

# **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.

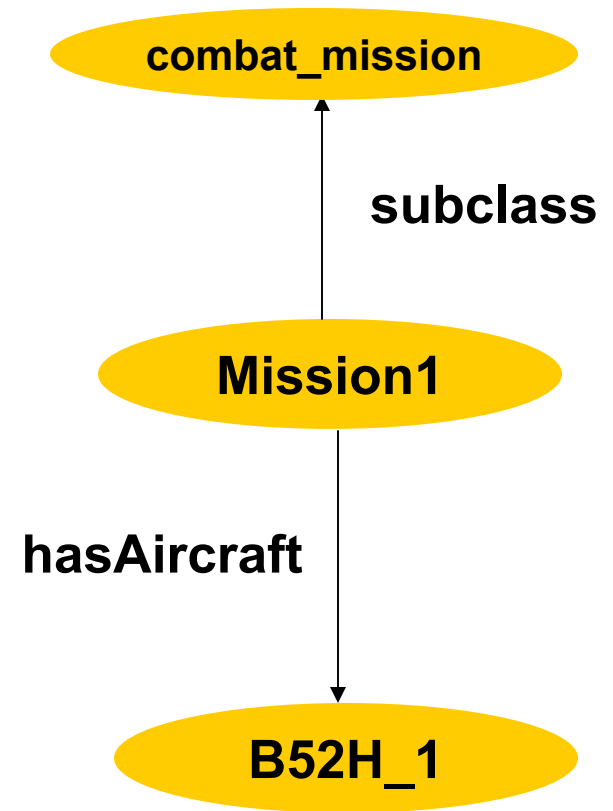


# Semantic Web Languages



- **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>
```





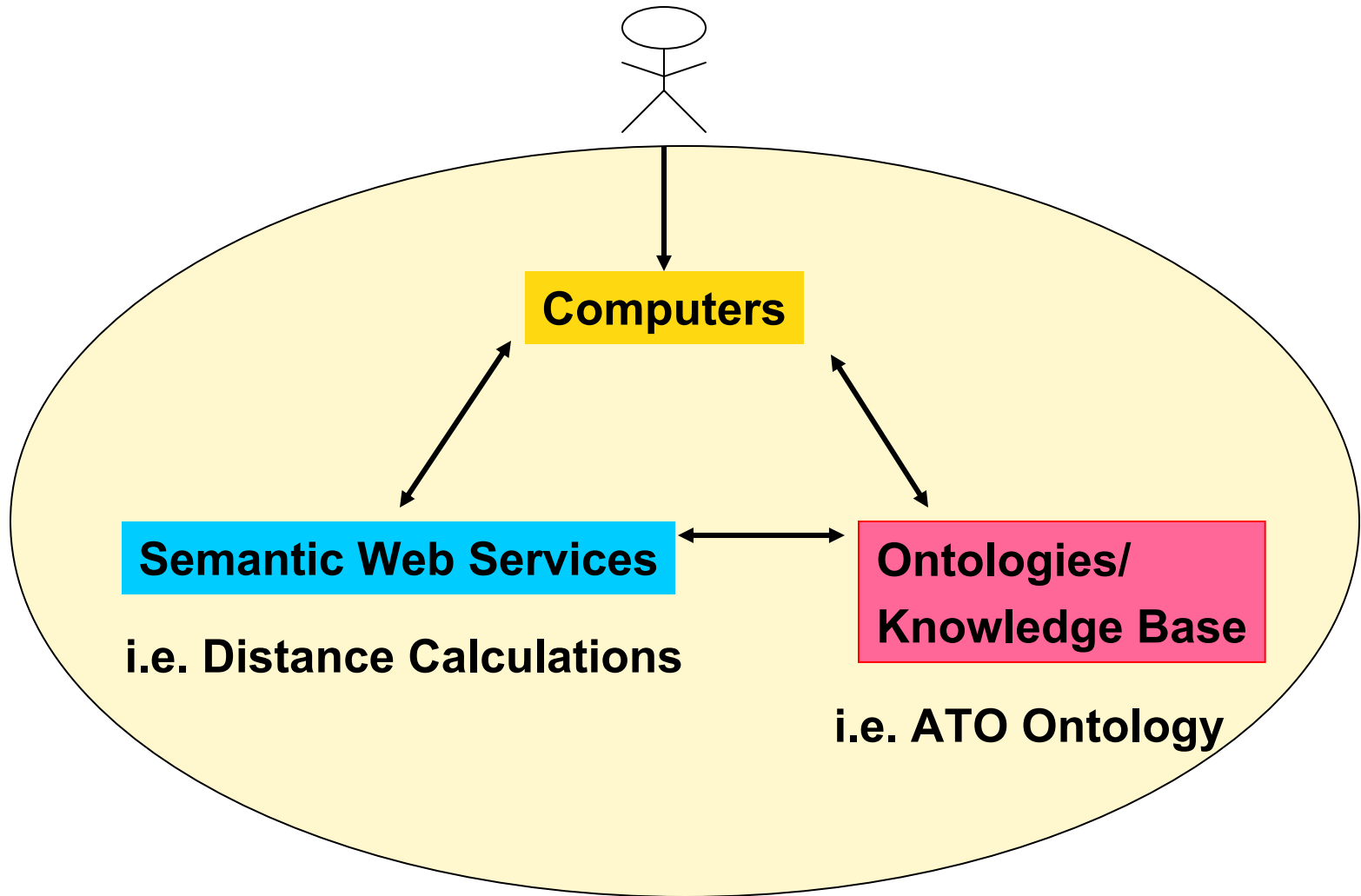
# Semantic Web Services



- **“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

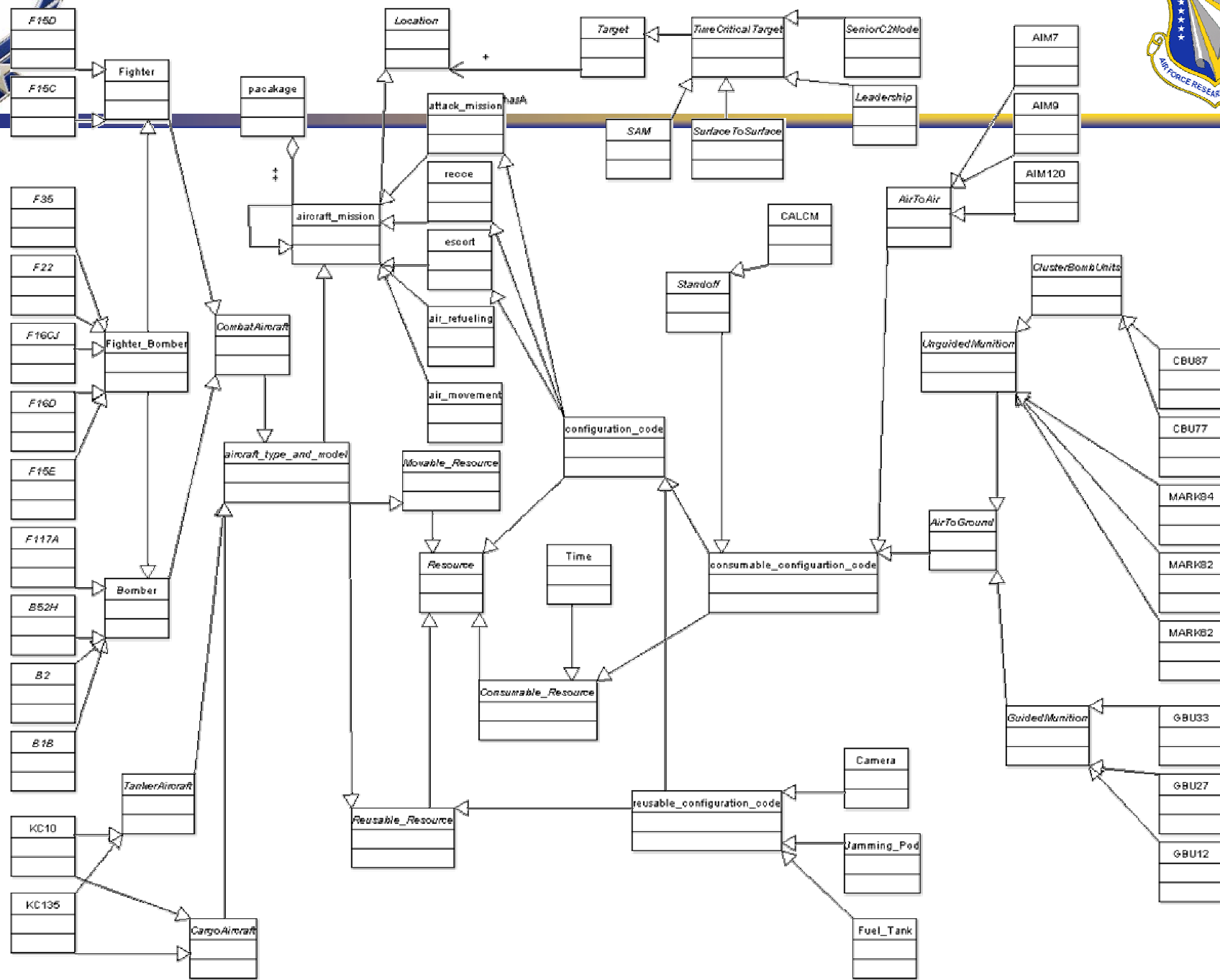
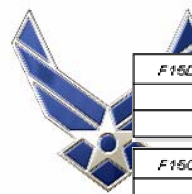




# ATO Ontology Time Sensitive Targeting Demo

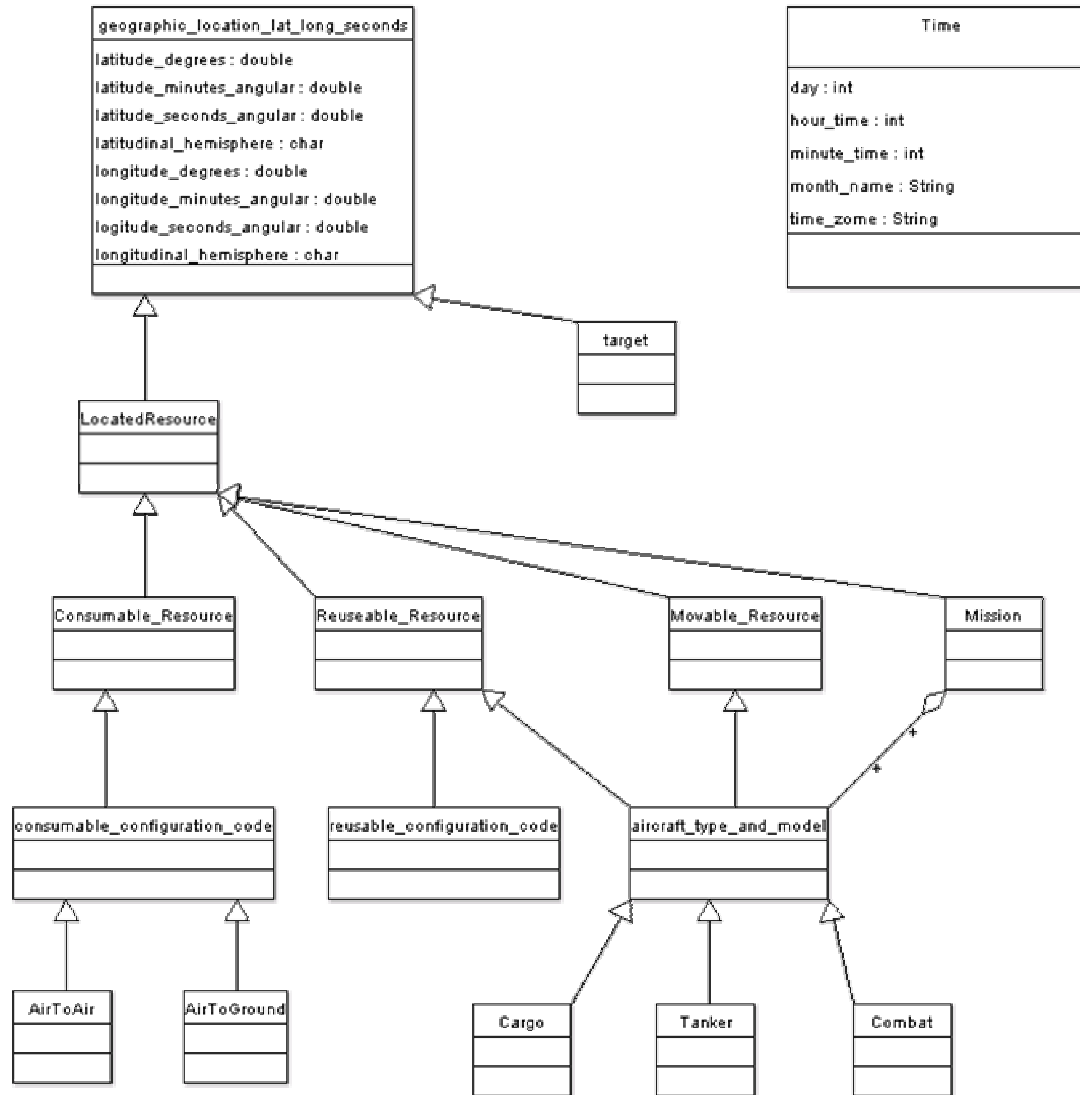


- **ATO – document that assigns aircraft to tasks**
- **Show UML design – used ArgoUML**
- **Show ontology – built with Protégé (Stanford Univ.)**
- **Show example rules**
- **Show reasoning – used RACER**



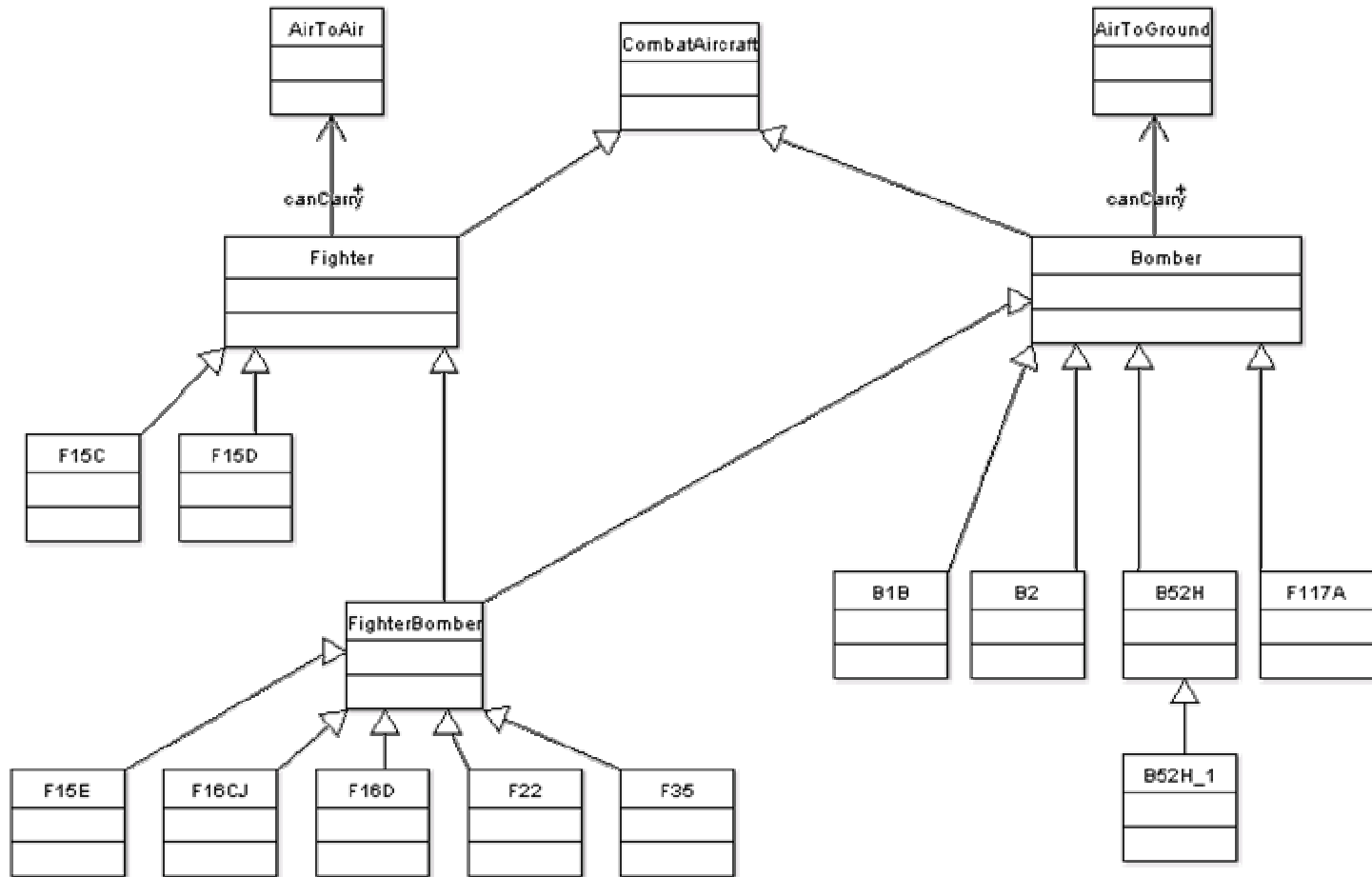


# Top of ATO Ontology





# 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



AircraftOnt Protégé 3.0 (file:\C:\Documents%20and%20Settings\frantza\Desktop\DistriOntologies\AircraftOnt.pprj, OWL Files (.owl or .rdf))

File Edit Project OWL Wizards Code Window Help

owl:Thing

- Aircraft
  - CargoAircraft
    - C5
    - KC10
    - KC135
    - MH47
  - CombatAircraft
    - Bomber
      - B2
      - B52H
      - F117A
    - Fighter
      - F15C
      - F15D
    - FighterBomber
    - Helicopters
      - H60
      - AH64
  - TankerAircraft
    - KC10
    - KC135

For Class: H60 (instance of owl:Class)

Name: H60

SameAs: [ ]

DifferentFrom: [ ]

Property	Value	Lang
----------	-------	------

Asserted Conditions

- Helicopters (NECESSARY)

Properties: [ ]

Disjoints: [ ]

Logic View Properties View



# A Constraint Violation



ATD Protégé 3.0 (file:\C:\Documents%20and%20Settings\frantza\Desktop\DistribOntologies\ATD.pprj, OWL Files (.owl or .rdf...)

File Edit Project OWL Wizards Code Window Help

OWLClasses Properties Forms Individuals Metadata

SUBCLASS RELATIONSHIP CLASS EDITOR

For Project: ATO

For Class: F15C\_1Class (instance of owl:Class)

Asserted Conditions

Condition	Constraint Type
p2:F15C	NECESSARY
∃ aircraftCanCarryConfig p1:GBU12	NECESSARY
	INHERITED

aircraftCanCarryConfig (multiple p1)

Logic View Properties View

Class	Changed superclasses
F15C_1Class	Inconsistent

Test Results Classification Results



# Protégé Rules



**CLASS EDITOR**

For Class: **CommandPostkiller** (instance of owl:Class)

Name: **CommandPostkiller**

Annotations:

Property	Value	Lang
----------	-------	------

Asserted Conditions:

- NECESSARY & SUFFICIENT**  
 $\exists$  mission\_has\_aircraft\_type ( $\exists$  aircraft\_carrying\_configuration ( $\exists$  configuration\_destroys\_target ( $\exists$  targetNotNearProhibitedTarget Mosque\_1Class)))
- NECESSARY**  
combat\_mission
- INHERITED**  
[from combat\_mission]  $\exists$  mission\_has\_aircraft\_type CombatAircraft

Classification Results:

Class	Changed superclasses
AMissionClass	Moved from combat_mission to SA20_1Killer, CommandPostkiller
BeyerleMissionClass	Moved from combat_mission to SA20_1Killer, CommandPostkiller
F15C_2Class	Inconsistent
MilvioMissionClass	Moved from combat_mission to SA20_1Killer, CommandPostkiller



# 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)**



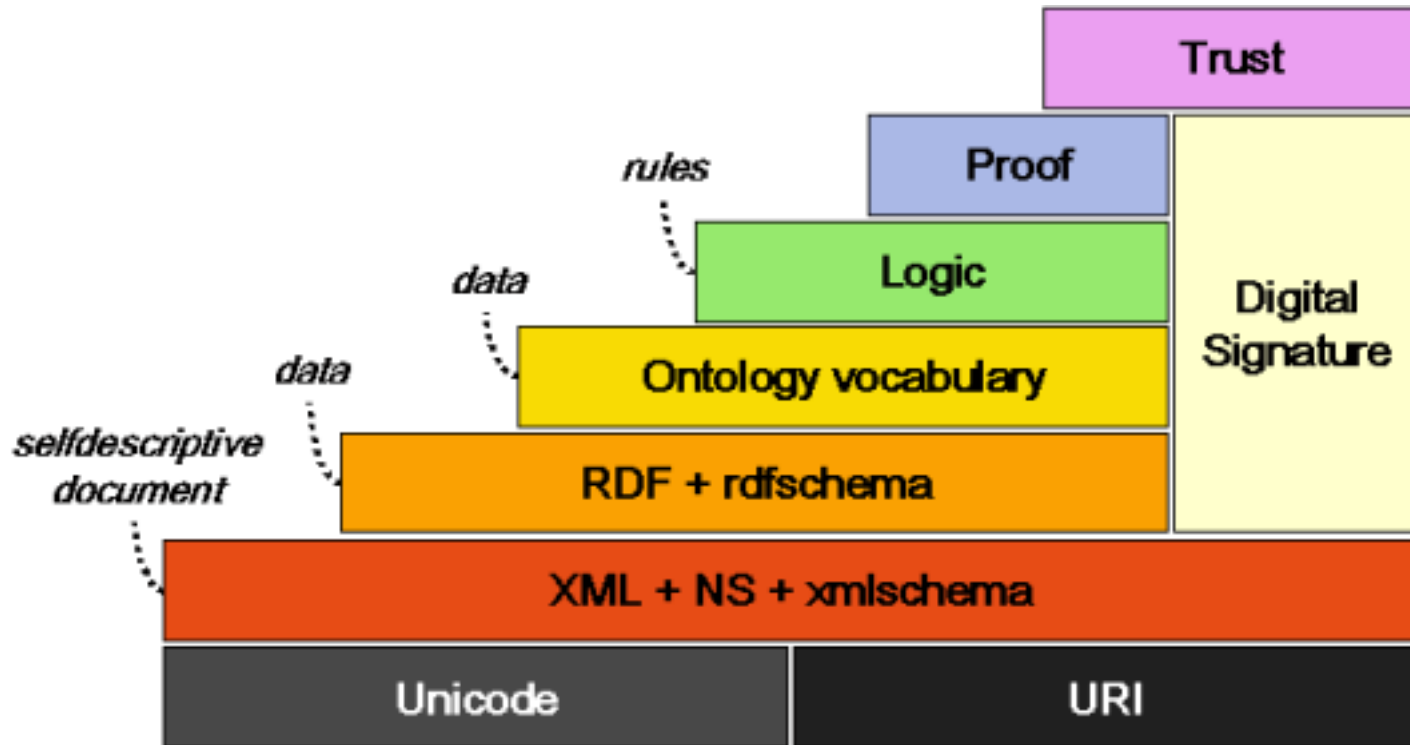
# Backup Slides



- **Backup Slides**



# Semantic Web Technology Layers





# Semantic Web Languages

## RDF –Resource Description Framework



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

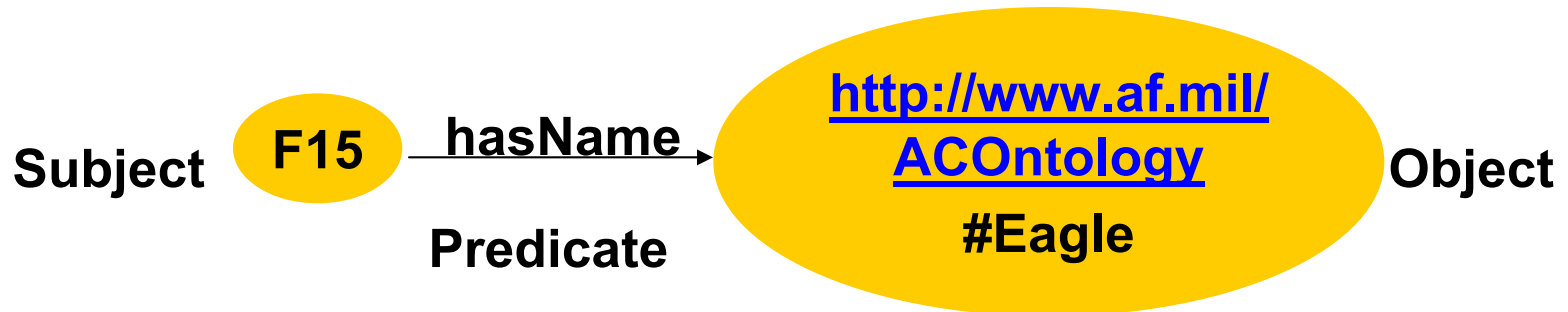
```
<rdf:Description rdf:ID="F15">
```

```
  <hasName>
```

```
    rdf:resource= "http://www.af.mil/ACOntology#Eagle"
```

```
  </hasName>
```

```
</rdf:Description>
```





# Semantic Web Languages

## RDFS



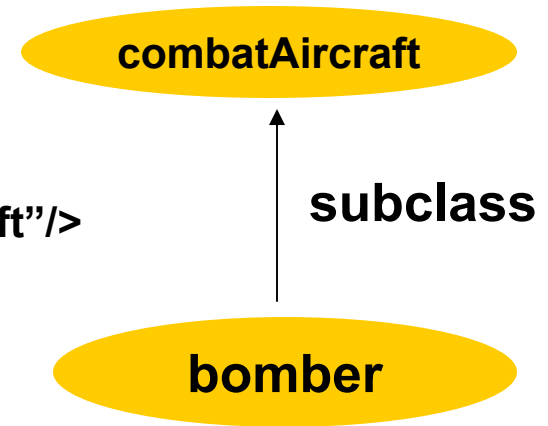
- **Resource Description Framework Schema – RDFS adds classes and properties**

- **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](http://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, textDescription, 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.
- $\text{hasParent}( ?x1, ?x2) \text{ and } \text{hasBrother}(?x2, ?x3) \Rightarrow$   
 $\text{hasUncle}( ?x1, ?x3)$



# 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>
```