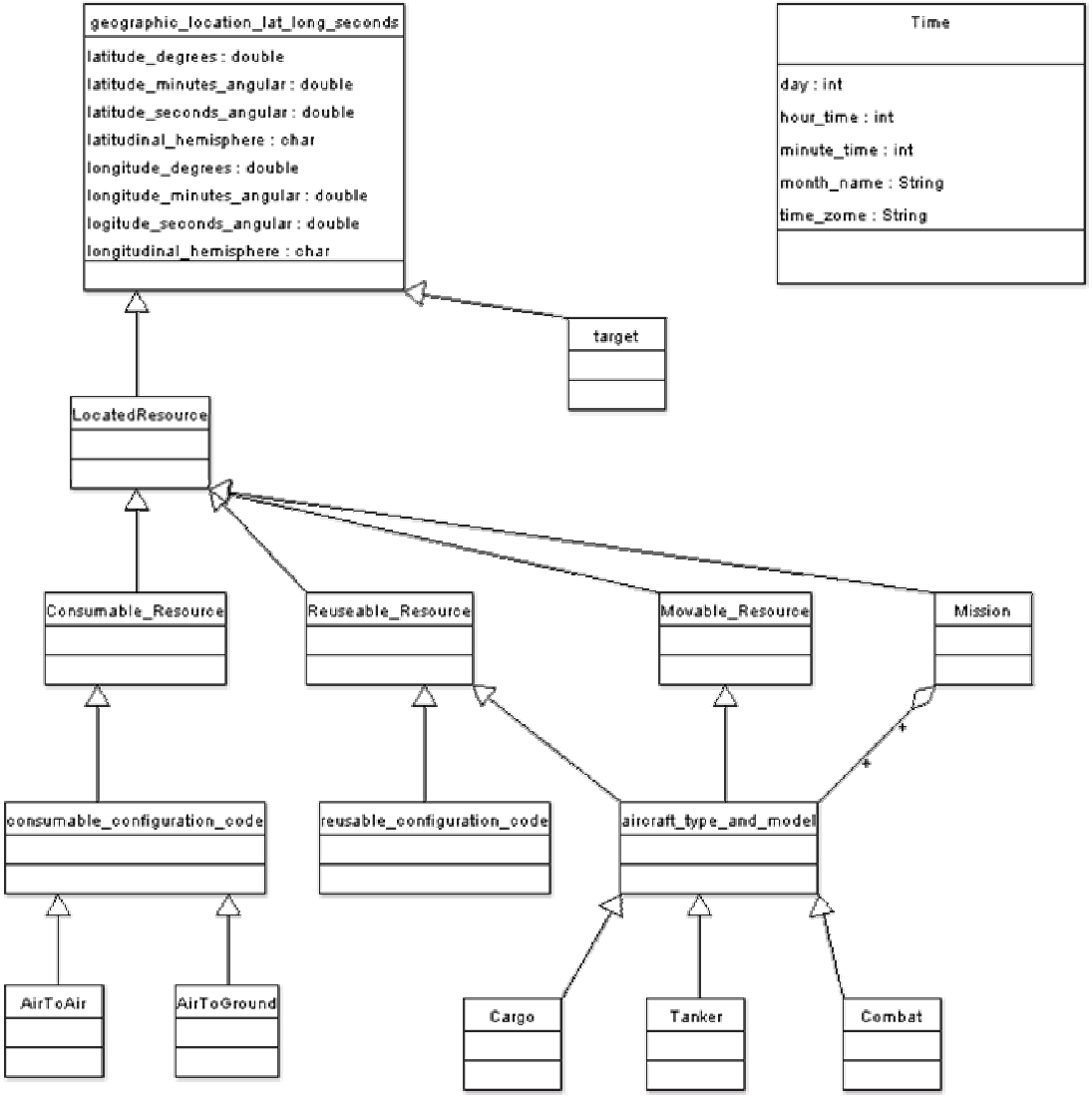


ATO Ontology Time Sensitive Targeting Demo

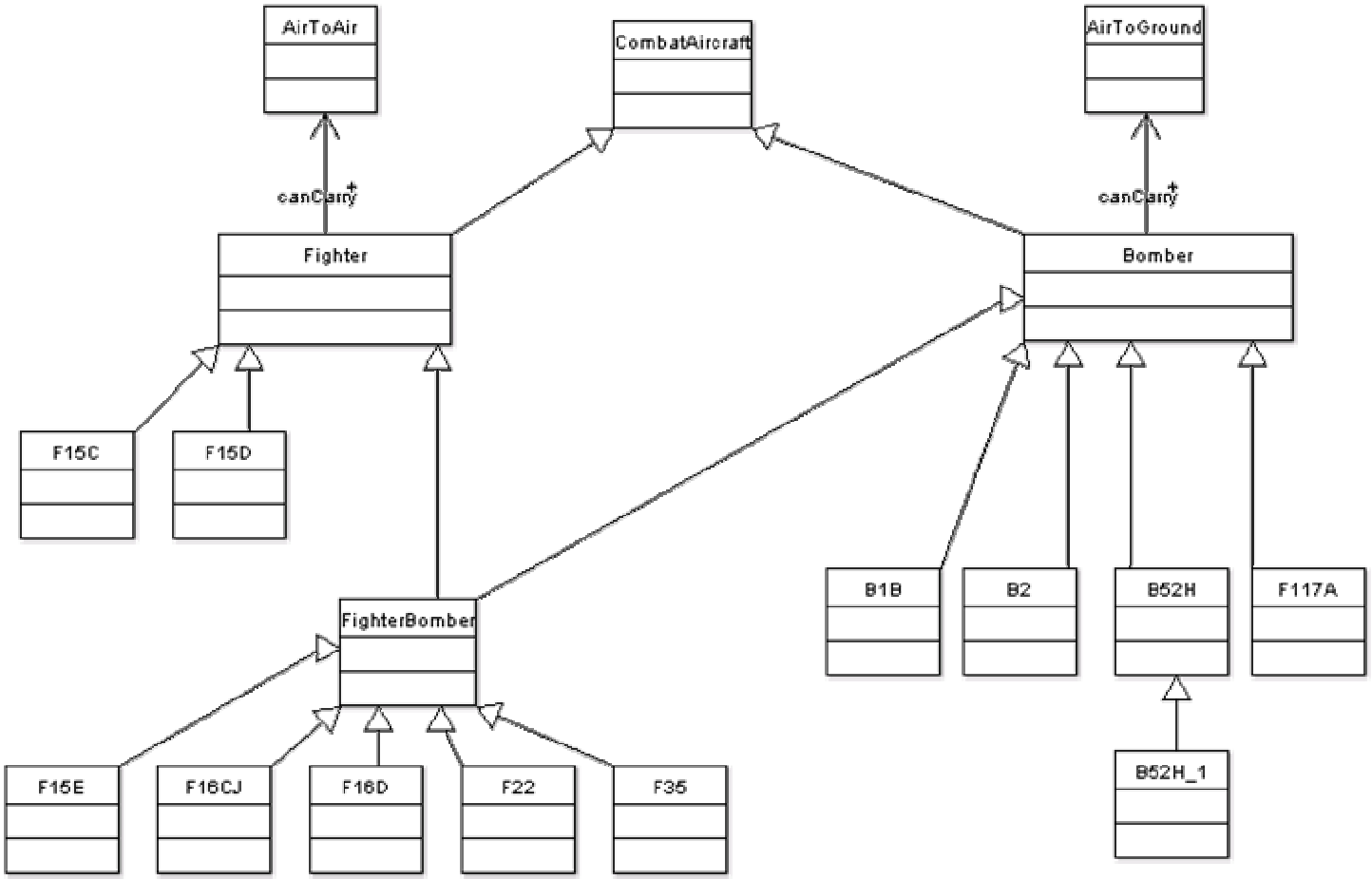
- ATO – document that assigns aircraft to tasks
- Show UML design – used ArgoUML
- Show ontology – built with Protégé (Stanford Univ.)
- Show example rules
- Show reasoning – used RACER


F15D
F15C
Fighter
package
Location
Target
TimeCriticalTarget
SeniorC2Node
Leadership
SAM
SurfaceToSurface
AIM7
AIM9
AIM120
AirToAir
attack_mission
recce
escort
air_refueling
air_movement
aircraft_mission
F35
F22
F16CJ
F16D
F15E
F117A
B52H
B2
B1B
Fighter_Bomber
Bomber
CombatAircraft
aircraft_type_and_model
Movable_Resource
Resource
Time
Consumable_Resource
Reusable_Resource
configuration_code
consumable_configuartion_code
reusable_configuration_code
CALCM
Standoff
AirToGround
ClusterBombUnits
UnguidedMunition
GuidedMunition
CBU87
CBU77
MARK84
MARK82
MARK82
GBU33
GBU27
GBU12
Camera
Jamming_Pod
Fuel_Tank
TankerAircraft
KC10
KC135
CargoAircraft

Top of ATO Ontology



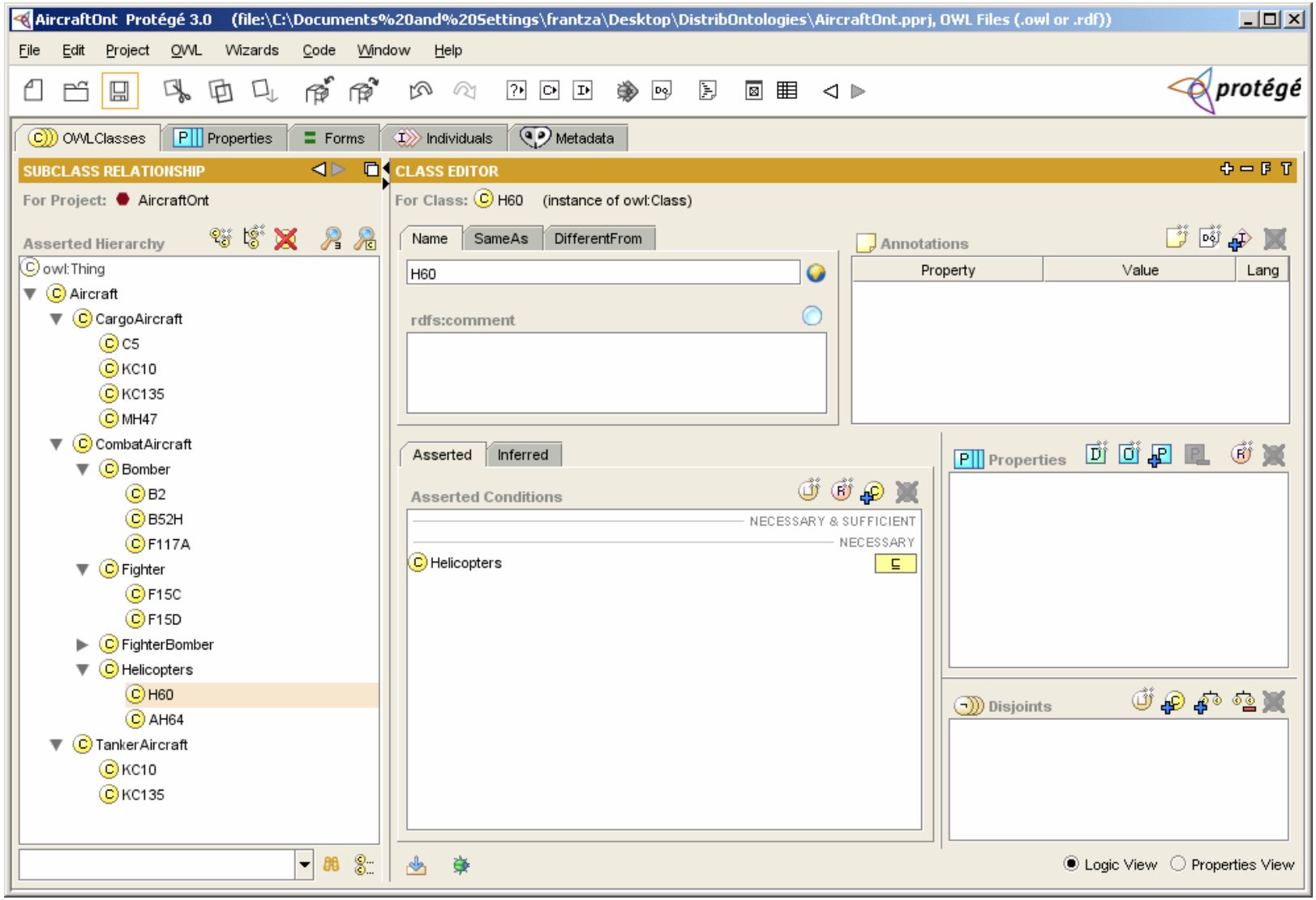
Combat Aircraft Ontology



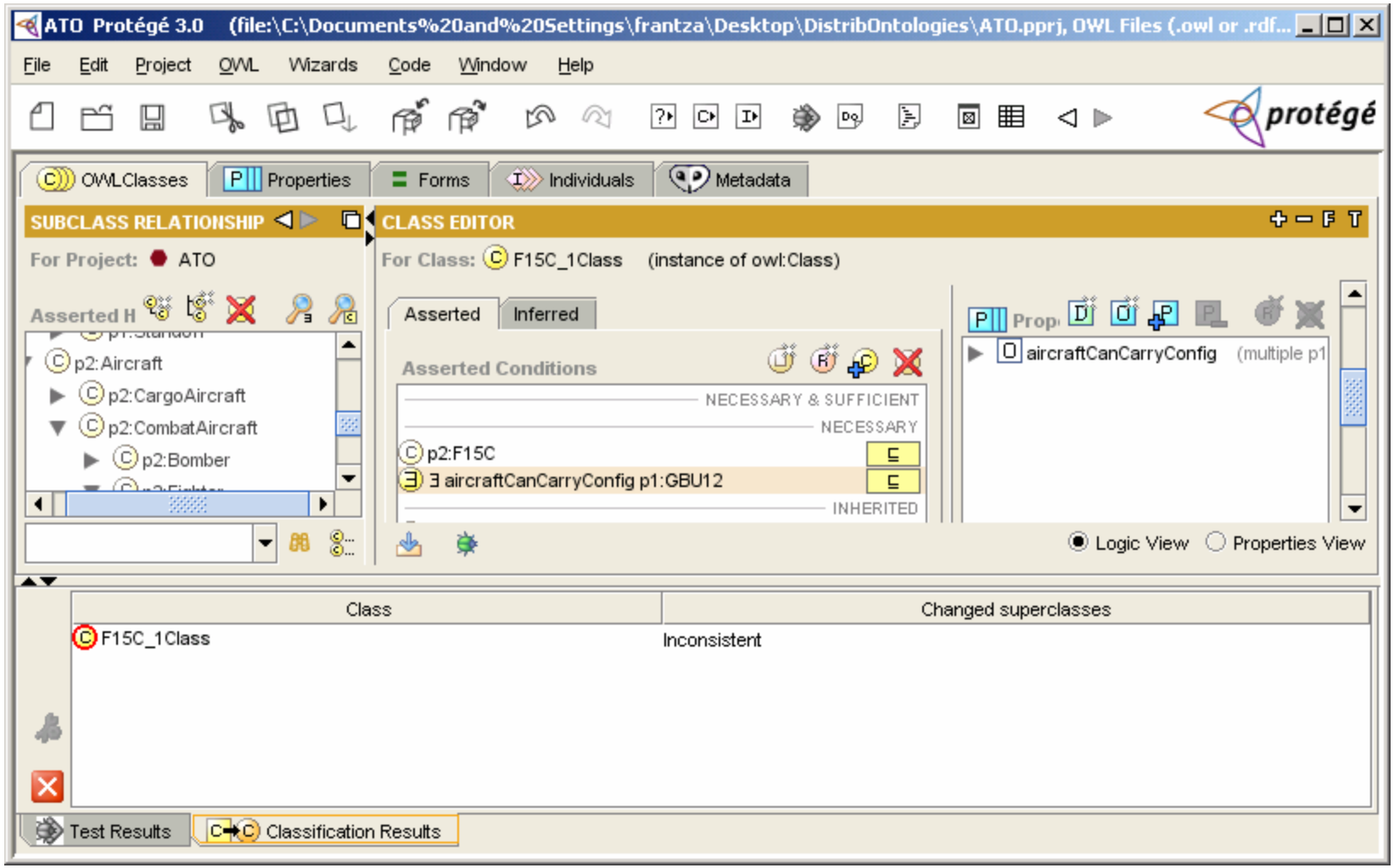
Air Tasking Order (ATO) Application
Time Sensitive Targeting

- The knowledge base has three time sensitive targets
  - SA20 near a mosque
  - SA20 not a mosque
  - Command Post
- Several Combat Missions
- Java application calculates if mission can reach target based on speed distance and time window.
- Reasoning rule states to divert a mission it must have aircraft, with the right weapons, to hit the target and not damage the mosque within critical time

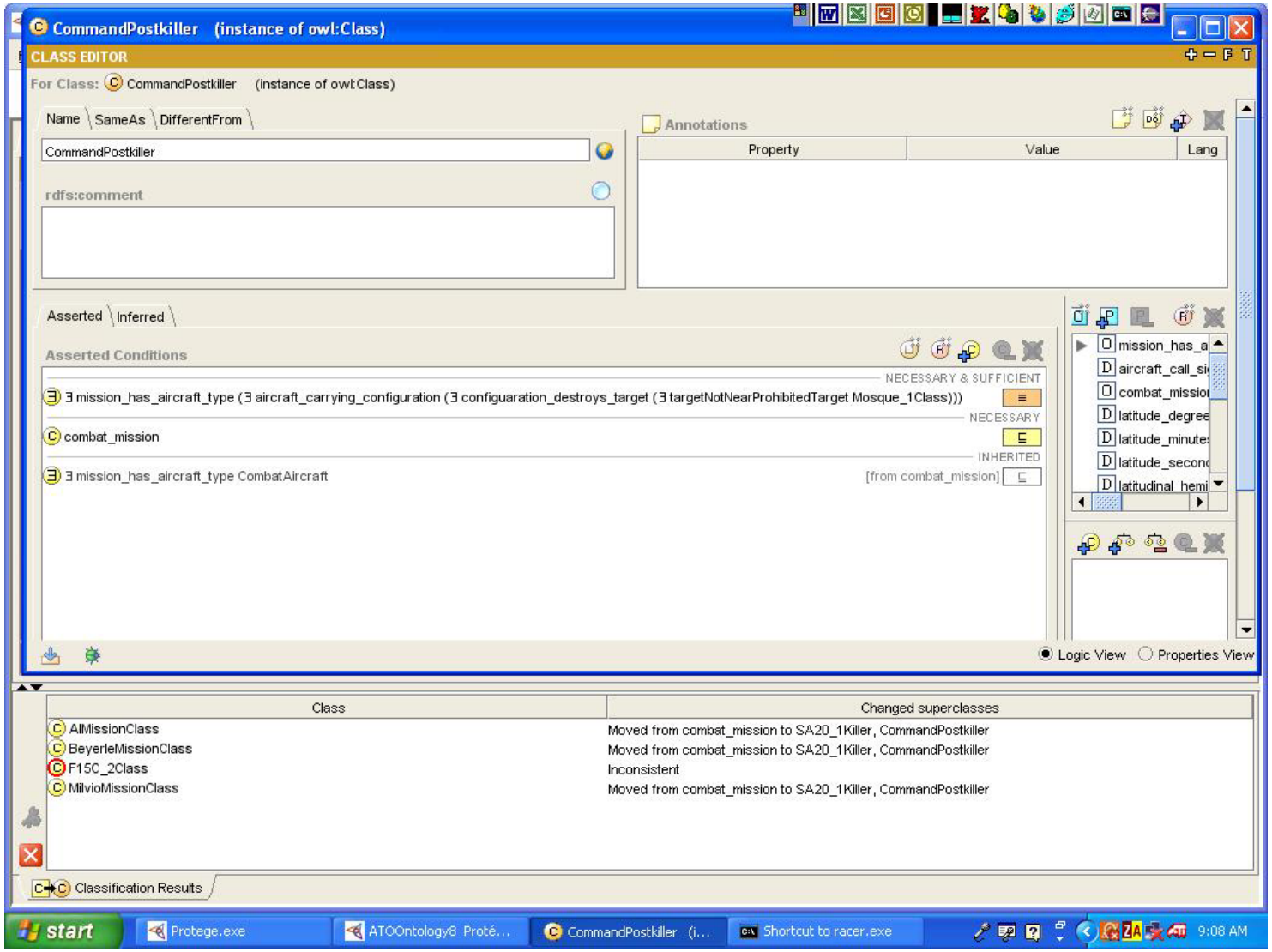
Aircraft Ontology in Protégé



A Constraint Violation



Protégé Rules

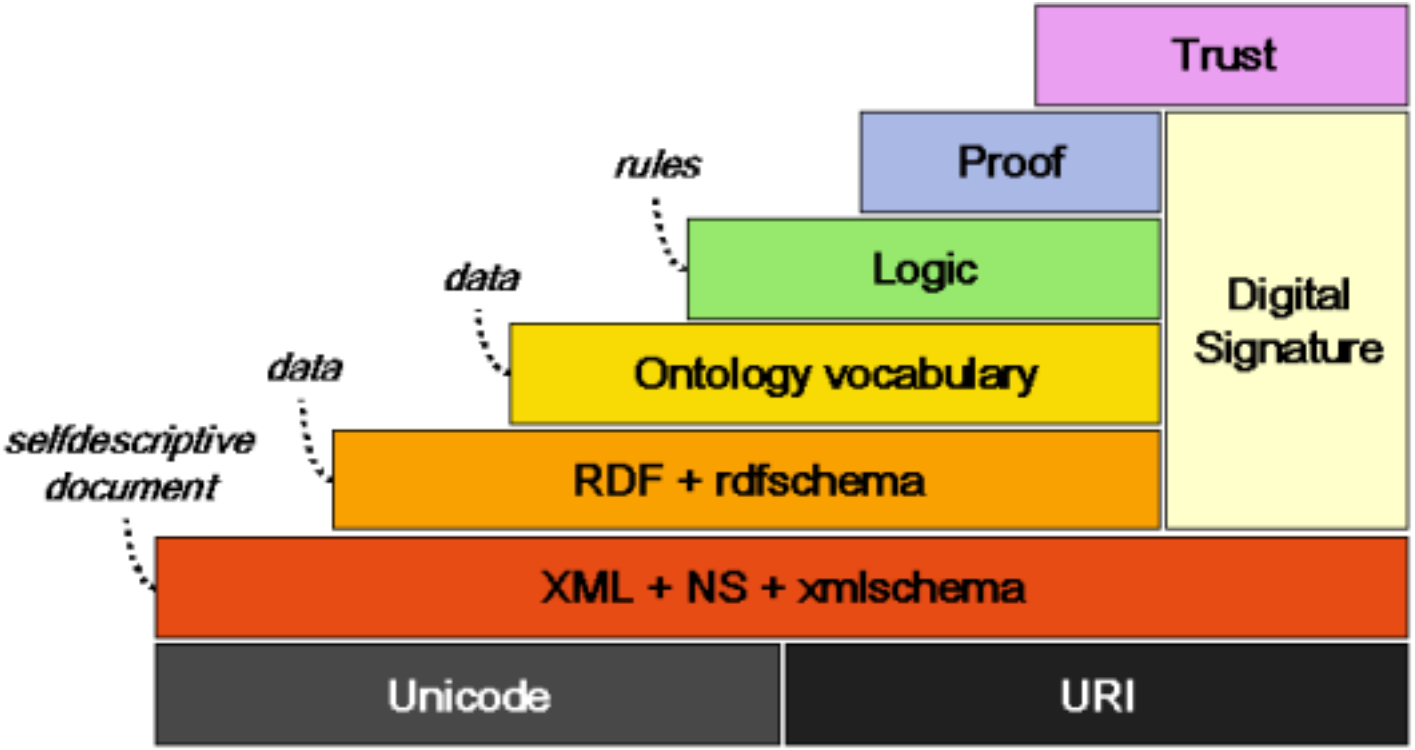


Potential Future Work

- Bring Prof. Selman back on through Intelligent Information Systems Institute
- Interface to Operational Net Assessment Ontology
  - Merge ontologies – collaborative
  - Map interface – show effects of diverting missions
- Make Java reachability application a semantic web service
- Demonstrate Resource Allocation
  - Use SWRL (Semantic Web Rule Language)
    - Time and numeric reasoning
- Interim/Final Tech. Report (currently 32 pages)

- Backup Slides

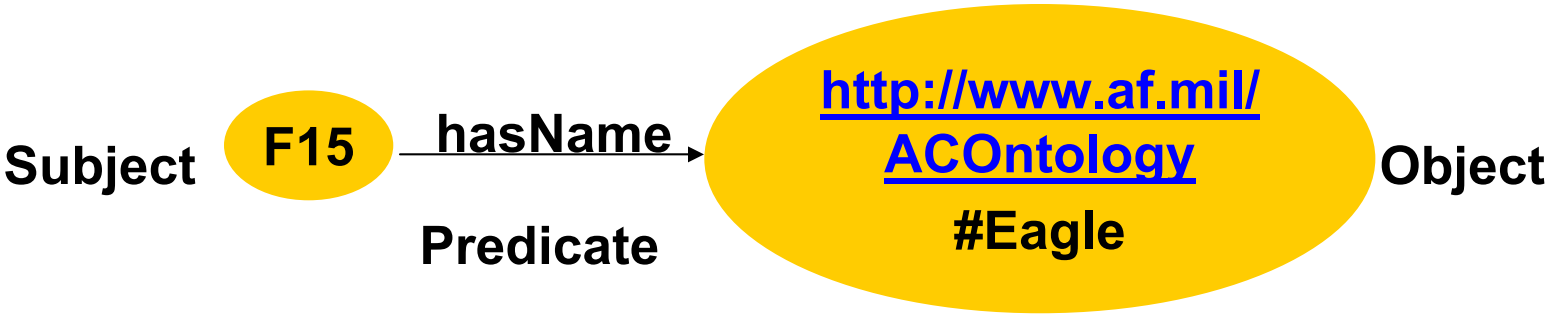
Semantic Web Technology Layers



Semantic Web Languages
RDF –Resource Description Framework

- Resource Description Framework Language: RDF
- Triple: Subject – Predicate - Object

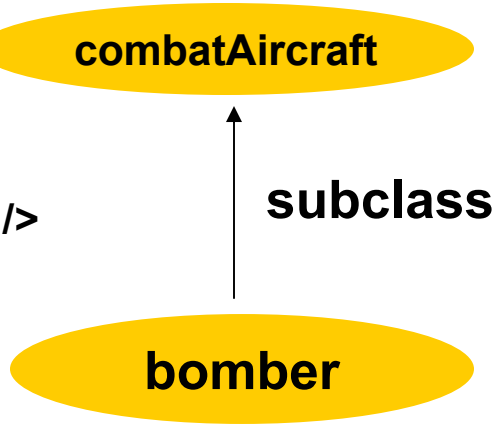
```
<rdf:Description rdf:ID=”F15”>
        <hasName>
           rdf:resource= ”http://www.af.mil/ACOntology#Eagle”
        </hasName>
</rdf:Description>
```



Semantic Web Languages
RDFS

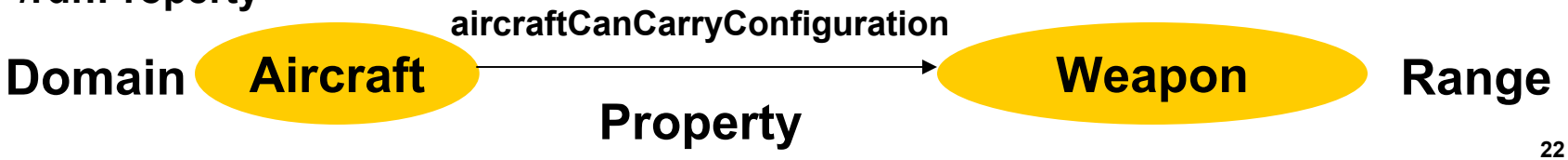
- **Resource Description Framework Schema – RDFS adds classes and properties**
- **Classes**

```
<rdfs:Class rdf:about=”bomber”>
        <rdfs:subClassOf rdf:resource=”combatAircraft”/>
</rdfs:Class>
```



- **Properties**

```
<rdf:Property rdf:ID=“aircraftCanCarryConfiguration”>
        <rdfs:domain rdf:resource=”#aircraft”/>
        <rdfs:range rdf:resource=”#weapon” />
</rdf:Property>
```



Computational Issues

- **Complexity: time and space complexity**
- **Decidability: a decidable problem has an algorithm that can solve the problem. May not be decidable in time *t* or space *s*.**
- **Completeness: algorithm is guaranteed to find a solution when there is one. (not complete algorithms may return some or none of answers)**
- **Expressiveness: as logic becomes more expressive in representing concepts computational complexity will typically go up.**

Air Tasking Order (ATO) Application
Time Sensitive Targeting

- Used US Message Text Format (USMTF) ATO message for ontology design in Unified Modeling Language (UML) -ArgoUML
- Design verified by John Beyerle, C3I Associates.
- Used Protégé to build the ontology and knowledge base. www.protege.stanford.edu
- Used RACER reasoner
- Used Protégé Java API to interface distance calculations to the ontology.

OWL-S

- Web Ontology Language for Semantic Web Services.
- Computer-interpretable description of a service.
- Supports automatic web service discovery, invocation, composition and interoperation and execution monitoring.
- Three parts:
  1. Service profile: declarative advertisements of service properties for capabilities and discovering services.
  2. Process model: detailed API description of a services operation. How to call service, execute it and what it returns.
  3. Grounding: details of how to interoperate with the service, via messages.
- Also developing a Resource ontology: allocation types, capacity types, resource composition

OWL-S

- **Profile: serviceName, textDesciption, contactInformation, hasParameter, hasInput, hasOutput, hasPrecondition, hasEffect, serviceParameters, serviceCategory (category name, taxonomy, value, code)**
- **Process Model: atomicProcess, simpleProcess, compositeProcess, sequence, split, split+join, unordered, choice, if-then-else, iterate, repeatUntil**
- **Grounding: required messages in Web Service Description Language (WSDL)**

Semantic Web Rule Language
SWRL

- Extends on OWL-Lite and OWL-DL.
- Unary/Binary Datalog RuleML sublanguages of Rule Markup Language.
- Includes high-level abstract syntax for Horn-like rules.
- Currently in W3C proposal stage.
- If antecedent (body) conditions are true, then consequent (head) conditions must be true.
- hasParent(?x1, ?x2) and hasBrother(?x2, ?x3) =>

  hasUncle(?x1, ?x3)

SWRL Example

```
<ruleml:imp>
    <ruleml:_body>
        <swrlx:individualPropertyAtom swrlx:property="hasParent"
            <ruleml:var>x1</ruleml:var>
            <ruleml:var>x2</ruleml:var>
        </ swrlx:individualPropertyAtom>
        <swrlx:individualPropertyAtom swrlx:property="hasBrother"
            <ruleml:var>x2</ruleml:var>
            <ruleml:var>x3</ruleml:var>
        </ swrlx:individualPropertyAtom>
    </ruleml:body>
    <ruleml:head>
        <swrlx:individualPropertyAtom swrlx:property="hasUncle"
            <ruleml:var>x1</ruleml:var>
            <ruleml:var>x3</ruleml:var>
        </ swrlx:individualPropertyAtom>
    </ruleml:head>
</ruleml:imp>
```