Commercial Observation for Spatio-temporal Monitoring for Indications of Change (COSMIC)

1. Program Overview

The aim of the Commercial Observation for Spatio-temporal Monitoring for Indications of Change (COSMIC) program is to formulate a methodology to leverage commercial remote sensing technologies and open source geolocated information to generate pseudo-persistent data (PPD). This will be done by combining and translating complex and novel data, such as non-nadir imagery and non-Red, Green, Blue (RGB) spectral bands, using artificial intelligence and computer vision-based methodologies into a layered, temporal geospatial model understandable by commercial agentic artificial intelligence (AI) systems. COSMIC will enable the development of an agentic AI analytic system trained by commercial vendors and equipped to answer intelligence questions by bridging the gap between IC data characteristics and the simpler solutions offered by commercial vendors.

COSMIC will foster routine updating and modelling of baseline geospatial information in areas through multi-source, persistent surveillance. New sensors will fluidly be incorporated into the generation of layered geospatial models as constellations and sources change over time. In addition to improving the temporal resolution of layered geospatial models, COSMIC also aims to reduce resource demands by streamlining the derivation of actionable intelligence from these models. By integrating commercial remote sensing data with existing geospatial information, the program aims to create a harmonized and up-to-date representation of the physical world that can be used by agentic processes to answer questions relevant to the IC.

2. Objectives

COSMIC aims to create a methodology to rapidly integrate multiple sources of information into a unified framework to allow for incorporation into a layered GEOINT model or PPD. Additionally, this source should allow the prediction and visualization of resolution and bands of data not provided for PPD construction through predictive processes such as image diffusion or other generative AI approaches. The COSMIC capability will enable the rapid assessment of intelligence through an AI interrogatable multi-sensor, multi-int data source that combines satellite images and geospatial data from a variety of systems into an interrelated framework. This framework should then be compatible with various state of the art change detection algorithms, object detection, and agentic systems identified by the government for the aid of intelligence analysts. For example, a change detection algorithm developed for a SAR system might be applied to imagery from a EO system, and the framework would need to be able to translate between the two domains.

Offerors shall address the following technical challenges (TCs) and objectives to meet the COSMIC goals to develop methodologies to rapidly integrate disparate remotely sensed imagery

and geospatial intelligence (GEOINT) into a visualizable framework to create a PPD that is useable by agentic AI in their candidate approaches:

- Incorporation of multi-resolution imagery and GEOINT data;
- Creation of a PPD over varying time scales;
- Incorporation of electro-optical, multispectral, and radar imagery and imagery collected at angles other than NADIR without manual manipulation;
- Incorporation of imagery collected at different altitudes with varying atmospheric effects such as unmanned aerial vehicle (UAV) or satellite imagery;
- Incorporation of non-image based GEOINT information with temporal elements (e.g. weather events, traffic data, building permit location);
- Prediction of missing spectra, resolutions, and temporal images and two-dimensional information;
- Visualization of PPD elements including imagery, data availability, and confidence metric reflective of the likelihood of hallucinations;
- Compatibility with existing change detection algorithms;
- Compatibility with Agentic systems
- Deployability on stand-alone systems
- Ability to identify and discriminate ephemeral events compared with persistent change;
- Generation of imagery of various modalities based on the PPD.

3. Program Scope and Limitations

Offerors are expected to address the following:

- Methods for relating data sources to each other such as:
    - Super-resolution;
    - Coregistration;
    - Resolution variance compensation methods;
    - Spectral harmonization;
    - Shared embedding spaces;
- Methods of predicting novel spectral bands not represented by data inputted into the PPD;
- Methods of predicting novel points in time at specified resolutions or image types not represented by data inputted into the PPD;
- Methods to incorporate and utilize non-image, high temporal frequency GEOINT data, such as weather or traffic information;
- Methods to improve the temporal resolution of layered GEOINT models

- Research & Development approach: White Papers shall describe the technical approach to robustly meet program objectives;
- Software Development: White Papers shall describe the approach to software architecture, modularization, and integration. If the Offeror leverages backbone diffusion models, the ability to "switch out" and retrain using future model releases is highly desirable.

Data sources that are to be ingested into the PPD may include, but are not limited to:

- Multispectral imagery collected from airborne and satellite altitudes and varying view angles;
- Pan EO imagery collected from airborne and satellite altitudes and varying view angles;
- SAR imagery collected from airborne and satellite altitudes and varying view angles;
- Existing GEOINT models
- Traffic data;
- Weather data.

Additional data sources may be available to selected performers and data sources may be removed at the discretion of the government. Proposed approaches should address how the above data sources may be incorporated.

The following areas of research and approaches are out of scope for the COSMIC program:

- Research that does not have strong theoretical and experimental foundations;
- Development of sensor systems or computation hardware;
- Development of sensor platforms, such as UAVs, vehicles, aerostats, towers, or camera systems;
- Research that utilizes proprietary data that cannot be delivered to the government;
- Methods that require a human-in-the-loop as part of the integrated end-to-end system;
- Approaches that consist merely of integrating currently existing software;
- Approaches that require non-cooperative real time augmentation to provided data, e.g., opportunistic data from sensors integrated into handheld devices, computers, or automobiles;
- Approaches that create a fixed data cube or embedding space that cannot accept new data;
- Development of novel change detection algorithms.
- Development of novel Agentic AI systems

The use of additional sensors, imaging or sensing modalities, filters, calibration targets, and publicly available ancillary data to assemble training data sets or to support modeling and simulation research is in scope if it is relevant to the proposed research approach.

Delivered software will be evaluated by an independent Test and Evaluation (T&E) team on sequestered and shared evaluation datasets. Performers will build prototype algorithms, and subcomponent modules, and/or systems for end-to-end that will be run and evaluated by the T&E team. Testing protocols do not allow for expert operators, human-in-the-loop operation, or any operations not deemed "turnkey." However, systems or algorithms that have been trained using human-in-the-loop methods may be submitted, provided they run autonomously. The systems will be tested using established change detection algorithms.

4. Program Specific Terms/Definitions

Pseudo-Persistent Data Source: A pseudo-persistent data (PPD) source is comprised of imagery and geospatial intelligence from multiple sensors, collected at multiple resolutions, and at different times that may be interrogated to answer questions such as "Is their large scale construction occurring in this area" Through the incorporation of many different information sources that are harmonized, the pseudo-persistent data source allows for constant monitoring of an area of regard.

GEOINT: Geospatial intelligence (GEOINT) refers to the intelligence derived from the analysis and exploitation of imagery, signals, or signatures with geospatial information. It involves describing, assessing, and visually depicting physical features and geographically referenced activities on Earth. GEOINT can be collected from multiple sources such as satellites, aircraft, maps, and commercial databases.

Harmonization: Harmonization refers to the processes by which disparate data sources collected over the same geospatial location, but at different times and from different sensors are made compatible to be interrogated over a reference frame.

Agentic AI systems: Agentic AI systems are artificial intelligence systems that operate with minimal human intervention to solve complex problems in near real time.

5. Human or Animal Subject Research applicable to this Program

N/A

6. Government Furnished Equipment/Information

The government intends to provide example data sets for the purpose of data ingestion. The volume of this data is not anticipated to be sufficient for training of algorithms.

7. Program Metrics

Delivered methodologies will be evaluated by T&E team(s) on curated test data sets. Performers will build prototype systems that the T&E team will run and evaluate in a closed computer environment. The T&E team will calculate metric scores. Delivered methodologies will be tested against a range of image and GEOINT data emulative of the variety that are available for the employment of change detection algorithms in a variety of locations distributed around the world. Performers will receive information about the change detection algorithms that will be employed in testing.

Candidate evaluation metrics for COSMIC are designed to test the ability of the PPD to facilitate change detection, predict images from novel temporal points, predict images from novel spectra, super-resolution of images, and image coregistration. Metrics may be added, modified, or removed at the discretion of the government. Offerors are encouraged to suggest metrics and evaluation methods in their white paper submission.

Table 1: Candidate metrics for COSMIC

Evaluation point	**Description**	Target Performance
Predicted image accuracy (for image products)	Structural similarity between synthesized image and hold out image	0.95
Relative Edge Response (for image products)	Standard image quality metric to reflect changes in smoothness of features in a super-resolved image	0.4
Change detection performance	Performance of change detection algorithm when applied to PPD versus a non-harmonized image collection	F1 improvement of 25% versus non-harmonized image collection. 25% reduction in the time to detect change
Sensor to Sensor Harmonization	Relative uncertainty across PPD measurements of the same location through time	±2.5%
Geolocation Error	Radius of circular error in which 90% of spatial misregistration exists (CE90)	10m
Answer fidelity	Accuracy of answers against benchmark intelligence questions	0.95

8. Program Waypoints, Milestones, Deliverables

COSMIC is a single phase 18-Month program with 9 evaluation milestones to evaluate Performers' progress to meet the program metrics. The program will culminate in the delivery of documented software that can be easily deployed by Government analysts in a cloud-based environment. Table 2 shows a timeline for the program with Government-defined milestones and deliverables.

Table 2: Program Waypoint, Milestone and Deliverables Testing Timeline

Event	Deliverables	
	Months after Kickoff	
Program Wide Milestone Kickoff	1	Read-ahead package due from Performers to the Government 7 days before meeting. If required by the PM, updates after the meeting are due 3 days after the meeting date.
Technical Review Meetings	Monthly	Read-ahead package due from Performer to the Government 1 day before meeting. If required by the PM, updates after the meeting are due 3 days after the meeting date.
Site Visits and Critical Design Review	4, 7, 10,13,16	Site visits
Evaluation Milestones (Software and Data Deliverables)	3, 6, 9,12, 15, 18	Performers will submit their software, development datasets and documentation to the T&E partner on the first business day of the month. Source code, build scripts and documentation for facilitating reproduction of system operation by an independent Test and Evaluation Team. All deliverables must be clearly labelled to identify IP assertions, which may be UNLIMITED or Government Purpose Rights.
Financial and Technical Reports	Monthly	Monthly financial and technical reports are due by the 15th day of the following month in the IARPA provided template.
Collaborative Workshop	12	A Collaborative Workshop held in the DC area
Draft Final Report	17	A draft of the final technical report outlining technical progress, methodology, challenges, successes, and recommendations for future efforts
End of Program, Final Report	18	Period of Performance Ends. Performers shall provide a final technical report outlining their technical progress, methodology, challenges, successes, and recommendations for future efforts.

8.1 Software Deliverable Formatting

Performers will be required to provide algorithm and software deliverables in a manner that conforms to a standardized industrial method or methods that will be provided at program Kickoff. To facilitate planning, Offerors may assume that the standardized configuration will

require the use of software containerization technology (e.g., Docker and a REST API). This means that the entirety of a Performer's system, including pre- and post-processing, must be included within the delivered software container. For models that require training, the expectation is for the initial model training to occur on Performer systems, with the ability for the T&E Team to re-train and test the model with the same and/or other data.

Each team is required to include, among their key personnel, a Lead System Integrator (LSI) who shall be responsible for preparing software Deliverable subcomponents, modules, and systems, performing quality control of Deliverable, and integrating key components into the primary COSMIC system(s). The LSI will also oversee communication and coordination across a Performer's research teams including subcontractors, if applicable, to ensure research products are functional, integrated and following software coding best practices (e.g., inline comments, documentation). Additional team members and roles are dependent on the proposed research, as such, there is no predetermined or required skill mix.

9. Place of Performance

Performance will be conducted at the Performers' recommended sites with Government's approval.

10. Test & Evaluation

T&E will be conducted by an independent team of Government and contractor staff carrying out evaluation and analyses of Performer Deliverables using program test datasets and protocols. Evaluations will occur during months 3, 6, 9, 12, 15, and 18 that will exercise Performer solutions across technical challenges.

Performers are encouraged to develop methodologies for a self-contained / self-hosted environment for use by government transition partners on their own network/systems. White papers must specify the processing dependencies needed to carry out the proposed research and what architecture and library characteristics are necessary for their approach(es) to be successful at meeting program objectives. Performers will have specific Deliverable Milestones at which all subcomponent and system algorithms and software will be delivered to IARPA and its designated T&E Team. The T&E Team will then conduct evaluations at the direction of the COSMIC PM and with the objective of characterizing the quality, functionality, and performance of the COSMIC Deliverables. In addition to quantitative measurements, T&E will be carried out to establish a thorough understanding of the progress, status, and limitations of the Performer's research. T&E results and feedback will be provided to Performers at regular intervals to keep them abreast of current independent performance measurements and to inform and improve their R&D approaches and methods. T&E results from all Performers will be shared with all teams to establish an understanding of the current state and progress of COSMIC research; T&E results

will also be shared with United States Government external stakeholders, including their contractors, for Government purposes.

11. Technical Exchange Meetings/Workshops/Site Visits/Travel Requirements

Performers are expected to assume responsibility for administration of their projects and to comply with contractual and program requirements for reporting, attendance at program workshops, and availability for site visits. The following paragraphs describe typical expectations for meetings and travel for IARPA programs as well as the contemplated frequency and locations of such meetings. In addition to ensuring that all necessary details of developed software, algorithm, and operational instructions are clear and complete, each Performer will be required to be available for questions and troubleshooting from the T&E Team in weekly or bi-weekly status meetings.

All Performer teams are expected to attend a collaborative workshop, to include Key Personnel from prime and subcontractor organizations. The workshop will focus on technical aspects of the program and on facilitating open technical exchanges, interaction, and sharing among the various program participants. Program participants will be expected to present the technical status and progress of their efforts to other participants and invited guests.

Site visits and critical reviews by the Government Team will generally take place at months 4, 7, 10, 13, and 16 during the life of the program. These visits will take place at the Performer's facility or as a virtual meeting at the discretion of the COSMIC PM. Reports on technical progress, details of successes and issues, contributions to the program goals, and technology demonstrations will be expected during these visits.

12. Anticipated Period of Performance

COSMIC is an 18-Month Program.