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Ontological Considerations for Uncertainty Propagation in High Level Information Fusion

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Where Innovation Is Tradition

Introduction

- **Data explosion increases information fusion needs and opportunities**
- **Uncertainty pervades fusion**
- **Information fusion divided into**
  - **Low level: entity oriented, uncertainty reasonably understood**
  - **High level: relationship oriented – emphasis on symbolic techniques**
- **Multiple techniques for representing / assessing / uncertainty; no consensus on how to compare techniques**
- **Need to systematize understanding of where / how uncertainty occurs and interacts in a high level fusion process**

Outline

- **Fusion Level Definition**
- **Level 2 HLIF taxonomy**
- **Fusion model**
- **Uncertainty in fusion**
  - Input (data) uncertainty
  - Representation uncertainty
  - Process uncertainty
  - Output uncertainty
- **Conclusion**

Fusion Level Definitions

Modified Joint Directors of Laboratories (JDL) model

Level	Title	Definition
0	Signal / Feature Assessment	Estimate signal or feature state.
1	Entity Assessment	Estimation of entity parametric and attributive states (i.e. of entities considered as individuals)
2	Situation Assessment	Estimate the structures of parts of reality
3	Impact Assessment	Estimate the utility/cost of signal, entity or situation states, including predicted utility / cost given a system's alternative courses of action
4	Process Assessment	A system's self-estimate of its performance as compared to desired states and measures of effectiveness.

Low Level

High Level

Creating a Level 2 HLIF Taxonomy: Sowa's Ontology

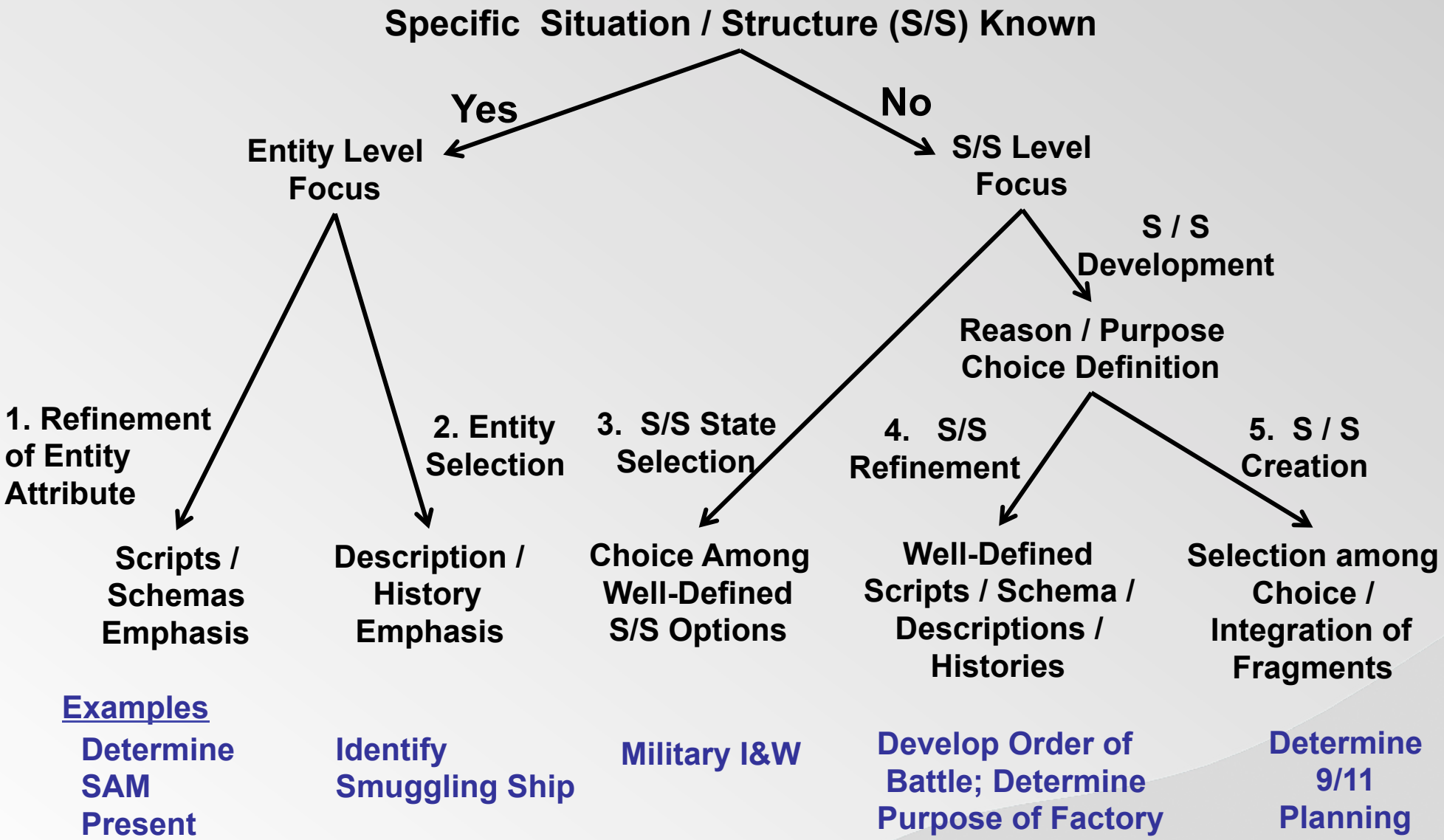
Relationships between Entities	Types of Entities: Physical – Continuant	Physical – Occurrent	Abstract – Continuant	Abstract – Occurrent
Independent	Object	Process	Schema	Script
Relative (Few / Focused)	Juncture	Participation	Description	History
Mediating (Many / Interacting)	Structure	Situation	Reason	Purpose

Level 1

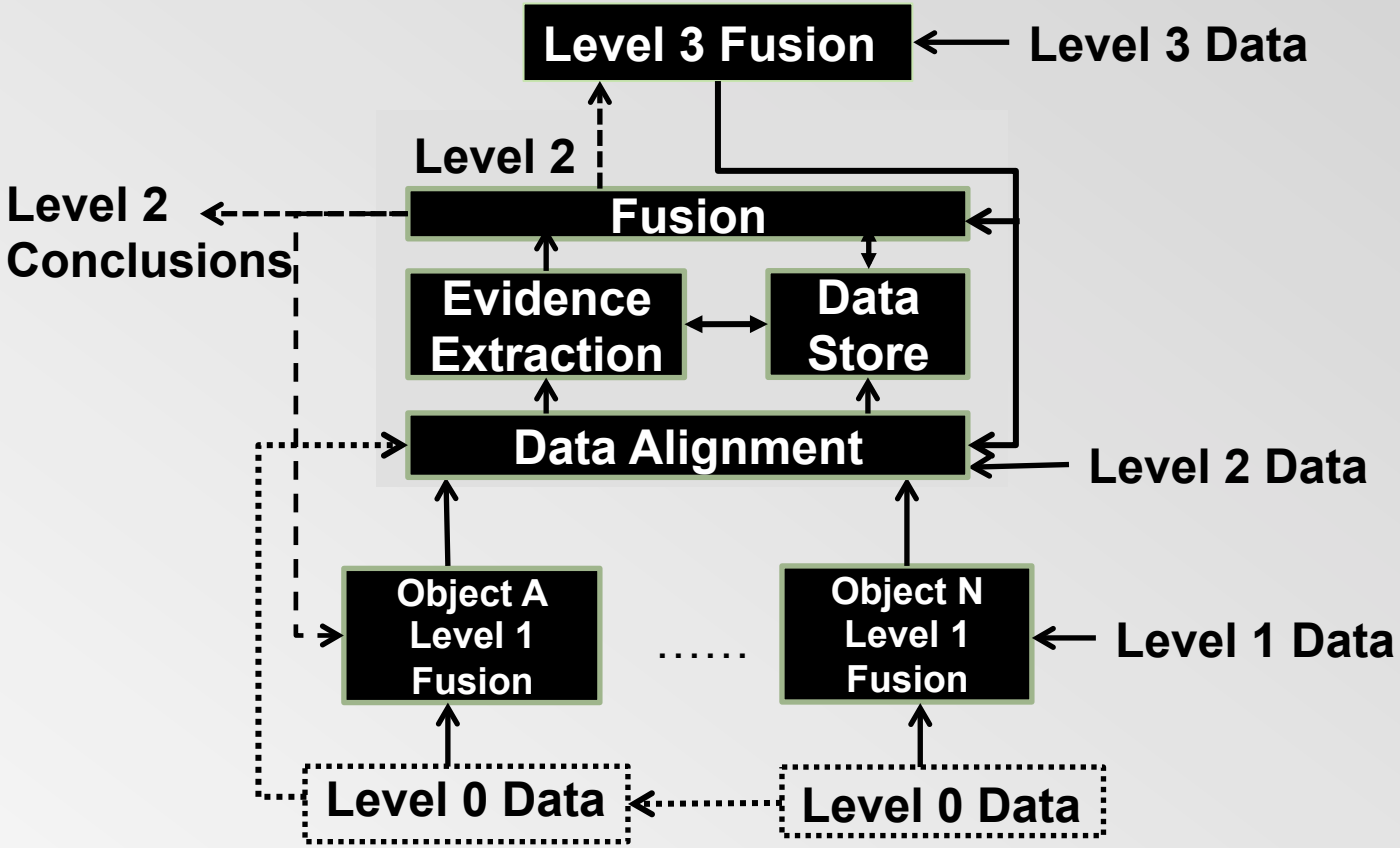
Level 2

- Viewpoint matters – Airplane both an object and a structure
- Timescale matters – Ice cube as continuant and occurent

Taxonomy of Level 2 HLIF Types



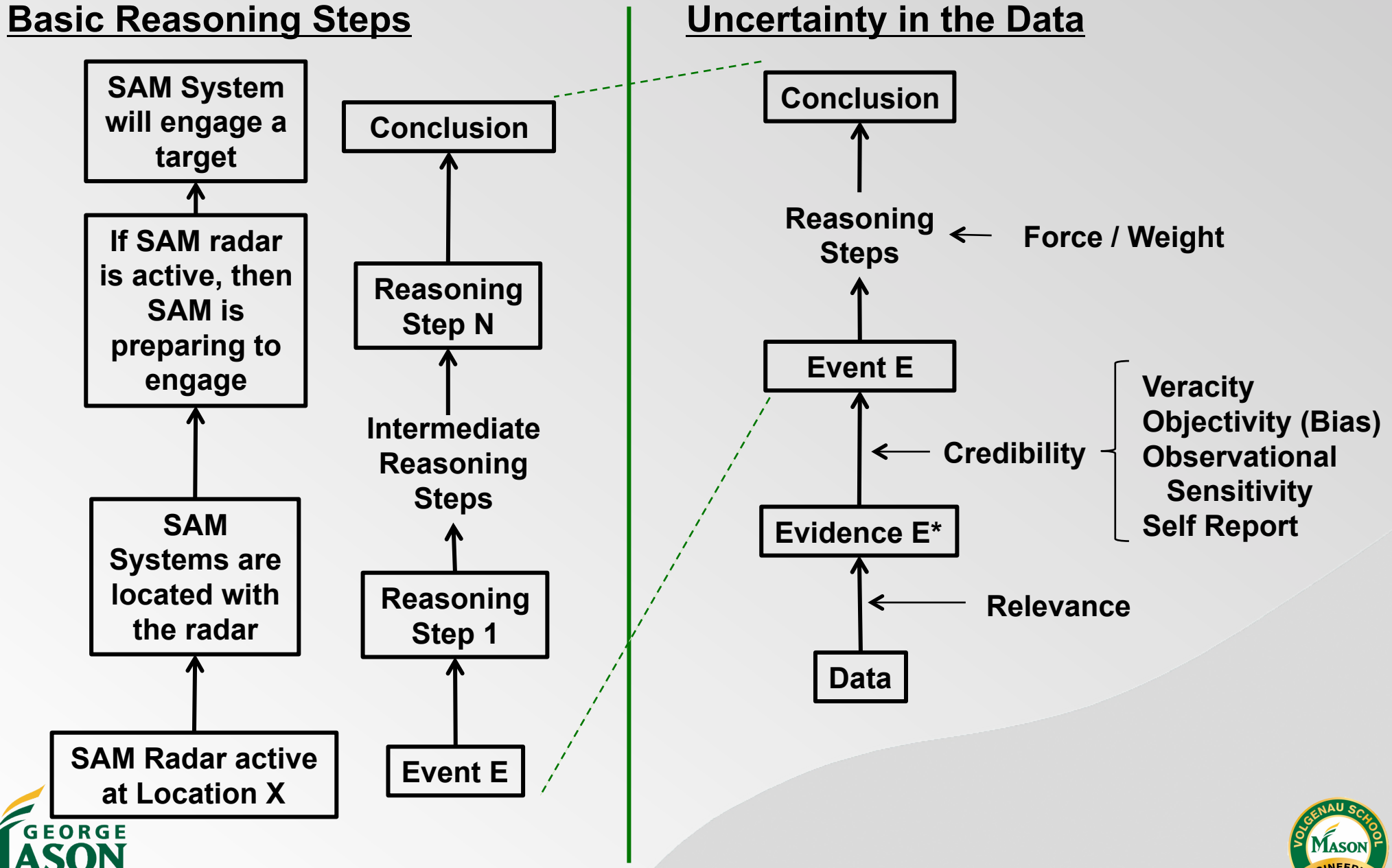
Level 2 Fusion Process Model



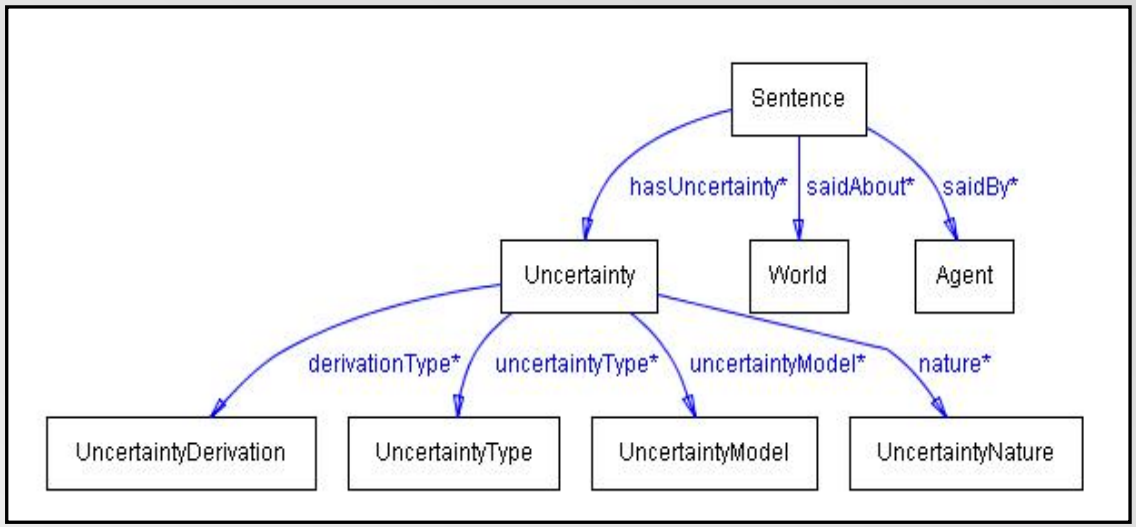
Uncertainty Areas

- Input (data) Uncertainty
- Process Uncertainty
- Representational Uncertainty
- Output Uncertainty

Input (Data) Uncertainty



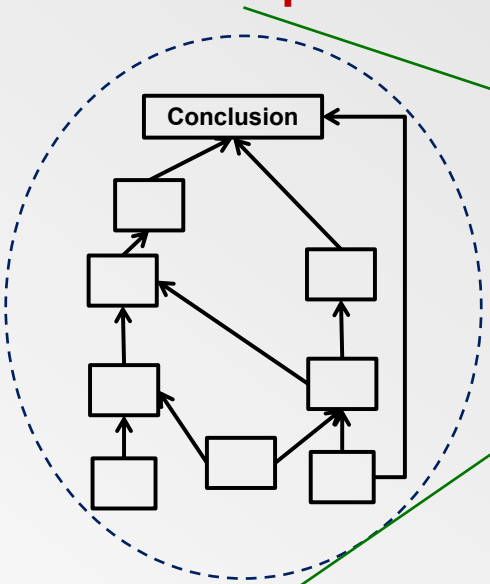
Representation Uncertainty

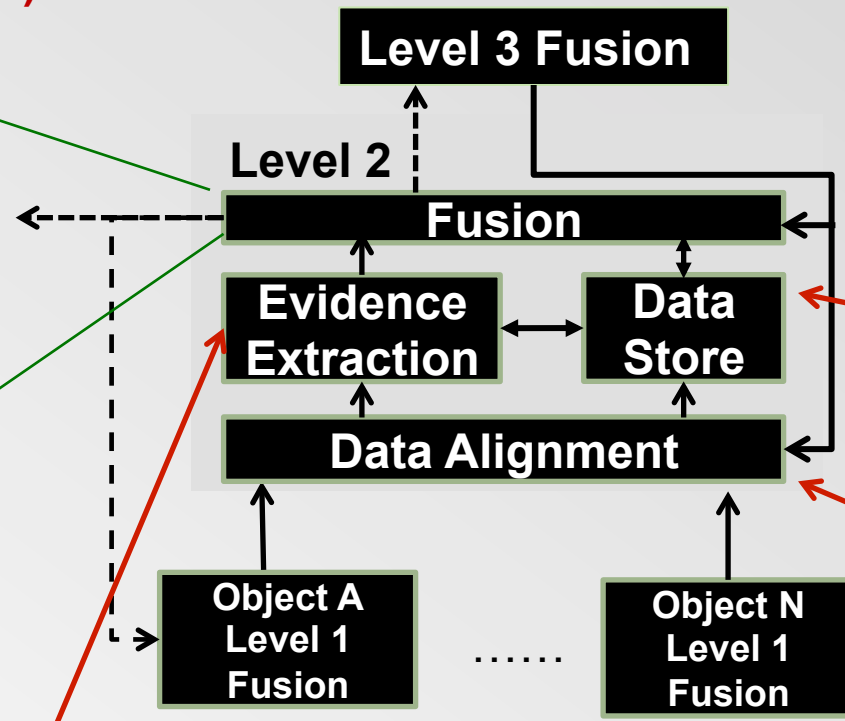


- **Uncertainty Derivation**
  - Objective
  - Subjective
- **Uncertainty Type**
  - Aleatory
  - Epistemic
- **Uncertainty Model**
  - Bayesian
  - Dempster-Shaffer
  - Possibility Theory
  - Imprecise Probability
  - Random Set Theory
  - Fuzzy Theory / Rough Sets
  - Interval Theory
  - Uncertainty Factors
- **Uncertainty Nature**
  - Ambiguity
  - Empirical
    - Random
  - Vagueness
  - Incompleteness
  - Inconsistency

Process Uncertainty

Fusion Model Uncertainties (Process / Representational)





Inaccuracies / Incompleteness (Process)

Data Alignment Errors (Representational)

Extraction Errors (Data Uncertainty)

Output Uncertainty

- **Completeness of the hypothesis set**
  - **Open versus closed world assumptions**

Conclusion

- **Uncertainty In the Fusion Process Model**