



***Integrity ★ Service ★ Excellence***

# Semantic Information Management Control of Mission Asset State Changes

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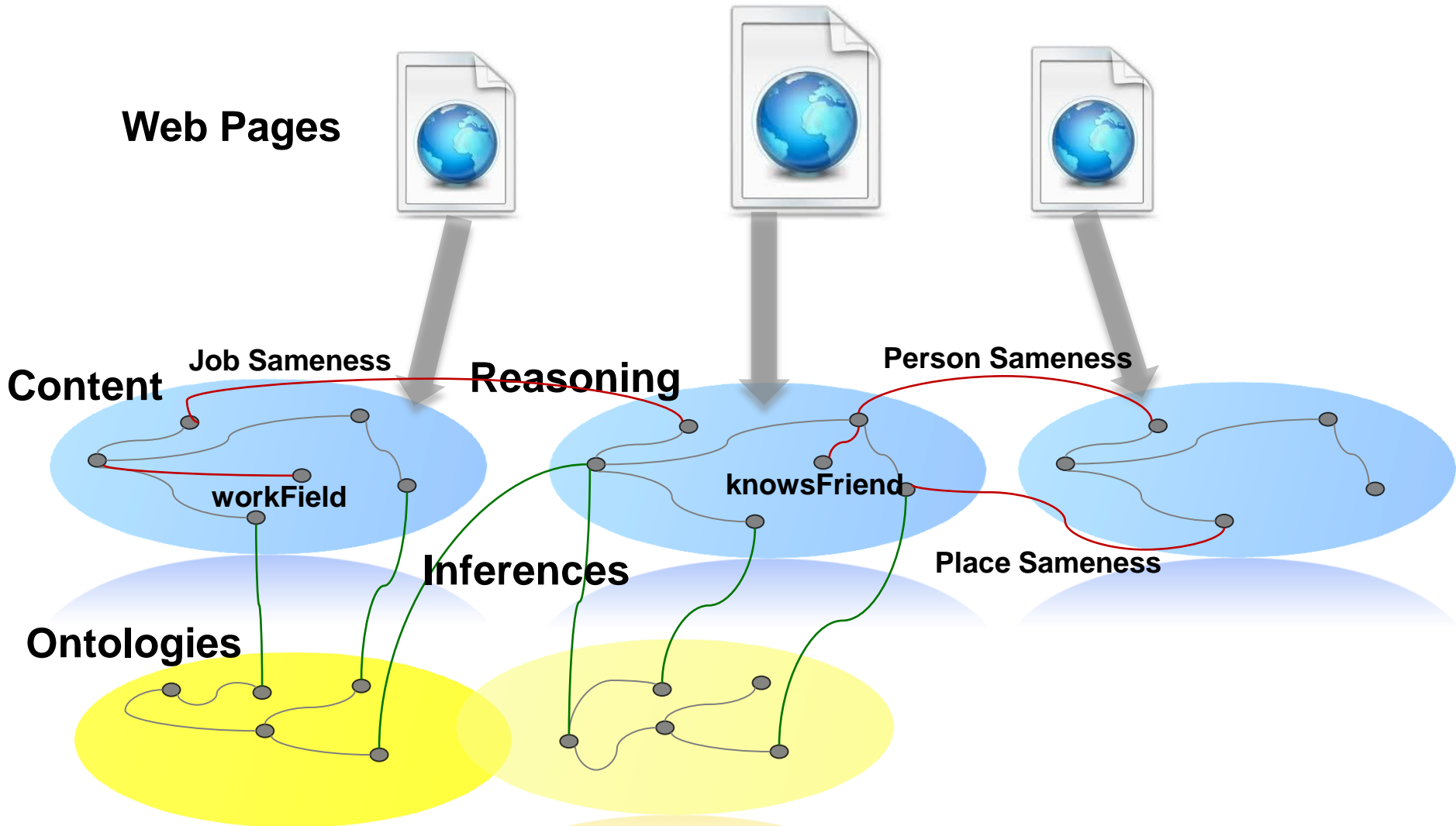
# Outline



- **Motivation**
- **Historical Challenges**
- **Possible Solutions**
- **Proposed Solution**
- **Applied Use Cases**
- **Results**
- **Conclusion**



# Motivation (Background)





# Motivation: What we want



**To manage semantic relationships with values that change over time**



# Historical Challenges



- **Reification**
- **Provenance**
- **Entity data and object state transitions**



# Possible Solution 1



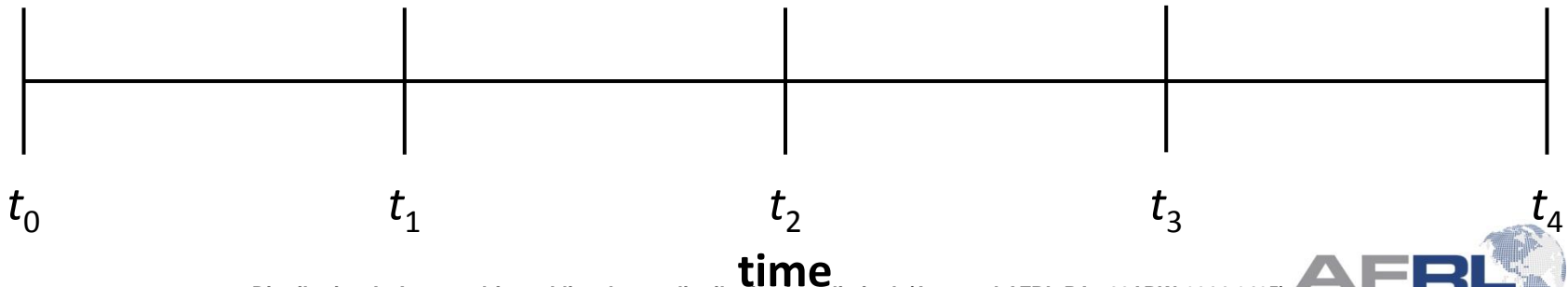
Single semantic instance continually updated with new “present” values

Tail: ZZ

Model: F15

lat:  $y_0$

long:  $x_0$





# Possible Solution 1



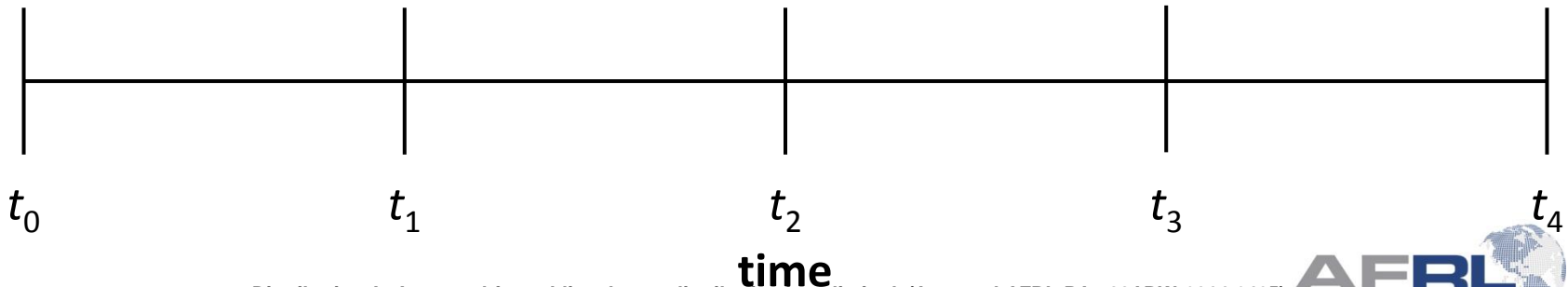
Single semantic instance continually updated with new “present” values

Tail: ZZ

Model: F15

lat:  $y_1$

long:  $x_1$





# Possible Solution 1



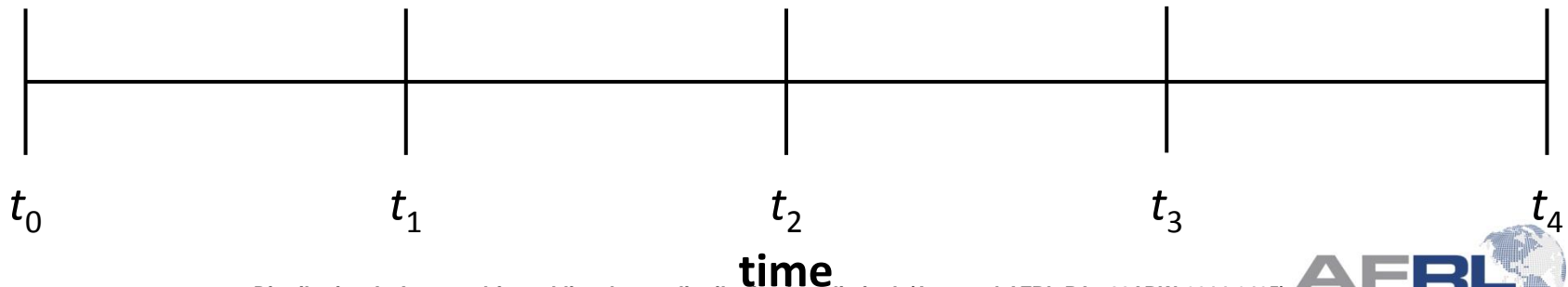
Single semantic instance continually updated with new “present” values

Tail: ZZ

Model: F15

lat:  $y_2$

long:  $x_2$







# Possible Solution 1



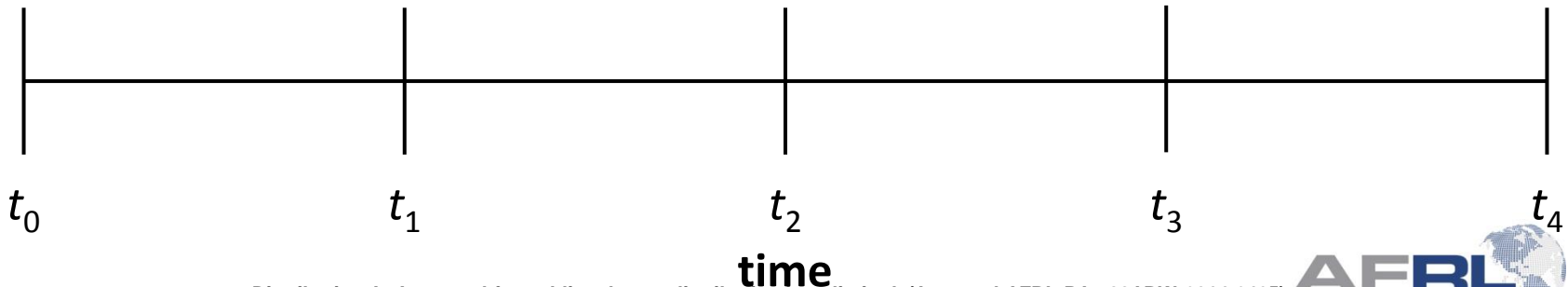
Single semantic instance continually updated with new “present” values

Tail: ZZ

Model: F15

lat:  $y_3$

long:  $x_3$





# Possible Solution 1



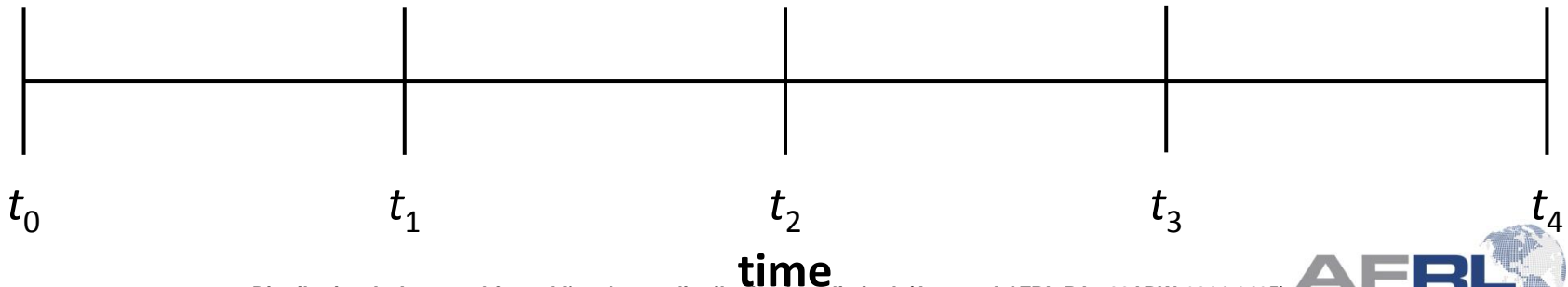
Single semantic instance continually updated with new “present” values

Tail: ZZ

Model: F15

lat:  $y_4$

long:  $x_4$





# Possible Solution 1: Problem!



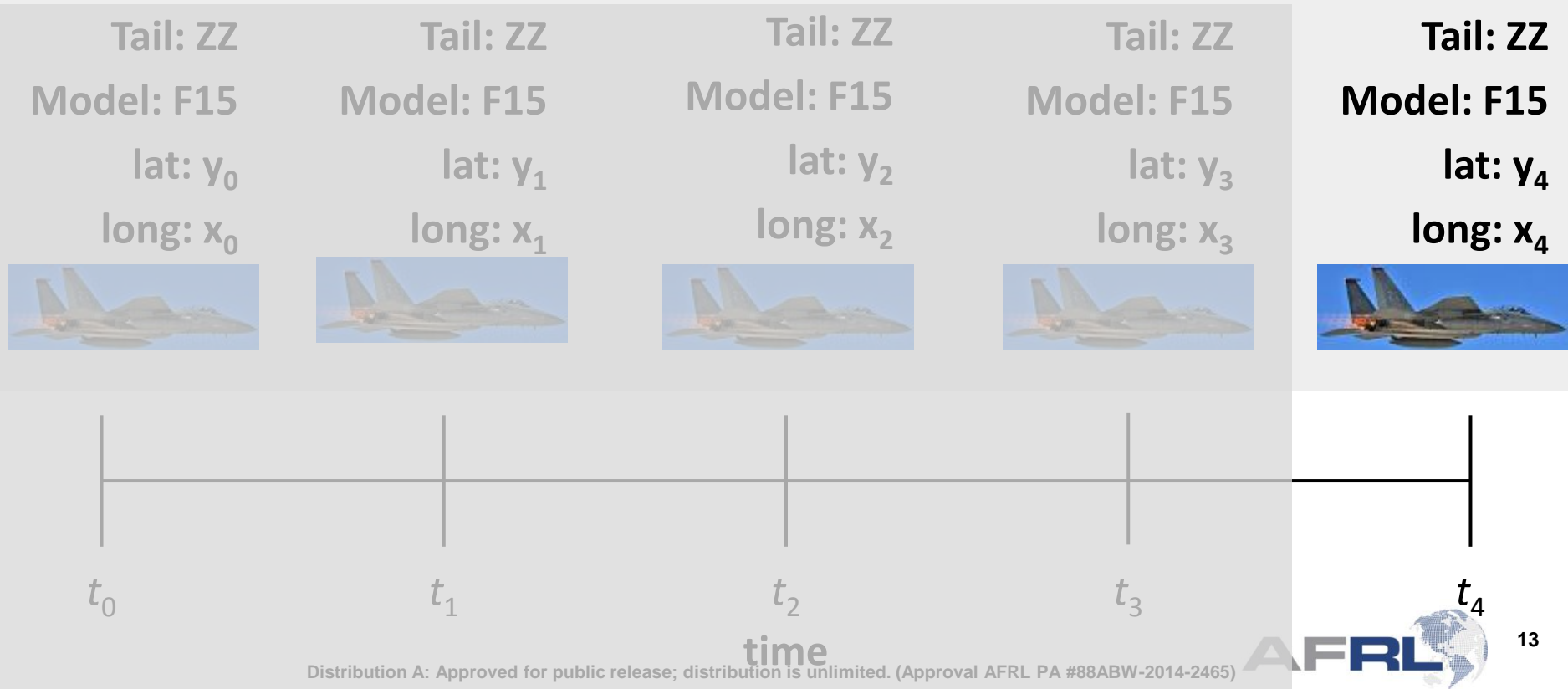
## Past/Present State Blindness



# Possible Solution 1: Problem!



## Past/Present State Blindness





# Possible Solution 2



**Semantic instance copied**

**THEN**

**updated with new “present” values**



# Possible Solution 2



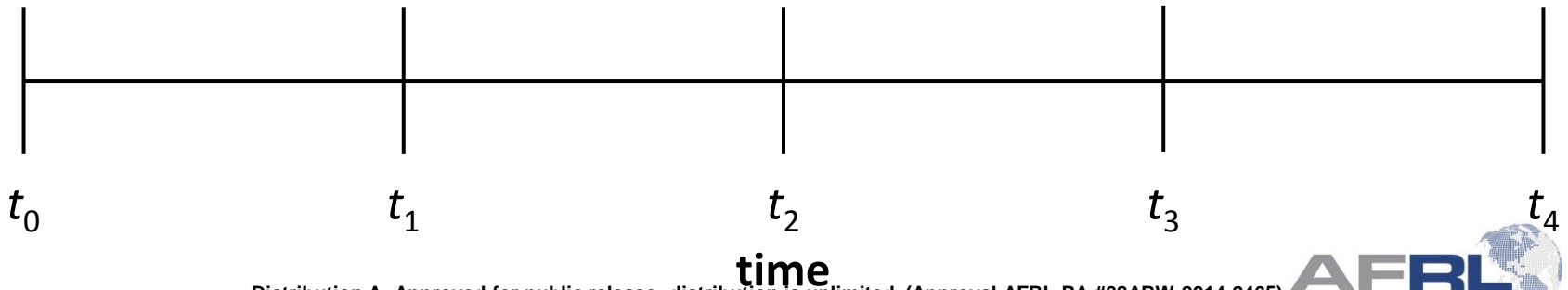
**Version: 0**

**Tail: ZZ**

**Model: F15**

**lat:  $y_0$**

**long:  $x_0$**





# Possible Solution 2



**Version: 0**

**Tail: ZZ**

**Model: F15**

**lat:  $y_0$**

**long:  $x_0$**



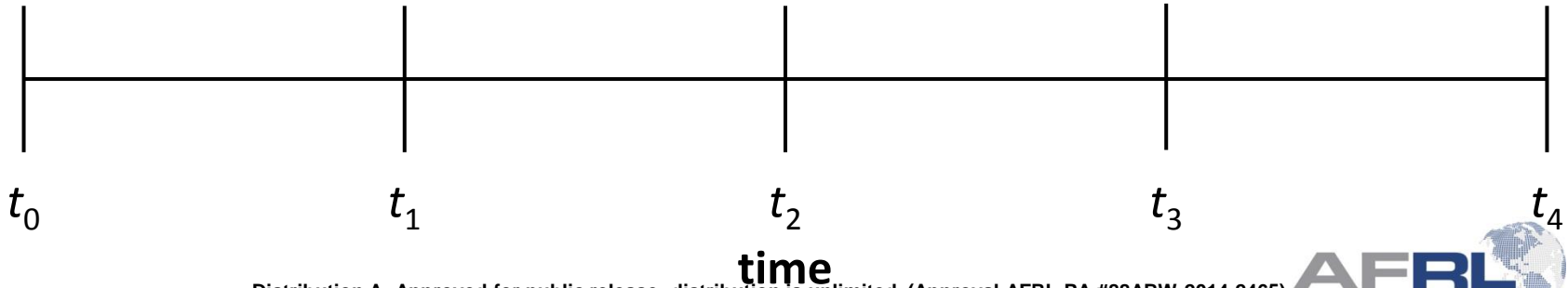
**Version: 1**

**Tail: ZZ**

**Model: F15**

**lat:  $y_1$**

**long:  $x_1$**





# Possible Solution 2



**Version: 0**

**Tail: ZZ**

**Model: F15**

**lat:  $y_0$**

**long:  $x_0$**



**Version: 1**

**Tail: ZZ**

**Model: F15**

**lat:  $y_1$**

**long:  $x_1$**



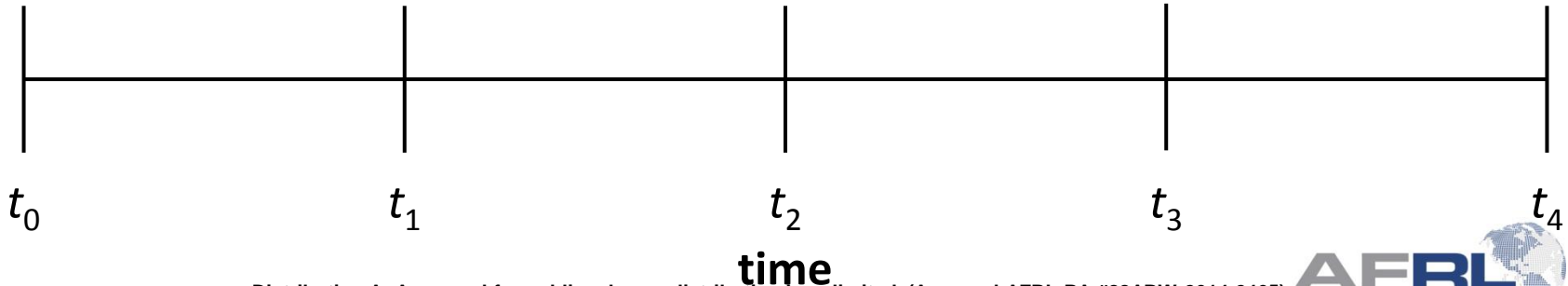
**Version: 2**

**Tail: ZZ**

**Model: F15**

**lat:  $y_2$**

**long:  $x_2$**







# Possible Solution 2



**Version: 0**

**Tail: ZZ**

**Model: F15**

**lat:  $y_0$**

**long:  $x_0$**



**Version: 1**

**Tail: ZZ**

**Model: F15**

**lat:  $y_1$**

**long:  $x_1$**



**Version: 2**

**Tail: ZZ**

**Model: F15**

**lat:  $y_2$**

**long:  $x_2$**



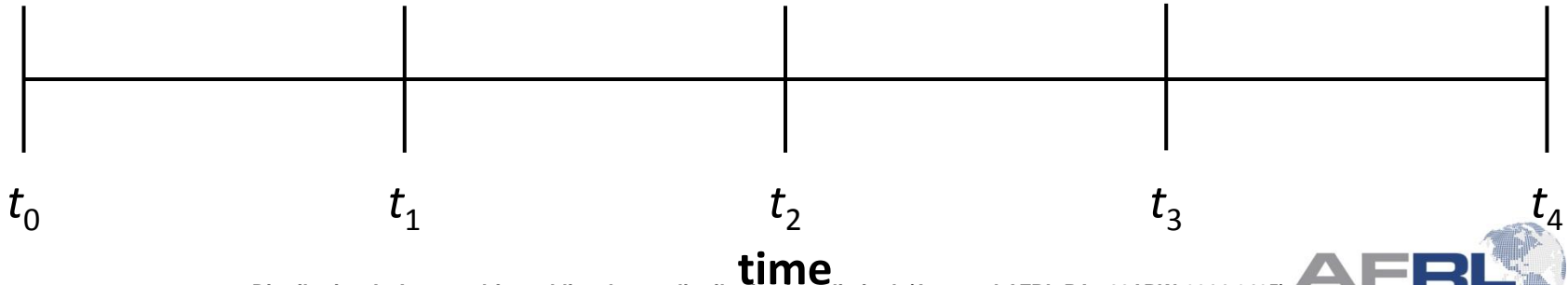
**Version: 3**

**Tail: ZZ**

**Model: F15**

**lat:  $y_3$**

**long:  $x_3$**





# Possible Solution 2



**Version: 0**

**Tail: ZZ**

**Model: F15**

**lat:  $y_0$**

**long:  $x_0$**



**Version: 1**

**Tail: ZZ**

**Model: F15**

**lat:  $y_1$**

**long:  $x_1$**



**Version: 2**

**Tail: ZZ**

**Model: F15**

**lat:  $y_2$**

**long:  $x_2$**



**Version: 3**

**Tail: ZZ**

**Model: F15**

**lat:  $y_3$**

**long:  $x_3$**



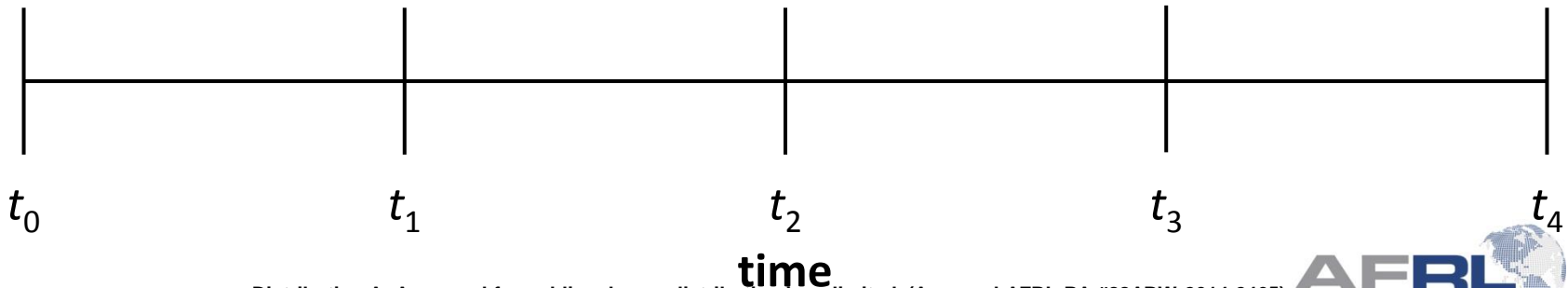
**Version: 4**

**Tail: ZZ**

**Model: F15**

**lat:  $y_4$**

**long:  $x_4$**





# Possible Solution 2: Problem!



**Lots of duplicates!**

**Complex queries!**



# Proposed Solution



## Event-based state specializations



# Specialization Model



**A single asset definition exists, but alterations to its relationship states generate “specializationOf” entities with state deltas**



# Specialization Model

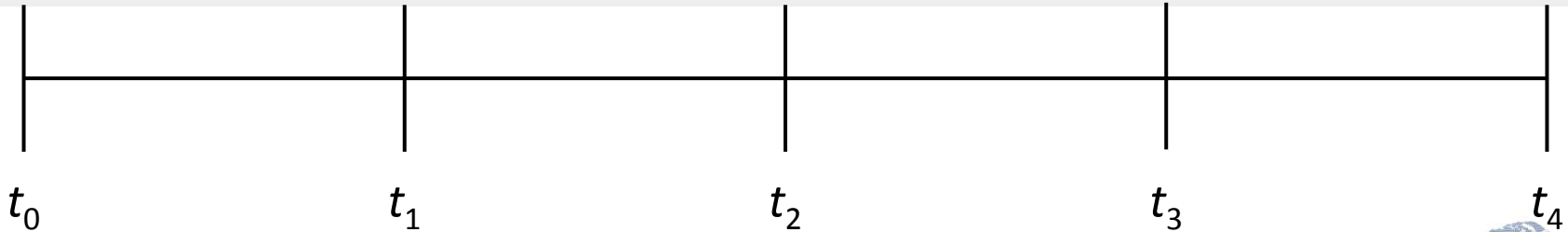


Tail: ZZ

Model: F15

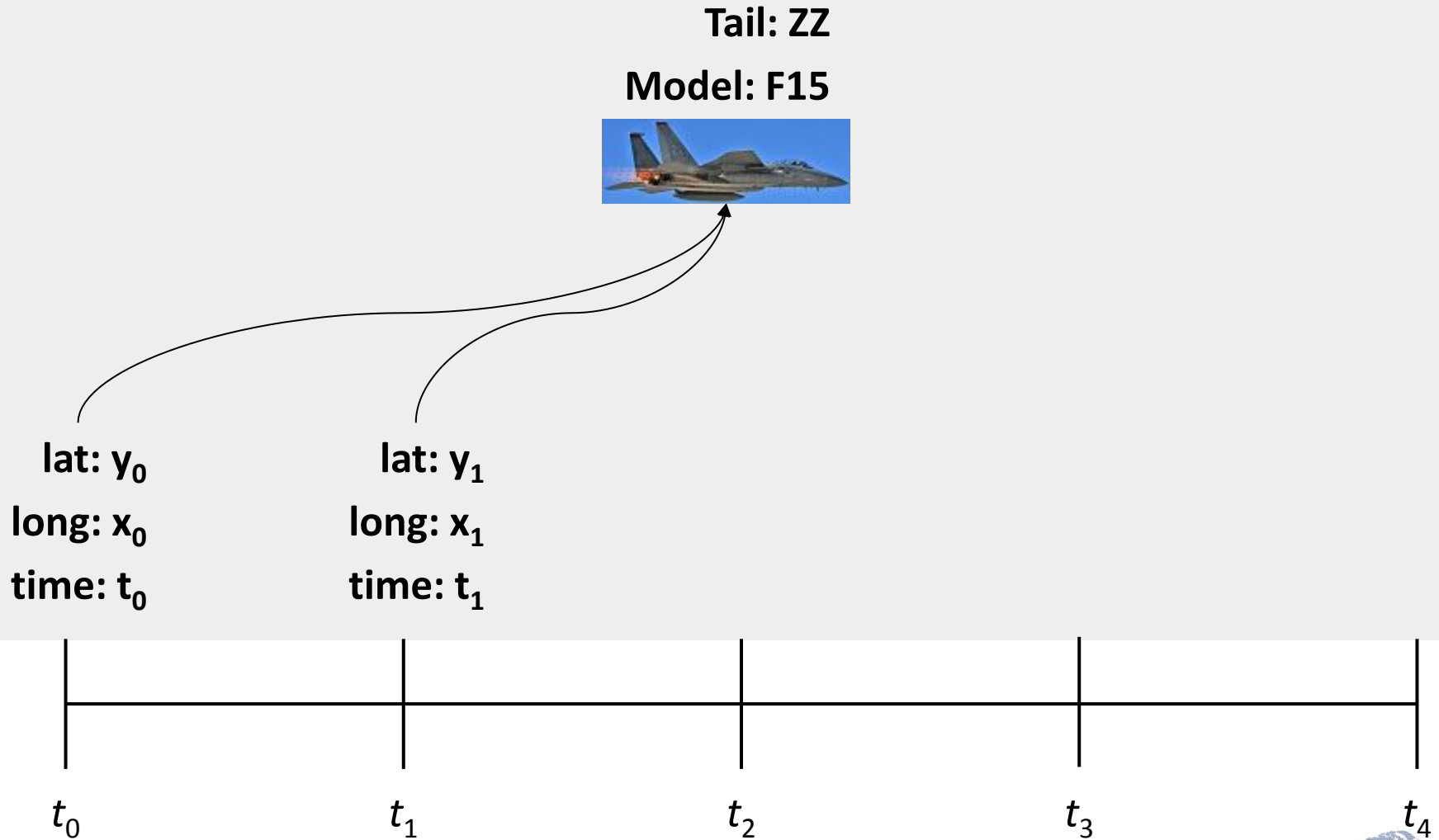


lat:  $y_0$   
long:  $x_0$   
time:  $t_0$



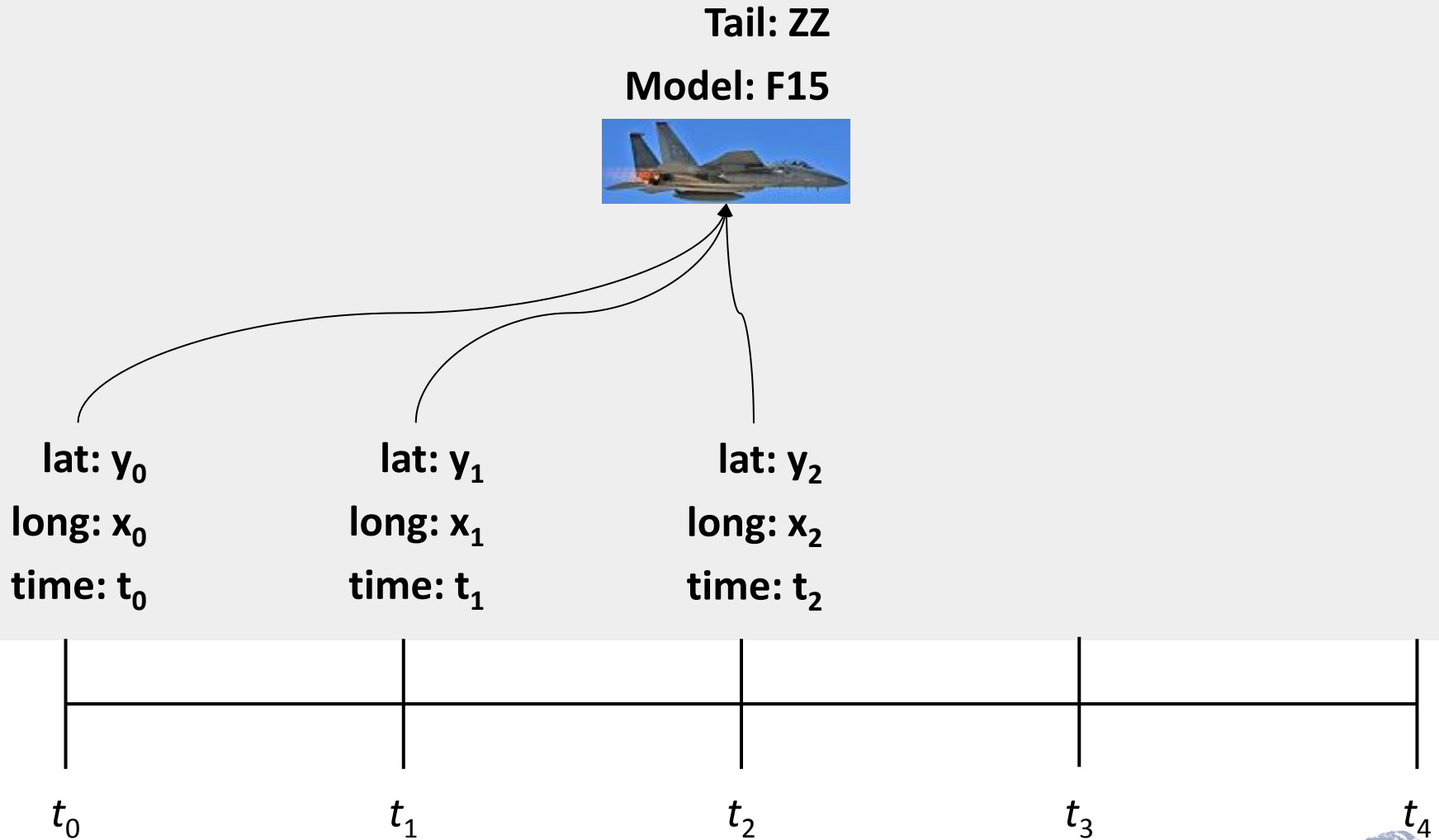


# Specialization Model





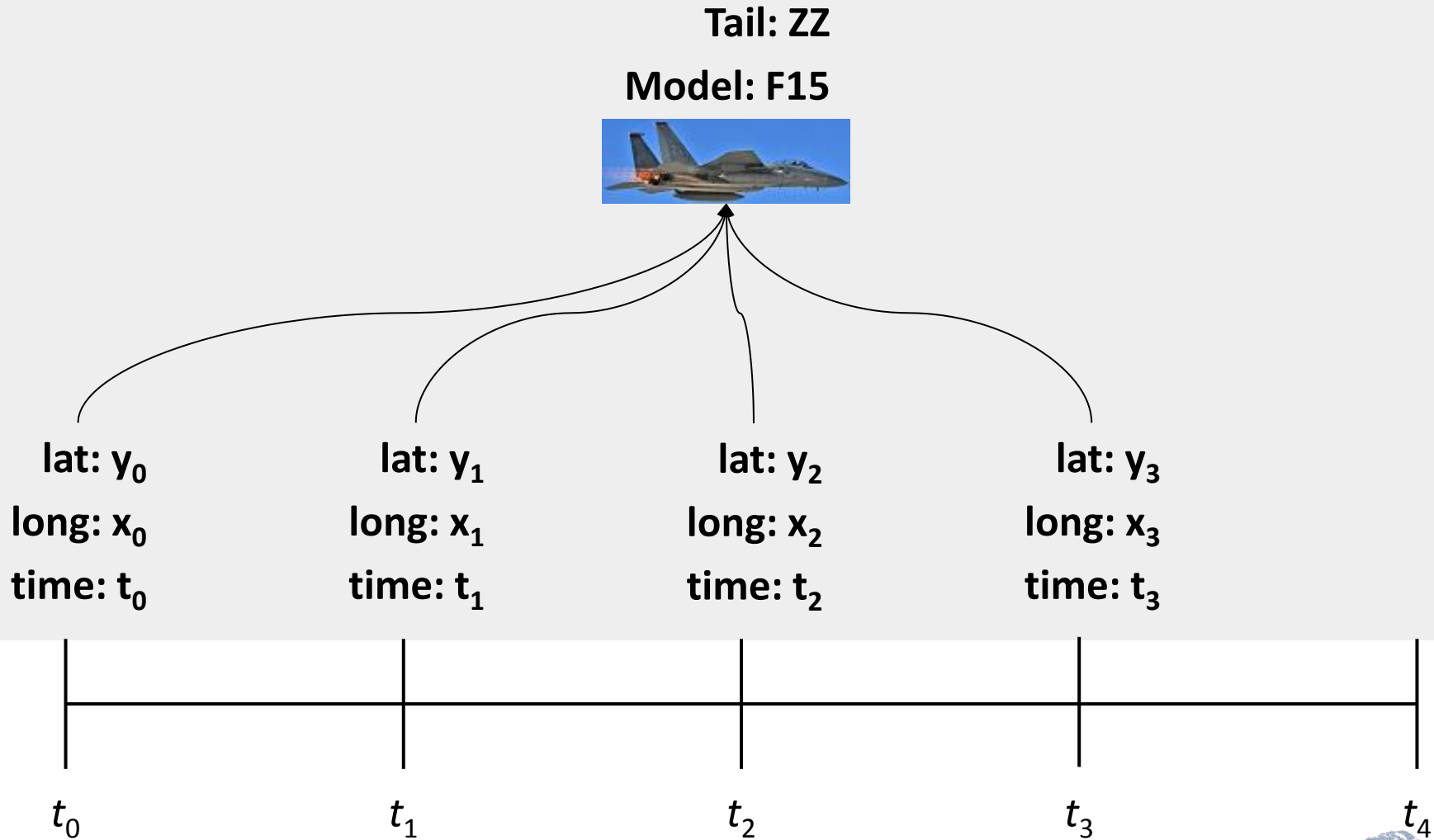
# Specialization Model





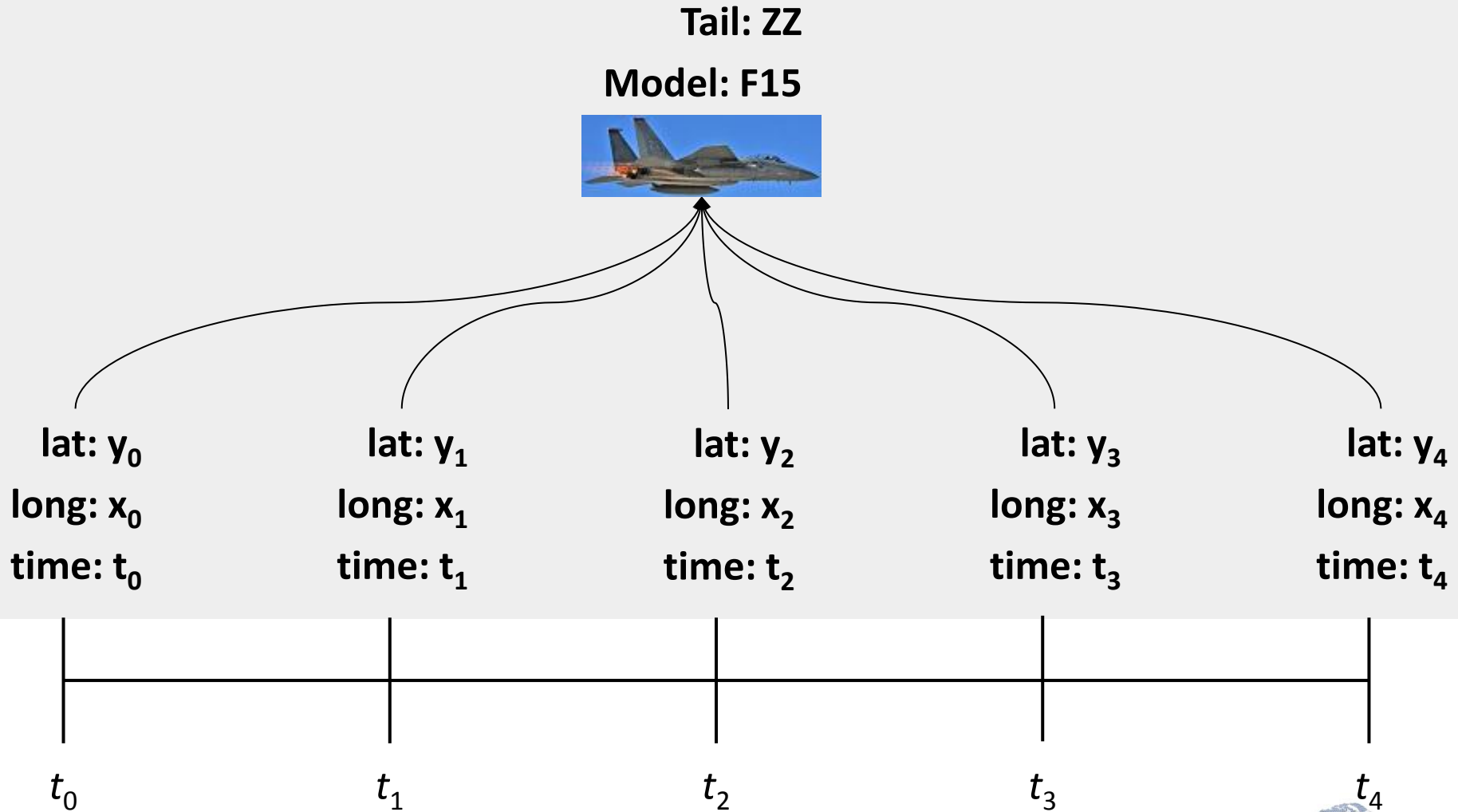


# Specialization Model





# Specialization Model





# Applied Use Case 1



## State Trending Query

PREFIX prov: <http://www.w3.org/ns/prov#>

SELECT \*

WHERE {

?s prov:specializationOf prov:airsortie\_tail \_ AA .

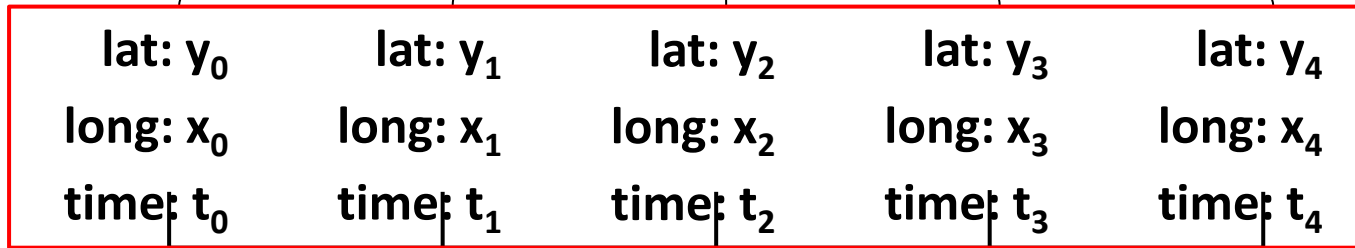
?s prov:startedAtTime ?time . }

**Tail: ZZ**

ORDER BY DESC(?time)

LIMIT 10

**Model: F15**



$t_0$

$t_1$

$t_2$

$t_3$

$t_4$



# Applied Use Case 2



## Newest State Query

PREFIX prov: <http://www.w3.org/ns/prov#>

SELECT \*

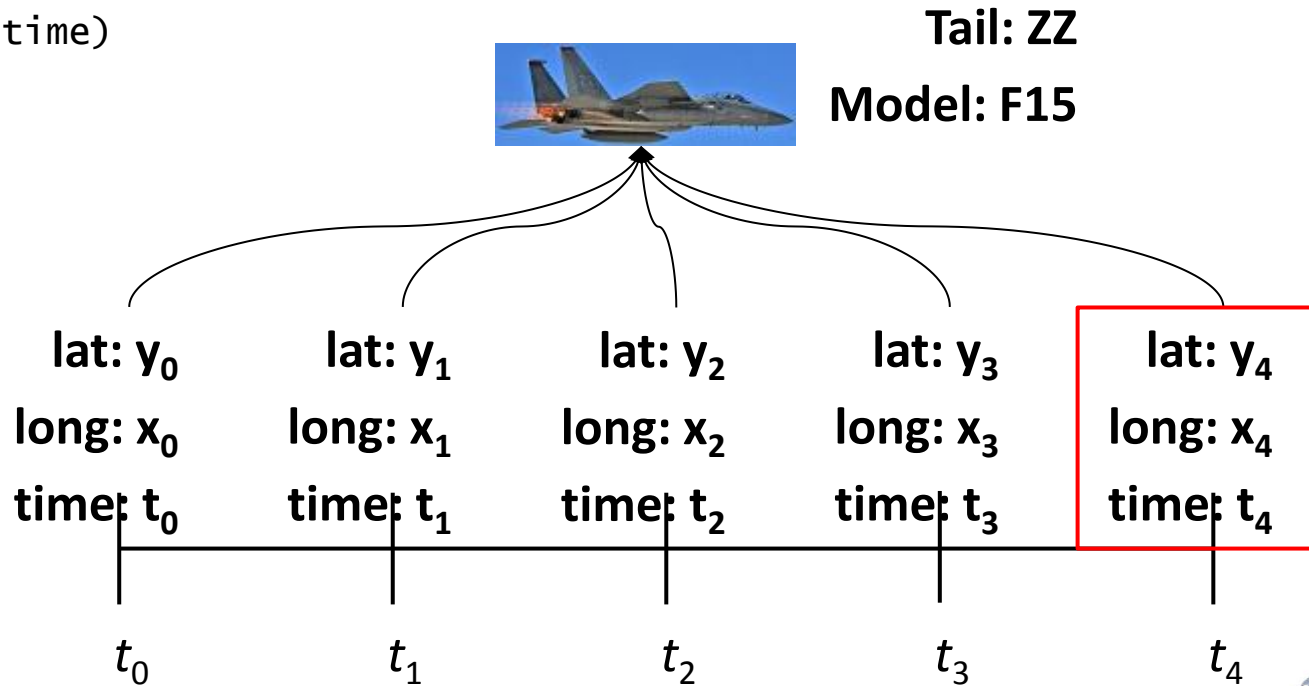
WHERE {

?s prov:specializationOf prov:airsortie\_tail \_ AA .

?s prov:startedAtTime ?time . }

ORDER BY DESC(?time)

LIMIT 1





# Key Results



**Scenario: 240 Blue Force Tracking Messages**  
**~62% Decrease (including specialization of relationship overhead)**

	Relationships / Msg	Total
Mass Duplication Scenario	<b>24.4</b>	<b>5892</b>
Specialization Scenario	<b>9.5</b>	<b>2280</b>



# Future Work



- **Semantic state traceability paired with semantic graph analytics**
- **Reasoning over stateful trends within segmented time periods**



# Conclusion



## What's new?

- **Applies state management to mission assets in a way that reduces the required number of relationships**
- **Adopts W3C Provenance Ontology**
- **Simplifies queries for state-based trends**



# Questions?

