

Questions and Answers

DARPA-PS-26-03

Frosty

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Technical questions on Government Furnished Information (GFI) and Data

1. Q. Is sensor placement and quantity of sensors up for negotiation to strive for optimal performance or should we assume fixed / existing / government chosen sensor sites?
Q. How much flexibility should performers assume in receive array geometry when developing and demonstrating algorithms?
Q. May performers propose specific receive array geometries for government data collections?
Q. Is there a possibility of having multiple receive arrays beyond the two mentioned?
Q. What is the approximate size (baseline) of each array and when multiple arrays are used what is their configuration and baseline?
Q. Should we assume that the receive system includes multiple “widely separated” receive arrays?

A. We recognize that the signal processing algorithms and array layout are mutually dependent in achieving the Frosty goals. As a result, performer input on experiment design is needed. See the Program Solicitation, Amendment 2, where one of the deliverables (QPR4) is stated on Page 11 as: “Inputs for final test and data collection in the form of a conceptual experiment design incorporating the developments with a focus on array layout processing algorithms and computational needs.” Additionally, proposers are encouraged to provide preliminary experiment design inputs and corresponding rationale as part of their abstracts and/or oral presentations to inform government planning for earlier GFI data collections.
2. Q. Do we have control of the source waveforms and source arrays including their time, frequency, polarization, location, number of elements, and amplitude properties?
Q. What degree of control over transmit waveforms is permitted?
Q. Can you provide any information on the waveforms and/or transmit/receive arrays and their placement in the GFI data?
Q. Will FROSTY be able to have the cooperative illuminator waveform transmit FROSTY-defined waveforms?
Q. For Phase 1, should performers assume any ability to design/schedule transmitted waveforms from coordinated sources, or should we assume illumination is generally not performer-controlled?
Q. Regarding the source(s) shown in Figure 1. Are these source(s) assumed cooperative or non-cooperative? Specifically, may we assume their location, time of transmission, frequency of operation, and spectral characteristics are known for the purposes of this program?
Q. For each dataset, will “illuminator information” include (as applicable) center frequency/bandwidth, waveform or modulation description, transmission timing/schedule, and source location/geometry?
Q. What frequency ranges and bandwidths are anticipated?
Q. With regard to the stand off transmitter, what bandwidth and which waveforms will be used to illuminate the ionosphere?

- Q. Will the collected data be based on post-propagation of traditional structured cyclic waveforms, or will the waveform be noise-like even pre-propagation?
- Q. Does the GFI contain the transmitted (source) waveform and polarization?
- Q. What are the waveform and bandwidth limitations for the active illuminator? Will the waveform bandwidth be restricted to tens of kilohertz, or can the bandwidth be extended to a 1MHz or more?
- Q. What parameters should be assumed for the controlled high power stand-off sources?
- Q. What are the planned Tx illuminators, frequencies, polarizations, and waveforms of the GFI data?
- Q. Will DARPA provide illumination source location and waveform?

A. At this time, only the use of the High-frequency Active Auroral Research Program (HAARP) transmitter, operated by the University of Alaska Fairbanks, has been coordinated. See <https://haarp.gi.alaska.edu/>.

We hope to bring in additional transmitters and encourage those who operate existing systems to respond proposing collaboration.

The HAARP operates from 2.7 to 10MHz and will be programmed to transmit conventional repeated linear frequency modulated waveforms. The HAARP operates as a secondary user of the band and as a result has the typical constraints that result from operating in a not-to-interfere basis, including operating with bandwidths that tend to be limited to a few 10's of kHz, although in some cases the bandwidth can be much higher. We do not expect to have an ability to adapt waveforms in real time other than through operator interaction. Metadata on the transmissions needed to understand what was radiated and when will be recorded and provided to performers.

Also, note the requested deliverable on Page 11 of the Program Solicitation, Amendment 2, which states: "Inputs for final test and data collection in the form of a conceptual experiment design incorporating the developments with a focus on array layout processing algorithms and computational needs." These inputs should also include recommendations for the transmit waveforms and array configuration. Additionally, proposers are encouraged to provide preliminary experiment design inputs and corresponding rationale as part of their abstracts and/or oral presentations to inform government planning for GFI data collections.

If control of the transmit waveform is considered a key enabler of the proposer's approach, proposers are encouraged to bring that information forward in their abstract for government consideration.

3. Q. What is the spatial extent (beam widths) used in the illuminators and how much overlap is considered if multiple illuminators are used?

A. See the answer to the previous question.

4. Q. Will illuminators used for the GFI data collection be 'cooperative' OTHR transmitters? That is, cooperative in the sense that transmit schedule, frequency and waveform is known?

A. All man-made illuminators used in this phase of the program, where we are focused on the algorithm development, will be cooperative. Use of non-cooperative man-made illuminators is not in scope.

5. Q. Is full RF I/Q from each receiver antenna element available?
 - Q. What data format(s) will be provided in the GFI? Will raw IQ data be available?
 - Q. Can you provide additional details on the data management plan (expected data formats provided to performers)?
 - Q. Are the receive channels provided as complex baseband I/Q per element (and polarization, if applicable)? If so, are the samples raw voltages or will they have been pre-processed (e.g., AGC, filtering/decimation, FFT, or beamforming)?
 - A. Data from each receiver will be captured and recorded as in-phase/quadrature (I/Q) baseband data from each element filtered to include the transmission band(s) of interest with some data being wider bandwidth (e.g. 8 MHz) data sets. A read package will be provided that documents the file format and that provides the ability to read the data into a program such as MATLAB.
6. Q. For the GFI receive arrays (~24 elements), will DARPA provide the metadata needed for beamforming such as calibration coefficients and array geometry?
 - A. Array geometry and calibration coefficients will be provided to performers. The accuracy of the calibration coefficients may be insufficient for some high resolution techniques so approaches should be resilient in the face of calibration errors.
7. Q. Can we assume shared timing between Rx sources like chip scale atomic clock or GPSDO?
 - Q. Are channels phase coherent across elements? Across arrays?
 - A. Receiver systems at the same location are driven by a common GPS disciplined oscillator and trigger, so data collected is coherent. While the collected data is coherent across elements of each array and between arrays, the propagation channel will decorrelate the illuminating waveforms, potentially even within the same array.
8. Q. Will any ionospheric characterization data (e.g., soundings or TEC estimates) be available, or should all channel effects be inferred solely from received RF data?
 - Q. What environmental/context data will be provided with the GFI and test events?
 - Q. What ionospheric channel probe data will be made available contemporaneously with the government-collected received HF data?
 - A. While we expect oblique ionospheric sounding data to be available, this has not yet been fully coordinated.
9. Q. Will the receive array for the GFI data be 2D, or polarization-diverse?
 - Q. Can we assume polarization diversity at each receive node or between multiple nodes?
 - Q. What is the specific hardware configuration of each of the two HF receive arrays (e.g., antenna element type, polarization, array spacing, system receive bandwidth, etc.)?
 - A. We expect to use a mix of horizontal and vertically polarized elements. The array layout is likely to start as a limited 2-D array. Note the deliverable on Page 11 of the Program Solicitation, Amendment

2 asking for performer input on the experimental design. Proposers are also encouraged to provide such input, as available, during the abstract and/or oral presentation phases.

10. Q. Are particular target bistatic scattering geometries anticipated?

A. There is not a preferred illumination geometry. Page 6 of the Program Solicitation, Amendment 2 notes the need to correct for dispersion which is inherent in the physical geometry.

11. Q. What ranges of target velocities (with respect to background clutter) are expected?

A. Data will be collected to stress the processing so will include target speeds that vary from zero to ambiguous with respect to the transmitted waveforms.

12. Q. What sources of clutter will be present in the datasets provided?

Q. Do we anticipate icebreaker type ships to be in the list of potential target returns to process?

More specifically will targets embedded in icy environments be a scenario that generates clutter we will need to be capable of addressing.

A. This should be apparent from the solicitation, but we expect land, sea, meteor, auroral and other ionospheric clutter to be present.

13. Q. Are the 24-element HF receive arrays used in the Phase 1 data collection capable of digital or analog beamforming?

A. Element level data will be provided. Any beamforming that is needed will be accomplished by selected performers.

14. Q. Related to GFI data, what is the planned data collection location, and transmit/receive geometry?

A. With the transmitter that is currently coordinated specifically for Frosty, the data collections will be in Alaska. Additional test locations are desired, which is why the call expressly solicits participation by organizations from outside of the United States in Section 4.7 of the Program Solicitation, Amendment 2.

As noted in the ancillary information provided along with the Program Solicitation, data that was collected by the Defense Applications of Innovative Remote Sensing (DAIRS) program will be made available to the performers. This data is low latitude data with lower power illumination sources and through a low latitude equatorial ionospheric spreading channel rather than one that is auroral.

15. Q. What is the planned truth data for the targets of opportunity and controlled test targets (maritime and air platforms)?

Q. For the government provided datasets what will be the level of information provided on the ground truth in terms of target location?

- A. GPS position and time is expected for the controlled test targets. For targets of opportunity, truth data will be via Automatic Identification System (AIS) or Automatic Dependent Surveillance–Broadcast (ADS-B).
16. Q. Will transmit systems have multi-antenna transmit capability in Phase 1 collections? If so, will we be able to define the multi-channel MIMO transmitted waveforms, or should we assume illumination sources are single-channel?
- A. If the proposer believes that Multiple-input, multiple output (MIMO) waveforms are a key enabler for addressing the processing challenge, we encourage you to make that case.
17. Q. For ambient endogenous illumination, will the GFI/test events include a reference beam? Or should performers assume the reference must be constructed from the same surveillance data without a guaranteed direct-illumination source beam?
- A. See the answer to Question 6. Also, this question assumes a spatially-discrete noise-like source. Endogenous noise like sources are expected to be diffuse.
18. Q. Attachment A notes DAIRS polarimetric arrays and that DAIRS data may provide initial data to Frosty. Will any Phase 1 GFI include polarimetric (multi-component) receive channels? If so, can you share the expected format (e.g., channels per element / per site) and any available calibration metadata?
- A. DAIRS data has been collected with two arrays using eight triad (3-polarization) antenna elements. Some calibration data will be provided to performers.
19. Q. Will the provided datasets include an observation window with an absence of targets?
- A. There is no way to ensure that there will not be target-like returns in the collected data since returns from meteor trails or aircraft well outside of the plane of illumination can be observable.

Technical System Design and Operational Concept

20. Q. The figure in the announcement implies that the transmitter to target path is via sky wave while the target to receiver path is via surface wave or line of sight. Is this correct?
- A. Yes
21. Q. The Frosty focus is stated on Page 5 to be “develop advanced processing techniques to utilize the noise-like waveforms that result when illumination passes through the turbulent ionosphere to detect and track targets.” This is with known transmitted waveforms. The solicitation also states: *“this program will explore and develop radar techniques using ambient endogenous noise* Ambient endogenous noise is not a controlled man-made source. Aren’t these contradictory requirements?
- Q. The announcement mentions using ambient endogenous illumination. Can you clarify this? Are

you asking us to use ambient noise, or do we process the man-made illumination.

Q. Is the primary focus of this program the processing of a channel-distorted waveform from the active illuminator, or the processing of ambient background noise?

A. Per the Program Solicitation, Amendment 2 at the bottom of Page 6, “In Frosty, the primary focus will be to develop advanced processing techniques to utilize the noise-like waveforms that result when illumination passes through the turbulent ionosphere to detect and track targets.”

The focus is on the use of man-made and known transmissions that pass through a turbulent dispersive propagation channel. And as noted on the top of Page 6, achieving that goal would also enable the use of ambient endogenous illumination, which we intend to explore, particularly since understanding unconstrained endogenous illumination provides bounds and insight resulting from the use of controlled illumination.

22. Q What is the polarization of the received signal?

A. There are two aspects to this question. The first aspect is the data that will be collected during this phase of the program, which is answered in Question 9. The second, is the propagating signal that is received by the array, where the polarization will depend on the decorrelation of the illuminating waveform and the filtering effect of the propagation. The second aspect is not well known at this point and will likely change dynamically along with environmental conditions.

23. Q. Is the presence of a controlled Tx site in the OV-1 there only for data collection in this phase to validate algorithms? Is that the ultimate system CONOP? Or, does the ultimate CONOPS leverage ambient emitters of opportunity passively? Or could the ultimate CONOPS include a source with a post-facto obtainable waveform (e.g. a digital shortwave broadcast station simulcast on the internet).

A. This phase of the program is focused on development of the signal processing using controlled source(s). When successful, we expect the results of this phase will be used to inform future development and concept of operations (CONOPS).

24. Q. Does DARPA view partial or intermittent waveform coherence (e.g., localized in time–frequency or angle) as a viable source of processing gain for Frosty sensors?

Q. Is the use of other ancillary data on ionospheric conditions (e.g. ionograms, ionosphere forecasts, TEC information, etc.) allowed in the processing?

Q. Do we have to come up with a solution for a hybrid system that includes both OTHR (Sky-wave) and Surface wave propagation?

Q. Do you anticipate ionosphere sounding techniques to play a significant role in the final application? And can we include these techniques and their requisite devices in our approach?

A. It is up to the proposer to determine their proposed path that addresses the processing challenges.

25. Q. Should we assume that the direct path is observable at the receiver for the processing?

- A. This question is unclear, but see the answer to the previous question.
26. Q. Is Phase 1 primarily focused on algorithmic feasibility and insight, or on end-to-end detection and tracking performance using representative data?
- A. Progress on the development of the algorithms is assessed by the metrics table shown in the Program Solicitation, Amendment 2, on Page 7. Achieving these metrics needs an end-to-end processing chain.
27. Q. Is it within the program scope to use knowledge of the transmitted waveform properties?
- A. Yes. See the answer to Question 24.
28. Q. Can you make available information relevant to the radar range equation / SNR calculations (power of standoff illuminator, minimum/maximum target RCS, antenna gains, duty cycle, etc.)?
- A. This phase of the program is not a system development, but development, demonstration and test of new processing capabilities. As a result, this question is not applicable at this time.
29. Q. Is there an expectation that the proposed hardware design concept (as part of phase 1) for the end-to-end solution that will be developed in Phase 2 is similar to or leveraging the data collection hardware architecture used to provide the GFI data?
- A. This is a lesson that we expect to learn in the first phase of this program.
- Programmatic/Solicitation Scope
30. Q. Can we utilize our own transmitter or will data only be collected using the government-furnished transmitters?
- Q. We have previously deployed receiver systems to Arctic locations. Can we deploy our receiver systems for this program?
- Q. Could performers augment the government furnished data with additional data that they collect themselves?
- Q. Is DARPA open to performer-proposed supplemental receive assets during test events (subject to logistics/safety), or will Phase 1 collections be limited to Government-provided receiver infrastructure?
- A. If you have hardware, data sets, or receiver systems that would benefit the program, we encourage you to put the use of those assets and information forward in your abstract or by contacting the Frosty Procurement team as described in Section 1.4 of the Program Solicitation.
31. Q. Would the government entertain a proposal that has a hardware design aspect in addition to novel detection and tracking algorithms?

A. The focus of the program is on algorithm development. If you have existing hardware that could be applied to assist with reaching that goal, then we encourage you to put that forward. If your proposed work is hardware design or development then the expected capabilities would need to be quite compelling to be considered.

32. Q. Our team has a unique facility consisting of a high-power HF transmitter. Is use of this system within scope?

A. Yes. Moreover, we are soliciting collaboration and use of existing test assets.

33. Q. Will the government support solutions that require a highly correlated hardware design component to utilize novel Frosty algorithms? Or is the government only interested in algorithms that can leverage existing hardware and existing data streams?

A. It is not clear what this question is asking. The receiver systems that will be used for the GFI data are coherent. See the answer to Question 8.

34. Q. Is a Cost Proposal required with the abstract submission?

A. No, a cost proposal is not requested to be submitted along with the abstract. A budgetary rough order of magnitude (ROM) cost estimate is requested as part of the abstract submission; see Program Solicitation, Amendment 2, Page 15.

35. Q. Do we correctly understand that a cost proposal must be submitted with the Oral presentation/proposal.

A. See the Program Solicitation, Amendment 2 Section 3.4 (c) which requests the “budget by element of the WBS”

36. Q. Is there a preference of whether a non-U.S. organization is a subcontractor to a U.S. organization or whether they are a prime, possibly with U.S. subcontractors?

A. The organization of a team is best determined by the proposer based on personnel and organizations skills and the proposed work. Non-U.S. organizations are allowed to respond directly. See the Program Solicitation, Amendment 2. Section 4.7.

Contracting questions

37. Q. Will Phase 2 be a separate solicitation and contract?

A. Per the Program Solicitation, Amendment 2 on Page 8, “This PS is only soliciting proposals for Phase 1. Phase 2 will be solicited separately.”

38. Q. If a Phase 2 award is to a Phase 1 performer, would it be “Add-Work” to an existing Phase 1 contract or a new contract?
- A. The appropriate contracting mechanism for Phase 2 will be determined at the time of a Phase 2 solicitation.

Security questions

39. Q. We want to submit a classified abstract. How do we send it?
- A. Per Section 3.1(i) of the program solicitation, we are not accepting classified abstracts for this phase of the program.
40. Q. Will DARPA provide a classification guide?
- A. This phase of the program is unclassified and a controlled unclassified information (CUI) guide will be provided as described in the Program Solicitation, Amendment 2, Section 4.2.