Silver Bullet Solutions, Inc. (Silver Bullet) specializes in:

1. ***Data Fusion.*** Silver Bullet develops multi-hypothesis probabilistic ontology-based data fusion and artificial intelligence algorithms, databases, and software.

2. ***Architecture & Systems Engineering (A&SE)***. Silver Bullet develops C4ISR and enterprise architectures and A&SE data repositories, ontologies, and tool translation software.

3. ***Databases and Ontologies.*** Silver Bullet develops enterprise-level databases and formal ontologies in relational, RDF/OWL, big data, and graph formats.

Locations	Washington, DC and San Diego, CA		
Ownership	All United States, no foreign ownership		
NAICS Code	334511, 541330, 541511, 541512, 541611, 541712, 541990		
Personnel ressources	▪ software engineers / programmers ▪ systems engineers and architects	▪ AI developers ▪ database and ontology developers ▪ probabilists / statisticians	
Clients	▪ Navy (SPAWAR, NAVSEA NAVAIR, SECNAV)	▪ Army (CCDC) ▪ OSD	
Business size and eligibility	Economically Disadvantaged Woman Owned Small Business		
Point of Contact	Ms. Elizabeth McDaniel, CEO (703) 893-1423 bethm@silverbulletinc.com 1512 Emerson Avenue, McLean, VA 22101		
CAGE	1SWY3	DUNS	020810276
Number of years in business	20	Facility Clearance	TS

Brief descriptions of three recent projects follow on the next few pages.

1 Cyber Ontology (CybOnt) Data Fusion

CybOnt is a Phase II SBIR project at Army Intelligence and Information Warfare Directorate (I2WD). It performs ontology-based fusion for cyber threat behavior estimation to contribute to an operator's cyber Situational Awareness (SA) and Situational Understanding (SU). It is unique in that, (1) it is architected following the Joint Directors of Laboratories (JDL) fusion levels, (2) it uses formal ontology for the T-Box (types) and A-Box (actuals), and (3) it computes mathematically-principled -- and thus robust -- likelihood ratios (Λ) of attack behavior hypotheses. Inference links are visualized in a graph database tool developed by I2WD that allows customized viewing tailored to operator requirements. The likelihood ratios can be thresholded to give operators control over display clutter. It currently runs in a tactical cloud environment developed by I2WD and uses big data technologies. In the next phase, the current fusion system will train a deep learning component that can learn and adapt and whose results can be explained by the fusion component.

Λ is the likelihood ratio of a Hypothesis of some piece of Cyber Situational Understanding data type i regarding engagement between two sets of Assets (blue, red, grey, neutral). If Λ is greater than 1, then the probability that the information is true is greater than that it might just be noise.

The hypothesis Λ's are generated from an integration of Sensor Evidence from sensor types s and evidence type v, normalized to the CybOnt Observation and Feature ontology.

The ontology has a formal foundation that is set-theoretic, higher-order, 4-dimensional, and meroptopologic so that computations across it are mathematically principled.
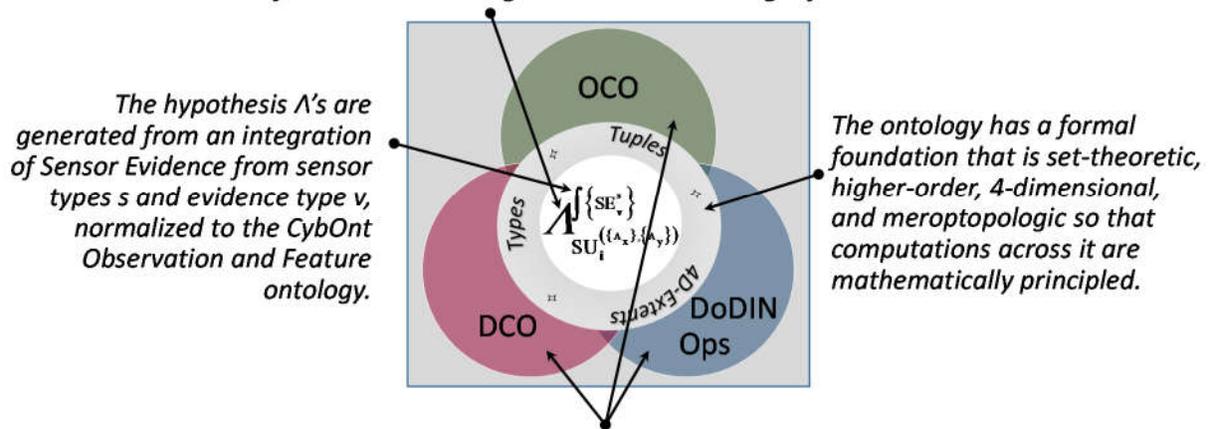

Figure 1. The CybOnt Logo

2 Semantic Distance Function (SDF)

SDF computes semantic distances between pairs of text documents in the form of likelihood ratios of the likelihood that the same concepts would have produced the pair compared to the likelihood of the null hypothesis. What is unique is, (1) the principled mathematics, (2) the concept of semantic mass and semantic mass ratios, and (3) an innovative way to compute the expected semantic mass ratio for the null hypothesis. SDF was inspired by long-standing JDL Level 2 fusion track correlation problem as shown in Figure 2. A key element is a Gram Frequency Data Base (GFDB) implemented in Hbase for quick lookup of gram frequencies by distributed processors computing the semantic distance. For some experiments the GFDB was initialized
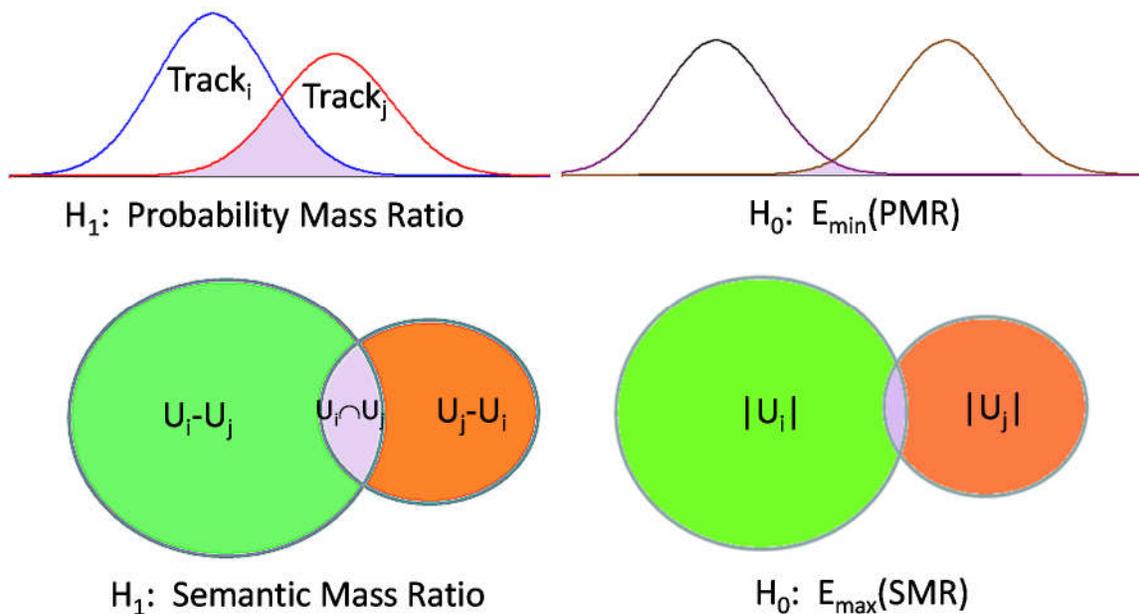

Figure 2. Analogy of Probability and Semantic Mass Ratio Concepts in Track Data Correlation and Text Correlation

using Google's Web 1Terabyte database of one-to-five gram frequencies. For cyber experiments, a domain-specific GFDB was developed by processing cyber corpii including Exploit DB (40K entries) and the Common Vulnerabilities and Exposures (CVE) database (100K entries). The GFDB adapts as input documents are processed so the initialization only needs to bootstrap the processing. Experiments have been run using newstories, the Enron email corpii, SNORT rules, and the Common Attack Pattern Enumeration and Classification (CAPEC) database.

3 Formal Ontologies

Silver Bullet is DoD's lead engineer for the DoD Architecture Framework (DoDAF). Silver Bullet was key in moving DoD architectures from, 1) unstructured documents to structured data, 2) qualitative to quantitative, and 3) templates to fit-for-purpose models. This derived from Silver Bullet's role as the U.S. DoD technical lead to an international defense team that developed a formal ontology for coalition data exchange called International Defence Enterprise Architecture Specification (IDEAS). It is formal in that it has a mathematical foundation that implements high order type theory and four-dimensional mereotopology. This ontology is being used in:

- DoD Architecture Framework (DoDAF) Meta Model (DM2)

- Cyber Ontology (CybOnt)

- DoD Information Enterprise Architecture (DIEA)

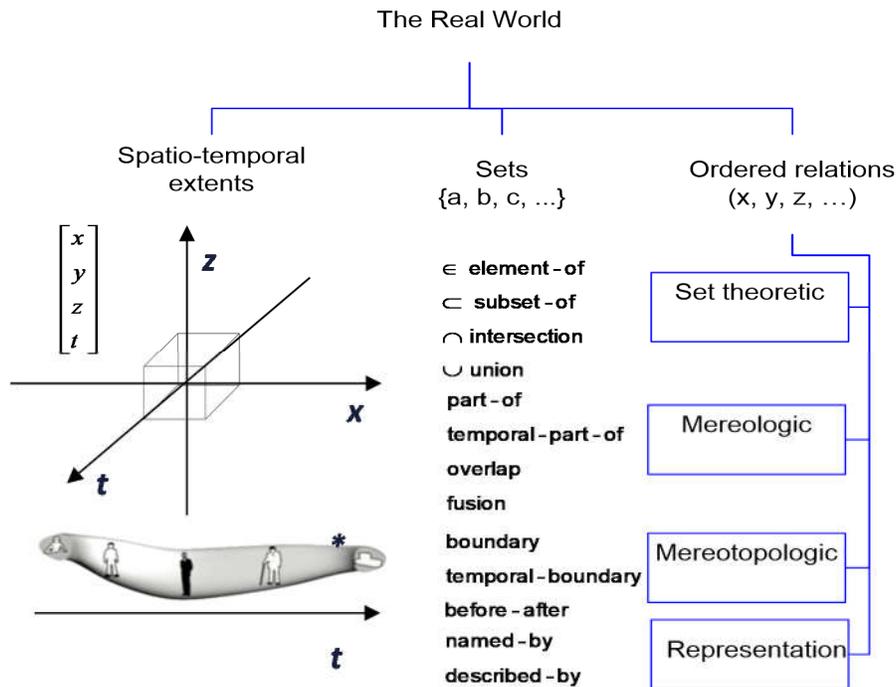- Joint Artificial Intelligence Center (JAIC) Common Foundation (JCF) architecture

Figure 3. Real world modeling with formal ontology