

## Scalable Data Fusion and Knowledge Graph Integration for Enhanced Air Force Targeting Capabilities

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## Glossary

**AFRL (Air Force Research Laboratory):** A scientific research organization operated by the United States Air Force Materiel Command dedicated to leading the discovery, development, and integration of aerospace warfighting technologies.

**AI:** Artificial Intelligence

**ATO:** Authority to Operate

**CAGR:** Compound Annual Growth Rate

**CDAO (Chief Data and Artificial Intelligence Office):** An office within Department of Defense components and agencies responsible for the oversight and integration of data analytics and AI technologies.

**CRADA (Cooperative Research and Development Agreement):** A legal agreement between a federal laboratory or office and one or more non-federal parties to collaborate on research and development.

**CtF (Certificate to Field):** A certification process that ensures technology systems meet the necessary requirements for field use within the Department of Defense.

**DAF:** Department of the Air Force

**DoD:** Department of Defense

**FedRAMP (Federal Risk and Authorization Management Program):** A government program that provides a standardized approach to security assessment, authorization, and continuous monitoring for cloud products and services.

**Geo-Inference Engine:** A proprietary AI system developed by Lovelace AI, designed to integrate and analyze vast amounts of data in real-time to support decision-making.

**IMPACT:** A data management system used within the Department of Defense for intelligence and operational data handling.

**ML:** Machine Learning

**NIS (National Intelligence Strategy):** The unified strategy for the United States intelligence community.

**OIE (Operations in the Information Environment):** A DoD strategy that focuses on information-related capabilities and operations to gain a competitive advantage.

**PAI (Publicly Available Information):** Information that anyone can lawfully obtain by request or observation.

**SAR:** Synthetic Aperture Radar

**T&E (Test and Evaluation):** The process by which a system or components are measured and evaluated under controlled conditions.

**TSA (Target Systems Analysis):** A detailed examination of potential target systems to determine the necessary actions to achieve desired effects.

**USSOCOM:** U.S. Special Operations Command

**UI:** User Interface

## 1. Executive Summary

The People's Republic of China's ambitions in the South and East China Seas, and their rapid military modernization, represent a significant challenge to the United States and our regional allies. Deputy Secretary of Defense Kathleen Hicks highlighted the critical need for rapid adaptation in her keynote address at the August 2023 NDIA Emerging Technology Conference: "The pace at which technological change is affecting national security is breathtaking, and we must adapt our systems and policies to keep pace with these changes if we are to maintain our competitive edge." Existing commercial off-the-shelf (COTS) intelligence tools are insufficient, struggling to efficiently process and integrate the vast and varied sensor data critical for accurately monitoring adversarial movements and strategic intentions. To effectively compete with China's advancements, our military requires enhanced analytic capabilities that leverage cutting-edge technologies to improve situational awareness and decision-making in contested environments.

Lovelace AI proposes a revolutionary solution to this need: our Geo-Inference Engine, a **Scalable Data Fusion and Knowledge Graph Integration for Enhanced Air Force Targeting Capabilities**. With a \$7 million venture investment and a two-year development plan, our technology integrates scalable data fusion and knowledge graph capabilities to transform extensive datasets into actionable intelligence. Designed to enhance Air Force targeting operations, our solution reduces the amount of time analysts spend developing targeting, significantly upgrading the decision making process, and allowing for timely, more precise targeting actions and anomaly detection against emerging threats.

Lovelace's advanced analytics and real-time tracking capabilities align with the Air Force's S&T Strategy for Rapid, Effective Decision Making and our solution's ability to fuse and interpret diverse and interpret diverse data sets supports *Operational Imperatives #2 & #3: Moving Target Engagement and Operationally Focused ABMS*. By offering real-time tracking and advanced analytics, the engine addresses critical gaps in current DAF intelligence solutions and empowers the Air Force with proactive response capabilities, early threat detection, and increased decision support using applied artificial intelligence methods.

Lovelace's Geo-Inference engine supports the Director of National Intelligence's 2023 National Intelligence Strategy (NIS) Goal #1 by providing timely and accurate insights into competitor intentions and capabilities. The engine processes millions of records in milliseconds, enabling sub-second reaction times for user queries and enhancing situational awareness through real-time data analysis and trajectory extrapolation.

During Phase II, Lovelace will collaborate with AFRL's Information and Integrated Capabilities Directorates (AFRL/RIEA and RSX) to align product requirements, develop prototypes, and demonstrate a mature SBIR-enhanced version of the Geo-Inference engine. This engine will integrate with AFRL's BULLSEYE and IMPACT intelligence tools, enhancing multi-source data fusion capabilities and data quality within the KNEAT and Custody Engine programs.

AFRL/RIEA's specific defense need to reduce the time required for Target Systems Analysis (TSA) by at least 50% underscores the necessity for scalable capabilities in fusing multi-modal, multi-source information. Lovelace's Geo-Inference Engine, employing advanced entity resolution techniques, addresses these needs by automating and enhancing the analysis of large, complex data sets.

Lovelace's approach aligns with the DoD's Strategy for Operations in the Information Environment (OIE) and supports intelligence efforts by providing interoperable and innovative solutions at scale. The AF's requirements for Geo-Inference capabilities are further **validated by the 613th Air Operation Center (613 AOC) Letter of Support, an active CRADA with USSOCOM's Chief Data and Artificial Intelligence Office (CDAO), and a \$2.5M private investment of matching funds from U.S. Innovative Technology**.

Following a successful Phase II, AFRL/RIEA and AFRL/RSX will coordinate with ACC A22M to leverage multiple contracting types to secure the required Certificate to Field (CtF) and Authority to Operate (ATO), ensuring the Geo-Inference engine's integration into the suite of targeting systems analysis tools and its alignment with classified requirements.

2. Identification and Significance of the Problem or Opportunity

The Department of the Air Force faces an urgent requirement to modernize its capabilities to manage and synthesize vast amounts of multi-source data in real-time, enhancing decision-making and operational effectiveness. Existing systems are inadequate, struggling with the scale and diversity of data, which leads to significant delays and potential intelligence oversights. The urgency to innovate and adapt is underscored by the growing threat posed by the People’s Republic of China in the South and East China Seas. Secretary of the Air Force Frank Kendall has starkly highlighted the pace at which China is modernizing its military, aiming to outpace U.S. capabilities and reshape regional dynamics. He warns, "We must be ready for a kind of war we have no modern experience with...If our power projection capability and capacity are not adequate to deter Chinese aggression against Taiwan or elsewhere, war could occur. If it does, and we cannot prevail, the results could cast a long shadow."



Table 1: Air Force Users Overwhelmed by Data

To face the PRC threat, enhancing the data fusion capabilities of the U.S. Air Force becomes not just an operational necessity but a strategic imperative. Effective data management directly influences our military's operational readiness and decision-making, making it critical to develop systems that can dynamically integrate and analyze data from diverse sources swiftly and accurately. Failure to advance our technological capabilities risks severe consequences, potentially jeopardizing our national security and strategic interests in the face of aggressive Chinese expansion and militarization.

3. Department of the Air Force Operational Imperatives

Our proposed solution aligns with the Air Force's strategic Operational Imperatives by enhancing decision speed and accuracy through superior data fusion and knowledge management. These capabilities are crucial for command and control functions and operational intelligence.

Lovelace’s advanced analytics and real-time tracking capabilities align with the Air Force’s S&T Strategy for Rapid, Effective Decision Making and our solution’s ability to fuse and interpret diverse and interpret diverse data sets supports *Operational Imperatives #2 & #3: Moving Target Engagement and Operationally Focused ABMS*. By offering real-time tracking and advanced analytics, the engine addresses critical gaps in current DAF intelligence solutions and empowers the Air Force with proactive response capabilities, early threat detection, and increased decision support using applied artificial intelligence methods.

Lovelace identified a specific requirement in the Intelligence Surveillance and Reconnaissance Capabilities and Requirements Tool (ISR CART) that supports OI-2 & OI-3. The ISR-CART requirement exists to better leverage non-traditional sources to improve the use of PAI and OSINT data. In addition to this unclassified requirement, we understand there to be several supporting requirements on SIPR this work directly aligns to and our transition plan includes obtaining the necessary clearances to access and modify our technology to address classified requirements.

By developing a robust knowledge graph that integrates data seamlessly and securely, the solution enhances the Air Force’s ability to rapidly interpret and act on intelligence. This system will provide a critical technological edge, allowing the Air Force to operate more effectively in complex global scenarios.

4. Non-Defense Commercial Solution

Lovelace AI's Geo-Inference Engine, currently at a TRL 5, is engineered to meet the urgent demands for advanced AI tools in overseas missions. While its initial focus is on defense, the engine's underlying technology has significant

potential for adaptation to non-defense commercial sectors. These include logistics, finance, crisis response, and urban planning, where large, unstructured datasets often hamper decision-making processes.

The Geo-Inference Engine utilizes cutting-edge AI to process and analyze massive, multimodal datasets in real-time, providing actionable intelligence that allows users to transition from reactive to proactive strategies. This capability is particularly valuable in commercial environments, enhancing operational efficiencies and decision-making speed. The technology not only addresses the needs of military operations but is also designed to tackle similar challenges in commercial industries, where there is a robust demand for sophisticated, real-time data analytics.

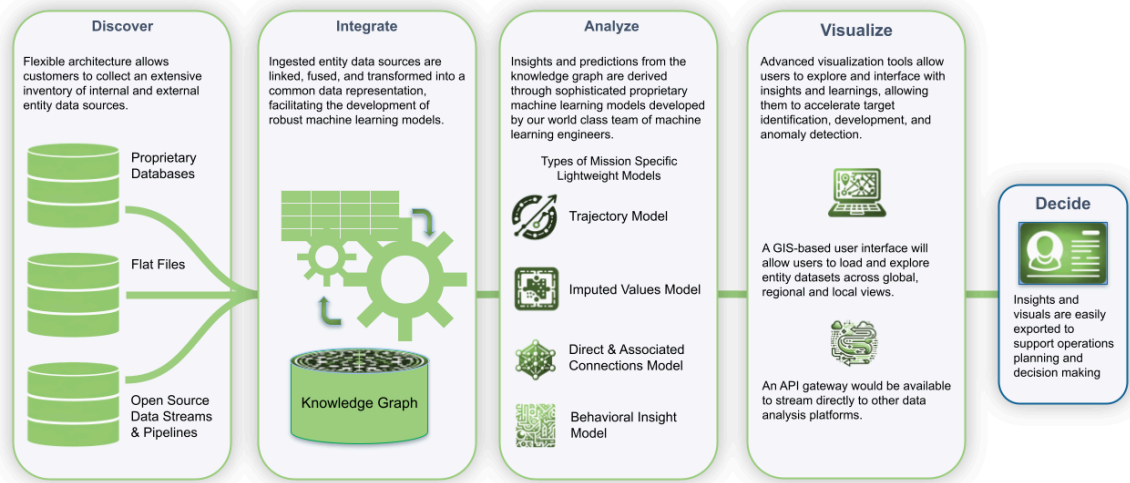


Table 2: How the Geo-Inference Engine Works

The engine builds upon existing data fusion technologies but introduces innovative enhancements with its hybrid Bayesian/generative models and prevision AI models. These advancements automate the analysis and interpretation of multimodal data, offering a novel standalone solution that can be adapted to most platforms. While the commercial application of our product is still in the conceptual phase, the core functionalities of our technology that we have developed in our current prototype—such as sub-second latency, advanced pattern recognition, and the generation of actionable insights—will transition into our commercial product.

The potential market for applied AI in non-defense sectors is significant, with McKinsey estimating the economic value of applied AI to be between \$17 trillion and \$26 trillion. The technology's capability to enhance real-time decision-making processes positions it well for future commercialization in high-growth sectors like transportation and logistics. Preliminary market analysis suggests that our engine could capture significant market share within the first five years post-commercialization, leveraging its versatility and the growing reliance on data-driven strategies across various industries.

5. Proposed Adaptation of Non-Defense Commercial Solution

For the Department of the Air Force (DAF), Lovelace AI is tailoring the Geo-Inference Engine to meet specific operational requirements, particularly to enhance situational awareness, accelerate decision-making processes, and improve operational planning. This adaptation is designed to leverage the engine’s core capabilities while ensuring seamless integration into military workflows, specifically by augmenting the analytical capabilities of DAF analysts and commanders.

The adaptation will undergo rigorous testing and evaluation with real operational data provided by AFRL end users. This ensures the platform meets the demanding conditions of military environments and directly addresses the specific needs of DAF operations. The evaluation process involves close collaboration with end-user analysts to refine the engine’s functionalities, making them more relevant and effective for military use.

The fundamental capabilities of the Geo-Inference Engine, such as handling large and diverse data sets, will be preserved. The modifications for DAF usage focus on enhancing security measures, ensuring data integrity, and optimizing compatibility with existing military systems. For example, the 613th Air Operations Center (AOC) Innovation Cell's MCHMR BattleCloud project, which aims to provide seamless tactical and operational connectivity across INDOPACOM, has highlighted the importance of these enhancements. They are building a mesh network to integrate sensor data into an Azure Cloud, ensuring connectivity in data-denied environments and supporting joint fires capabilities in critical locations.

Key features of the engine would be low-latency data processing, entity trajectory extrapolation, inferred missing information, and behavioral insight.

The expected quantitative benefits for DAF end-users are substantial, including a 50% reduction in the investigative burden on Targeting Systems Analysts for the development of their IADS reports. This improvement will significantly enhance the speed and accuracy of decision-making in mission-critical operations and operational planning.

The Test & Evaluation (T&E) of the adapted engine will validate these enhancements in real-world scenarios to ensure robust performance under the specific conditions of DAF operations. This T&E is critical in confirming that the adapted engine provides the expected operational benefits without compromising its commercial applicability.

To address identified risks such as data integrity and model overfitting, our strategy includes implementing rigorous validation protocols and employing advanced model generalization techniques to maintain accuracy and reliability. The system is designed with modular components to ensure platform agnosticism and adaptability for integration into existing military infrastructures. Here are the five areas where we anticipate risk:

- **Data Integrity:** Medium probability, high impact. Mitigation: Implement rigorous testing protocols and continuous data sanitation to maintain data integrity and model accuracy.
- **Model Overfitting:** High probability, medium impact. Mitigation: Use cross-validation, regularization, pruning, and a robust validation dataset to ensure model generalization.
- **Integration Complexity:** Medium probability, high impact. Mitigation: Design the system with modular components to ease integration, enhance scalability, and facilitate future enhancements.
- **System Integration:** Medium probability, high impact. Mitigation: Focus on user-centered design, iterative testing, and feedback to refine algorithms and system performance.
- **Field Deployment:** Small probability, medium impact. Mitigation: Conduct tests in controlled settings and real-world conditions over the next year to validate the solution's resilience and effectiveness.

## 6. Phase I-Type "Feasibility Study" Results

This Proof of Performance document outlines the dual capabilities of the Lovelace AI's Geo-Inference Engine that demonstrate our ability to integrate and analyze large, complex, multimodal datasets using AI and ML applications. The capabilities include 1) data fusion across AIS SPIRE, Adtech, and SAR overhead imagery, and 2) predictive analytics with explanatory capabilities of fused information..

Our team recognized the need for advanced data integration and predictive analytics in the complex and highly dynamic environment of national security and defense early on. This led to the development of a cutting-edge Geo-Inference Engine designed to not only fuse data from disparate sources but also to predict and explain potential security threats.

### Integration of Complex Multimodal Data Sources

The Geo-Inference Engine successfully integrates three major types of data:

- **AIS SPIRE Data Access:** Real-time maritime transponder data, essential for tracking vessel movements.
- **Adtech Data:** Commercially sourced behavioral data, crucial for understanding human patterns and potential threats.
- **SAR Overhead Imagery:** Satellite imagery providing real-time visuals of geographical and infrastructural changes.



This innovative approach was pivotal in laying the foundation for a comprehensive analysis and targeting system that enhances predictive accuracy and operational readiness of military analysts and commanders. The integrated data is ingested into our system, providing a unified view that supports dynamic and strategic defense operations.

### Predictive Analytics and Operational Insights

Building upon the success of the data integration capability, our team further advanced our prototype by developing predictive analytics that not only forecasts future movements but also provides explanatory insights into those predictions. Utilizing patent pending machine learning models and methods, our Geo-Inference Engine translates complex data sets into actionable intelligence by demonstrating trajectory extrapolation of ships, imputed values of ship properties not identified in data, and co-location of phones and ships (essentially demonstrating our ability to validate than a phone handset is on a vessel).

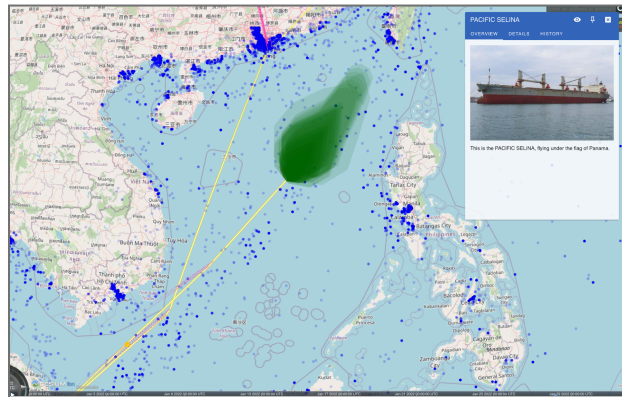


Table 3: Screenshot of our predictive trajectory model against a shipping vessel.

Our goal with this prototype is to demonstrate how our fusion and visualization methods can innovate analyst workflows but also facilitate a more agile and responsive targeting process due to the automation capabilities provided by our predictive models. By leveraging the power of AI-driven analytics, we enabled a seamless flow from data fusion to operational insights, enhancing the decision-making processes.

### Intellectual Property Development

Lovelace AI has filed two provisional patent applications to protect its innovations: see section 10 for more details.

### Engagement with AFRL and Air Force Stakeholders

Our prototype has not only facilitated meaningful conversations with key stakeholders at the Air Force Research Laboratory (AFRL) and other Air Force units but also led to significant collaborative developments. These discussions have provided stakeholders with confidence in Lovelace AI's capabilities to develop and deploy the technology solutions they need. For instance, our engagement with AFRL's Information Fusion Technology Branch highlighted our engine's potential to enhance the targeting cycle through advanced data analytics, leading to better decision-making processes in critical missions.

A pivotal outcome of these engagements is the Cooperative Research and Development Agreement (CRADA) we signed with USSOCOM's Chief Data and Artificial Intelligence Office (CDAO). This agreement was a direct result of demonstrating our prototype's capabilities in operational settings, which aligned perfectly with USSOCOM's strategic objectives to integrate cutting-edge AI technologies into their operations. The CRADA facilitates a deeper collaboration, allowing us to access unique operational insights and integrate feedback directly from end-users, thereby tailoring our solutions to meet the exact requirements of USSOCOM operations.

Through these engagements, we have not only validated our technology's utility and effectiveness but also aligned our development goals with the specific needs and priorities of the Air Force and USSOCOM. This ensures that our solutions are aligned with operational capabilities and needs of future end-users of our technology.

## 7. Compliance and Regulatory Activities

See attachment 12.

## 8. Phase II Technical Objectives and Key Results

### 8.1 Objective #1 - Establish Scalable Data Ingestion Infrastructure:

Develop and validate a scalable data ingestion system to handle diverse data types efficiently and securely. This system will be designed to meet the high-volume demands of both the Air Force and potential commercial applications.

#### Key Results:

- Deliver a data ingestion system processing up to 1 terabyte of PAI per day with 99.5% uptime, including validation, repair, normalization, and indexing.
- Demonstrate real-time data fetching handling spikes up to 10x normal volumes without degradation.
- Complete and document 3-4 AFRL workshop sessions resulting in approved system requirements and integration plans.

Commercial Application: Use the scalable data ingestion capabilities to offer services to commercial sectors (financial services, shipping and logistics, insurance, and retail) that require real-time data processing and analytics, enhancing business intelligence and operational decision-making. Typical data sources include planet-wide transponder data from multiple classes of vehicles, public internet analytics and social media, news and messaging.

### 8.2 Objective #2 - Enhance Multi-Source Data Fusion Capabilities

Create an advanced data fusion system that integrates multiple data sources into a coherent knowledge graph for real-time analysis.

#### Key Result:

- Reduce recall error by 66% compared to industry standards for any fixed user-specified precision rate.
- Reduce data processing latency by 50% compared to existing benchmarks.
- Implement a knowledge graph supporting real-time updates and integrating data from at least five distinct sources.
- Integrate and validate data fusion enhancements in a test environment, showing linked entities across two data sources.

Commercial Application: Provide the enhanced data fusion capabilities as a service to other commercial clients, enabling them to integrate diverse data sources into their operational environments and analysis processes efficiently, for example, to provide global supply chain visibility to provide an integrated view of data sources like container tracking systems, port logistics, weather data, and shipping manifests.

### 8.3 Objective #3 - Enhanced Data Quality and Usage Analytics

Implement systems to continuously assess and improve the quality of ingested data, providing actionable insights and enhancing the overall integrity of data used in targeting processes.

#### Key Result:

- Implement a data quality assessment system detecting anomalies within 2 minutes of significant deviation, including multivariate issues.
- Achieve a 25% improvement in data quality scores within 6 months, measured by predefined metrics.
- Generate monthly data usage and quality reports for identified end-users.

**Commercial Application:** Market the data quality optimization tools and usage analytics as standalone products or enhancements to existing business intelligence solutions, aiding organizations in maintaining high-quality data standards.



#### 8.4 Objective #4 - Ensure Integration and Accessibility of the Knowledge Graph Across Defense Platforms:

Develop integrated capabilities to export and share the knowledge graph data with common operating picture platforms and other intelligence systems.

##### Key Results:

- Develop and release standardized APIs accessed over 1,000 times per month by external systems.
- Implement secure data export functionalities supporting at least two different intelligence platforms.
- Conduct three successful pilot tests to validate interoperability and performance.

Commercial Application: Enable data sharing services for customers across their enterprise

### 9. Phase II Work Plan Outline

The Phase II effort focuses on the development and integration of a sophisticated data fusion system and the construction of an operational knowledge graph. This work aims to enhance real-time decision-making capabilities within the Department of the Air Force through improved handling and analysis of multi-source data. Major requirements and specifications include: Real-time data processing and update capabilities, integration compatibility with existing DAF data systems, high-level security and data integrity standards.

#### 9.1 Task Outline

Lovelace AI will conduct eight technical tasks throughout the 21-month period of performance to include the program management tasks and final reporting.

Phase II Tasks		1-3 Months	4-6 Months	7-9 Months	10-12 Months	13-15 Months	15-18 Months	18-21 Months
1	SBIR Phase II Program Management							
2	Phase III Transition Planning							
3	End-Customer & End-User Requirements							
4	Develop Prototype #1: Automated Data Ingestion Infrastructure w/Multi-Source Data Fusion							
5	Conduct Test Cycle 1: Demonstrate Prototype #2 in Lovelace Test Environment							
6	Conduct Test Cycle 2: Demonstrate Prototype #3 in End-Customer Environment							
7	Conduct Test Cycle 3: Perform Operational Assessment with Prototype #4 in End-Customer Environment							
8	Perform Product Training Sessions							
9	Produce Final Report							

**Table 4:** Phase II Work Plan

#### Task Descriptions & Technical Requirements:

**9.1 SBIR Phase II Program Management:** Oversee the execution and coordination of the entire Phase II

project to ensure compliance with goals, timelines, and budgets.

**9.2 Phase III Transition Planning:** Strategize and prepare for the transition of technology from SBIR Phase II to Phase III, focusing on commercialization and integration into defense systems.

**9.2.1 Extended User Research for Defense Applications (PRIVATELY FUNDED):** Conducting comprehensive research among defense personnel to tailor the product functionalities to the specific needs of future military end-users.

**9.3 End-Customer & End-User Requirements:** Gather and define the technical and operational requirements from direct end-users and customers to ensure the product meets their specific needs.

**9.3.1 Design Data Source Integration System:**

**9.3.1.1** Conduct 3-4 workshop sessions with AFRL to capture detailed requirements and identify and assess potential data sources.

**9.3.1.2** Define mandatory capabilities for real-time data processing and storage.

**9.3.1.3** Establish acceptance criteria and success indicators for the data ingestion framework.

**9.3.2 Determine Key Performance Metrics:**

**9.3.2.1** Draft a requirements document using AFRL/RIEA standard templates and host review sessions for validation.

**9.3.2.2** Define and track key performance indicators for data ingestion.

**9.3.3 Ensure Data Integrity and Security:**

**9.3.3.1** Establish data validation processes to ensure accuracy and integrity.

**9.3.3.1** Outline and implement security requirements compliant with DoD cybersecurity standards.

**9.4 Develop Prototype #1:** Automated Data Ingestion Infrastructure w/Multi-Source Data Fusion: Create a prototype that automates the ingestion and integration of data from multiple sources, enhancing real-time analysis capabilities.

**9.4.1 Develop Infrastructure Scalability**

**9.4.1.1** Design infrastructure to handle varying loads and peak times.

**9.4.1.2** Discuss integration with existing DoD systems (IMPACT, Maven Smart Systems, Palantir, Foundry, Advana).

**9.4.1.3 Research and Integration of Additional Sensors (PRIVATELY FUNDED):** Incorporating diverse data sources such as satellite imagery, ISR feeds, and other sensors to enrich the data fusion capabilities.

**9.4.1.4 Advanced Model Development for Predictive Analytics (PRIVATELY FUNDED):** Enhance the AI models to provide sophisticated predictive insights.

**9.5 Conduct Test Cycle 1:** Demonstrate Prototype #2 in Lovelace Test Environment: Test and evaluate the second prototype in a controlled environment to assess functionality and performance.

**9.5.1 Data Ingestion Fusion Development:**

**9.5.1.1** Develop state-of-the-art data fusion algorithms tailored to operational needs of AFRL.

**9.5.1.2** Optimize these algorithms for speed and accuracy.

**9.5.2 Implement Data Quality Enhancement:**

**9.5.2.1** Develop algorithms to enhance ingested data sets.

**9.5.2.2** Provide comprehensive analytics on data usage patterns.

**9.5.3 Optimize the system based on feedback from performance metrics.**

**9.5.4 Construct and Integrate Knowledge Graph:**

**9.5.4.1** Collaborate with AFRL/RIEA to define technical specifications for the knowledge graph.

**9.5.4.2** Develop and integrate advanced data fusion techniques such as entity resolution and contextual data integration.

**9.6 Conduct Test Cycle 2:** Demonstrate Prototype #3 in End-Customer Environment: Demonstrate the third prototype in the actual operational environment of the end-customer to evaluate its effectiveness and gather user feedback.

**9.6.1 Front-End Design and User Experience Enhancement (PRIVATELY FUNDED):** Focus on intuitive interface design to ensure ease of use and effective data presentation.

**9.7 Conduct Test Cycle 3:** Perform Operational Assessment with Prototype #4 in End-Customer Environment: Conduct a comprehensive operational assessment of the fourth prototype to validate its performance and impact under real-world conditions.

**9.7.1 Develop an API Platform for Enhanced Integration and Scalability (PRIVATELY FUNDED):** Creating a robust API platform to enable seamless integration with third-party systems and applications, enhancing the adaptability and utility of the product in diverse operational contexts.

**9.7.1.1** Design and implement standardized APIs to access the knowledge graph.

**9.7.1.2** Conduct pilot tests to validate the interoperability and performance of the sharing capabilities.

**9.7.2 Development of Alternate Production Environments (PRIVATELY FUNDED):** Creating versatile deployment options including cloud-based platforms, standalone systems for secure environments, and mobile applications for field operations.

**9.7.3 Achieve FedRAMP Authorization (PRIVATELY FUNDED):** Obtain Federal Risk and Authorization Management Program (FedRAMP) authorization to ensure our systems meet federal security requirements for cloud products and services.

**9.8 Perform Product Training Sessions:** Deliver training sessions to end-users to ensure they are equipped to utilize the product effectively.

**9.9 Produce Final Report:** Compile and submit a detailed report summarizing the project outcomes, findings, and future recommendations post-completion of the SBIR Phase II.

**Scope of Work Plan**

Lovelace AI will collaborate with our USAF science and technology partners and operator communities to develop a full set of technical requirements, build a prototype that achieves those desired requirements, and demonstrate the effectiveness of the prototype through various test cycles that meet a set criteria benchmarks during Phase II. Specific activities include:

1. Define and verify end-customer and end-user requirements, including technical specifications, integration, security, compliance, and deployment requirements.
2. Define preliminary Air Force pricing model and customer adoption criteria.
3. Collaborate with end-customer to establish a viable path to an Authority to Operate (ATO) for fielding.
4. Adapt existing commercial product to AFRL/RIEA, AFRL/RSX, and the operational community needs, including the delivery and validation of a scalable data ingestion system capable of handling multi-source publicly available information (PAI) at high volumes, efficiently, quickly, and securely.
5. Create an advanced data fusion system that integrates multiple data sources into a coherent knowledge graph for real-time analysis.
6. Implement mechanisms to continuously assess and improve the quality of ingested data and provide actionable insights on data ingestion and quality.

7. Develop integrated capabilities to export and share the knowledge graph data with common operating picture platforms and other intelligence systems.

Privately funded tasks are designed to complement and advance the research and development efforts identified under the SBIR funded work plan and address specific advanced development areas that are critical for achieving a comprehensive and versatile product for AFRL end users and scalable to broader defense applications.

## 9.2 Milestone Schedule

<b>TASK</b>	<b>DELIVERY</b>	<b>DELIVERABLE</b>	<b>ACCEPTANCE CRITERIA</b>	<b>PAYMENT</b>
<b>Milestone 1 - Kickoff and Sprint Planning</b>	Award + 1 month	Lovelace will provide a detailed project kickoff report and 30-60-90 day sprint plan to include business and technical tasks.	AFRL/RIEA attends the Kick-off and accepts the 30-60-90 day sprint plan.	\$100K
<b>Milestone 2 – Verify Customer Requirements and Specifications</b>	Award + 3 months	Lovelace will produce a detailed requirements document in collaboration with AFRL/RIEA including technical specifications, integration, security, compliance, and deployment requirements	AFRL/REIA and AFRL/RSX approves requirements documentation.	\$100k
<b>Milestone 3 – Design &amp; Develop Initial Prototype</b>	Award + 6 months	Lovelace will complete Prototype #1 with basic automated data ingestion infrastructure and demonstrate to AFRL/RIEA	AFRL/RIEA and AFRL/RSX approves Prototype #1 meets basic functionality, requirements and specifications	\$200K
<b>Milestone 4 – Refine and Test Prototype in Lovelace Environment</b>	Award + 9 months	Lovelace will complete Prototype #2, conduct Test Cycle 1 and demonstrate prototype meets 60% of test criteria including multi-source data fusion performance, integration, and UI evaluations.	AFRL/RIEA accepts Test Cycle 1 results and identifies areas for improvement.	\$200K
<b>Milestone 5 – Refine and Test Prototype in AFRL/RIEA Environment</b>	Award + 12 months	Lovelace will complete Prototype #3, conduct Test Cycle 2 and demonstrate prototype meets 80% of test criteria including enhanced data quality and usage analytics in an AFRL/RIEA environment.	AFRL/RIEA accepts Test Cycle 2 results and identifies areas for improvement.	\$200K
<b>Milestone 6 – Perform Prototype Operational Assessment with AFRL/RIEA</b>	Award + 15 months	Lovelace will complete Prototype #4, conduct Test Cycle 3 and demonstrate prototype meets 100% of test criteria including integration and accessibility across defense platforms in an AFRL/RIEA environment.	AFRL/RIEA accepts Test Cycle 3 report detailing operational assessment results with end-users in a real-world scenario.	\$200K
<b>Milestone 7 - Product Training Sessions</b>	Award + 18 months	Lovelace will provide training to AFRL/RIEA and AFRL/RSX engineers, complete training	AFRL/RIEA and AFRL/RSX accepts training	\$150K

		materials and comprehensive user documentation, and achieve a Net Promoter Score of 9.	materials and documentation.	
<b>Milestone 8 - Phase III Transition Planning</b>	Award +20 months	Detailed Phase III transition plan, including commercialization strategies and path ATO.	Approval and acceptance of Phase III transition plan by the AFRL/RIEA.	\$50K
<b>Milestone 9 – Final Report</b>	Award + 21 Months	Final report detailing the activities and capabilities developed and demonstrated.	AFRL/RIEA accepts Final Report.	\$50K

### 9.3 Required Reports

**Deliverables:** Deliverables will be produced within the 21-month development timeframe and delivered to potential Phase III customers at their discretion. All technical data and intellectual property generated under the program will be subject to SBIR data rights, (DFARS) 252.227-7018-Rights in Noncommercial Technical Data and Computer Software - SBIR Program. Specific deliverables are described in further detail below.

1. **Kickoff Meeting and Approved Work Plan:** A detailed kickoff meeting report and an approved 30-60-90 day business and technical work plan outlining the project's scope and objectives.
2. **Customer/End-User Requirements Report:** Comprehensive documentation capturing the results of Task 2, including design requirements, mission-critical application user interface, user experience, security, and regulatory requirements.
3. **Quarterly Status Reports:** Regularly updated progress reports, each no longer than 15 slides, describing the project's advancement towards Phase II objectives and key results. These reports will include a quantitative measure between 0 and 1 of progress toward each milestone.
4. **Test Cycle 1:** End-user will validate that Prototype #2 and Test Cycle 1 demonstration meets 60% of test criteria including multi-source data fusion performance, integration, and UI evaluations.
5. **Test Cycle 2:** End-user will validate that Prototype #3 and Test Cycle 2 demonstration meets 80% of test criteria including enhanced data quality and usage analytics in an AFRL/RIEA environment.
6. **Operational Assessment:** End-user will validate that Prototype #4 and Test Cycle 3 demonstration meets 100% of test criteria including integration and accessibility across defense platforms in an AFRL/RIEA environment, meeting the end-user's desired experience and quantifiable metrics specified by AFRL/RIEA.
7. **Phase II Summary Report:** A concise summary report, not exceeding 700 words, submitted upon the completion of the technical effort. This report will highlight the technological advancements, applications, and benefits for Government and private sector use.
8. **Draft Final Report:** To be delivered 30 calendar days post-completion of the Phase II technical effort, including a single-page summary of the project, a brief description of the work accomplished, and a listing of potential results and applications.
9. **Geo-Inference Engine Prototype:** On request, Lovelace will demonstrate the Geo-Inference engine prototype to AFRL/RIEA, AFRL/RXS, and other defense customers, showcasing its capabilities and potential applications.
10. **Geo-Inference Software, Training Documentation and User Manuals:** Comprehensive training materials and detailed user manuals will be developed, encompassing all aspects of operating and leveraging Lovelace's Geo-Inference engine. These resources will be designed to facilitate effective training sessions for DAF personnel and other potential end-users. The documentation will include step-by-step guides, best practices, troubleshooting tips, and practical use-case scenarios. The training materials will ensure that users are fully equipped to utilize the Geo-Inference engine to its fullest potential, enhancing their operational efficiency and model generation capabilities.

11. **Final Report/Presentation:** A comprehensive final report of no more than 25 pages will be submitted 90 days after the technical effort detailing the completion of project objectives, results obtained, and technical feasibility assessments for a successful transition to Phase III. Final report will include a completed SF 298 and a brief accounting of the investor fund's expenditures to support the Phase II.

## 10. Commercialization Strategy

**Company Information:** Our company consists of a team of senior leaders from Google, DoD and Amazon who have successfully deployed dozens of major real time AI decision and control systems, and we formed Lovelace AI to develop technology that transforms massive, unstructured data sets into actionable intelligence in real time. This capability is crucial for national security and has broad applications in commercial sectors such as logistics, finance, and urban infrastructure. Our potential clients include major corporations like JP Morgan, UPS, and Maersk. Lovelace AI has a history of collaboration with federal and non-federal entities, including a current Cooperative Research and Development Agreement (CRADA) with USSOCOM, positioning us uniquely for both defense and commercial market penetration.

**Customer and Competition:** Lovelace AI is positioned uniquely against competitors like Palantir, FADE/MIST, and Scale Donovan due to our engine's superior capabilities in sub-second latency, flexible integrations, and comprehensive multimodal analysis. Our technology is critical for sectors requiring rapid, reliable decision-making support, such as defense, logistics, and finance. Major hurdles include breaking into well-established markets dominated by long-standing players and gaining trust in the reliability and security of our AI-driven solutions.

**Market:** Our market strategy exploits the growing demand for AI-driven decision support systems across both defense and commercial sectors. The AI in the defense market is expected to grow at a 33% CAGR from 2023 to 2028, reflecting a robust demand for our technology. Similarly, the commercial market for AI applications in logistics, finance, and urban planning is rapidly expanding, with McKinsey estimating the potential economic value of applied AI between \$17 trillion to \$26 trillion. Our go-to-market strategy focuses on leveraging these growing sectors, targeting companies like JP Morgan, UPS, and Maersk, with the aim to secure a substantial market share within the first five years post-commercialization.

**Intellectual Property:** Lovelace AI's proactive intellectual property strategy is underscored by our development of a robust prototype, which has facilitated the filing of two key provisional patents: US Application Serial Number 63/642,631: "Geospatial Moving Entity Analysis Systems and Methodologies" and US Application Serial Number 63/642,633: "Data Infrastructure for Moving Object Tracking and Inference System"

**Financing:** Lovelace AI has successfully attracted \$7M in venture investment from U.S. Innovative Technology, demonstrating significant confidence in the team's ability to bring valuable technology to market. We plan to continue this trajectory by engaging with venture capital firms, other investors, and government grants to fund our scale-up operations and market expansion, with plans to raise a Series A round that couple be applied to a TACFI/STRATFI program. Our funding strategy is aligned with our growth objectives, focusing on securing investments that support our aggressive deployment and commercialization timelines.

**Assistance and Mentoring:** Lovelace AI benefits from strategic partnerships and mentoring through our CRADA with USSOCOM and connections with various technical and business development centers.

## 11. Military Applications/DoD Customers

Lovelace AI's Geo-Inference Engine is engineered to meet an immediate and critical military requirement for real-time, advanced data fusion and knowledge graph technologies. These technologies are vital across operations centers and analysis cells within the military and intelligence communities, where quick and precise decision-making is paramount for national security.

The 2024 Annual Threat Assessment of the U.S. Intelligence Community underscores the urgency, pointing out the People's Republic of China's aggressive military and maritime activities in the South China Sea. The report warns that these actions are escalating tensions to a level that could lead to catastrophic miscalculations and conflict. If not countered with advanced analytical capabilities, these tensions could escalate into open warfare, jeopardizing regional stability and U.S. interests. Lovelace's Geo-Inference Engine addresses this dire need by aligning with the



Director of National Intelligence's 2023 National Intelligence Strategy (NIS) Goal #1: delivering timely and precise insights into competitor intentions and capabilities. Processing millions of data records within milliseconds, our solution will drastically reduce the time analysts spend making sense of data, enhancing situational awareness and operational readiness with trajectory extrapolation and real-time data analysis with easy to understand reasoning.

By providing real-time data analysis and trajectory extrapolation, Lovelace offers a dynamic overview of an entity's pattern of life, thereby increasing situational awareness. Lovelace accelerates response times with sub-second data processing and analysis enhances decision-making speed. Delivering precision targeting and anomaly detection improves operational planning. **These benefits to the warfighter align with Lt. Gen. Leah Lauderback's strategy, as Deputy Chief of Staff for Intelligence, Surveillance, Reconnaissance, and Cyber Effects Operations at HQ USAF,** by fulfilling her vision for what she calls the fourth element of the sensing grid, the human element. Lovelace will equip our airmen with the necessary intelligence tools to fuse vast amounts of data and deliver actionable intelligence in milliseconds. Our approach supports the Air Force Future Operating Concept (AFFOC) key "fights" by 1) guaranteeing our joint forces, partners, and allies have the warfighting material and training necessary to compete with and deter adversaries; 2) integrating Lovelace's technology across the intelligence tool suites to prevent vendor lock, coordinate situational awareness from multi-domain threats, and ensure warfighter readiness; and 3) delivering modern intelligence tools that can deny adversary objectives with pattern of life predictions in near real-time.

	<b>Deliver Modern Intelligence Tools:</b> Lovelace will deliver a Geo-Inference engine with multi-source data fusion and predictive analytics	<b>Prioritize Interoperability:</b> Lovelace will integrate with BULLSEYE, IMPACT, Custody Engine and other intelligence tools	<b>Prevent Vendor Lock:</b> Lovelace will offer joint force training to the joint force, partners, and allies	<b>Eliminate Stovepipes:</b> Lovelace will engage operators to ensure system requirements align to real-world capability gaps
<b>Operational Imperatives (OI)</b>	OI 2	OI 3		
<b>AF Future Operating Concept</b>	Fight #5: Deny Adversary Objectives	Fight #2: Get Into Theater	Fight #1: Compete With and Deter	
<b>2023 National Intelligence Strategy</b>	Goal #1: Position the IC for Intensifying Strategic Competition	Goal #3: Deliver Interoperable and Innovative Solutions at Scale	Goal #5: Expand IC Capabilities and Expertise on Transnational Challenges	
<b>2023 DoD Strategy for Operations in the Information Environment</b>	LOE #2: Task D – Provide Intelligence Support to Enable OIE			
<b>Air Force S&amp;T Strategy</b>	Objective #2: Priority #1 – Global Persistent Awareness		Objective #2: Priority #3 – Rapid, Effective Decision-Making	
<b>OUSD (R&amp;E) Critical Technology Areas</b>	CTA #2: Trusted AI & Autonomy			

**Table 5: Lovelace Alignment to DoD Strategies**

Lovelace's problem sets and military applications for the Geo-Inference engine were validated by several of the following DoD organizations and individuals:

- Air Force Research Laboratory Information Fusion Technology Branch (AFRL/RIEA) – END CUSTOMER:** Specific defense need is to alleviate the investigative burden of the targeting analytical process and reduce the time required to complete the research phase of TSA by at least 50%, accelerating warfighter decision-making by months. AFRL/RIEA has shown a continuous interest in integrating cutting-edge data analytics to enhance operational capabilities. The Geo-Inference Engine aligns with AFRL's strategic goals for superior command and control technologies.
  - MEMORANDUM signed by Mr. Daniel Daskiewicz, Branch Chief, [daniel.daskiewicz@us.af.mil](mailto:daniel.daskiewicz@us.af.mil)**

- **MEMORANDUM signed by Ms. Emily Keane, Senior Computer Scientist/TPOC, emily.keane@us.af.mil**
- **Air Force Research Laboratory Integrated Capabilities Directorate (AFRL/RSX) – END USER:** Interest in bringing separate knowledge graphs in as a meta graph and tying/linking nodes together that have commonality. As new pieces of information or data points become available it is critical, they make their way into the infrastructure. Related to their work with Custody Engine.
  - **MEMORANDUM signed by Ms. Julie Moran, Experimentation Lead – SAINT, julie.moran@us.af.mil**
- **U.S. Special Operations Command (USSOCOM):** CRADA, signed in May 2024, focused on tailoring the Geo-Inference Engine to meet the unique operational needs of special mission units.
  - **CRADA signed by Lisa Sanders, Director / SOF AT&L-S&T, lisa.sanders@socom.mil**
  - **POC:** Nicole Nemmers, Chief, Data Governance and Capabilities Branch/AI Portfolio Manager, nicole.nemmers.civ@socom.mil
- **613th Air Operations Center (AOC), Pacific Air Forces (PACAF):** MCHMR BattleCloud initiative aims to enhance command and control capabilities by integrating sensor data across allied nations within the Pacific Theater.
  - **LOS signed by Lt Col Brian “Rookie” Grossweiler, Commander, 613 AOC Innovation Cell, brian.grossweiler.2@us.af.mil**
- **Air Combat Command, Intelligence (ACC A22M):** A requirement in the ISR CART aims to better leverage non-traditional sources for PAI and OSINT data. Additional SIPR requirements align with our solution, and we plan to obtain necessary clearances. The ACC Data Programs Branch found the Geo-Inference engine too early for an official Demo Day, which showcases high TRL solutions. Instead, ACC is arranging a separate event for Lovelace to present to A22, coordinating with the 363rd ISRG and 20th IS.
  - Lt Col Ugne Erickson, IMA to Deputy Division Chief, ugne.erickson@us.af.mil
  - **POC: SSgt Charles Hamilton, Innovation NCO, Data Programs Branch, charles.hamilton.16@us.af.mil**
- **National Air and Space Intelligence Center (NASIC):** NASIC’s Global Exploitation Intelligence Group (GX) is continually seeking to accelerate the collection, exploitation, and analysis of integrated intelligence. The Intelligence Exploitation Squadron (GXX) manages and analyzes PAI/OS data, from collection to dissemination. Lovelace is coordinating a meeting with the following individuals.
  - Mr. Steven Zech, Chief Data Officer, Director Future Capabilities and Assessment (A9), steve.zech@us.af.mil

Lovelace spoke to Col Shawn Ayers, USAF Warfare Center, who introduced Col Richard Schermer, Commander, 548th ISRG. Lt Col Jonathan Swinarski, Commander, 169th IS, recommended connecting with the 480th ISRG at Langley. Lt Col Lance Loveland, 151st ISRG, expressed interest in future research and transition efforts. Our collaboration with the S&T and operations communities will meet JADC2 interoperability requirements, aligning with NIS Goal #3 for scalable, interoperable solutions and the DoD’s OIE Strategy to provide intelligence support through advanced data systems.

Our Phase II effort will focus primarily on AFRL/RIEA’s and RSX’s unique needs as it relates to KNEAT and Custody Engine while refining a Phase III transition path for Lovelace to scale the Geo-Inference engine to the 613 AOC, and other DAF customers listed above.

## 12. Foreign Person

The research effort will not include any foreign person or non-U.S. citizens.

### 13. Key Personnel

**Andrew Moore, PhD, Principal Investigator, Co-Founder & CEO:** Dr. Andrew Moore is a prominent AI innovator with notable roles including leading Google AI Cloud and serving as the Dean of Computer Science at Carnegie Mellon University. His work focuses on integrating probability theory with AI for critical applications. He holds a PhD in Computer Science and has completed postdoctoral research at MIT AI Lab. Moore has contributed significantly to national security and AI policy as a commissioner on the National Security Commission for Artificial Intelligence and a member of the National AI Research Resources Commission. He has briefed two U.S. presidents on AI security issues, serves on the boards of Duolingo Inc and Dropbox, co-authored the "Handbook of Biosurveillance," published over 200 academic papers with an H-index of 77, and advised more than 20 PhD students.

**Toby Smith, Co-Founder & Head of Engineering:** Recognized in Pittsburgh's tech community for his exceptional design and engineering leadership, Smith has a history of spearheading complex projects in distributed computing systems at Google and NetApp, contributing to the team's capability to transform data into actionable insights.

**Brendan Dunne, Co-Founder & Head of Public Sector:** Brendan is a retired Special Operations Veteran with over 20 years in our country's Counter Terrorism National Mission Force with deep intelligence, cyber, and targeting experience. He most recently served as the Director of Joint Special Operations Command's "software factory" called the Global Analytics Platform building custom targeting tools. He brings a wealth of experience in applying high-tech solutions to national security challenges.

### 14. Non-Defense Commercial Customers

Lovelace AI has positioned itself as a defense-first company, and is concentrating on tailoring our Geo-Inference Engine to meet the needs of military and intelligence communities. Our underlying technology has significant potential for commercial use across diverse sectors. For instance, in logistics, the Geo-Inference Engine could optimize route planning and asset tracking, in finance, it could detect patterns of fraudulent transactions, and in crisis response, it could streamline emergency evacuations by analyzing population movements in real-time. As we continue to validate and refine our technology within defense contexts, we are poised to transition our proven capabilities to commercial markets, where early discussions with potential clients such as logistic giants and financial institutions have underscored the broad applicability and strong interest in our advanced analytical tools.

### 15. Investors and Partners

Lovelace AI is backed by US Innovative Technology (USIT), a strategic investment firm known for accelerating companies with dual-use technology applications across commercial and defense sectors. USIT has a strong track record, supporting major defense technology firms like Shield AI, Gecko Robotics, Primer, Ditto, and Capella Space. Additionally, Lovelace AI benefits from the strategic guidance of General H.R. McMaster, a retired United States Army lieutenant general and former National Security Advisor.

### 16. Related Work

Lovelace AI, recently out of stealth, does not have previous government program work, but our principal investigator has significantly influenced AI applications in both national security and commercial sectors. Dr. Moore's expertise in AI was emphasized in 2023 by General Kurilla, commander of CENTCOM, who stated, "Dr. Moore brings a level of expertise in AI, Cloud Computing, and Robotics that is unmatched."

Dr. Moore's has contributed to high-profile discussions with the DoD's Chief Digital and AI Office and briefed U.S. Presidents on AI's national security applications. Eric Schmitt, former Chairman of Google and former head of the Defense Innovation Board, has said publicly that the Google Office Dr. Moore built in Pittsburgh is responsible for tens of billions of revenue a year.