OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE

High Frequency Geolocation and System Characterization (HF Geo)

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LEADING INTELLIGENCE INTEGRATION

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HFGeo Proposers' Day, 22 June 2011

Updated to align with the BAA

Disclaimer

- This presentation is provided solely for information and planning purposes
- The Proposers' Day Conference does not constitute a formal solicitation for proposals or proposal abstracts
- Nothing said at Proposers' Day changes the requirements set forth in a BAA
- BAA supersedes anything presented or said at the Proposers' Day

Proposers' Day Goals

- Familiarize participants with IARPA's interest in Geolocation and characterization of High Frequency SkyWave systems

- Please ask questions & provide feedback; this is your chance to alter the course of events.

Schedule

- Once the BAA is released, questions can only be answered in writing on the program website

- Full Proposals are due ~45 days after BAA is published

High Frequency (HF) Intelligence Missions

Radar characterization

What is this radar doing?

HF Source Geolocation

Where is this transmitter?

- HF use has advanced significantly in last 20 years
  - Low entry cost relative to satellites
  - Ease of use with modern technology

This multi-phased program will develop technology to address geolocation and characterization of HF sources

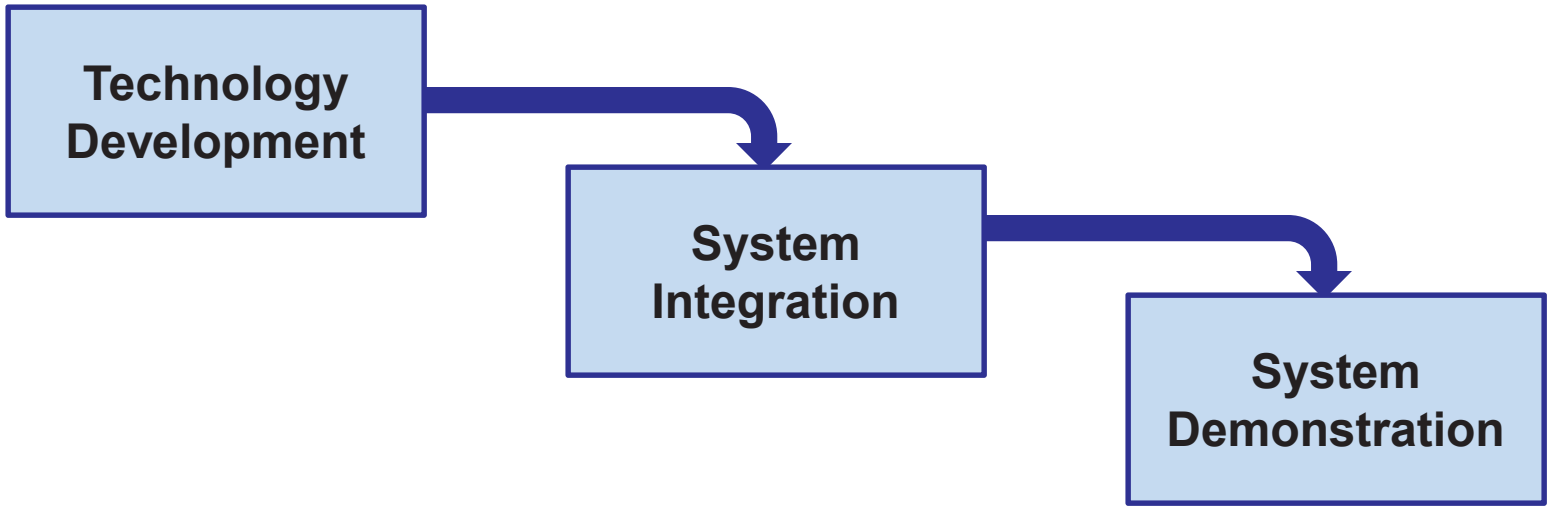
Array on dike: http://ifmaxp1.ifm.uni-hamburg.de/ANT_PET_1_100DPI.shtml

Antenna from: http://www.hamuniverse.com/ae5jufielddayantenna.html

HFGeo Program

- HF Issues of concern
  - Accurate ionospheric understanding
  - Desired signal selection vs. unwanted signals
  - System size and infrastructure requirements

- These issues require technology innovation prior to system development



Program Overview

- Phase 1, Enabling Technology

- Phase 2, System Integration and non-real-time Field Test
  - Transition from “component” technology to system development
    - System design
    - Prototype system hardware development
    - Off-line signal processing demonstration proof-of principle
  - Initial field testing with surrogate targets
  - Technology maturation and transition

- Phase 3, Real-time Field Test and Demonstration
  - Implement real-time signal processing capabilities
  - Test against realistic targets in realistic environment
  - Incorporate accuracy and signal processing enhancements

Enabling Technology Approach

Phase 1A

- Innovative HF sensors
  - Potential to shrink system size and cost and improve noise performance
- Advanced signal processing techniques
  - Signal selection enabling noise suppression and fewer geolocation sites

Phase 1B

- Accurate ionospheric measurements integrating novel sources

Innovative Sensors

Goals:

- Precisely determine angles-of-arrival of impinging signals (azimuth and elevation)

- Separate multiple signals
  - By arrival angle
  - By polarization state

- "Small" footprint

Vector Sensing

- Provides single element to determine direction of arrival (DOA) and signal polarization state

- Full vector sensors require six axes
  - Arrays of elements with fewer axes may provide similar benefits

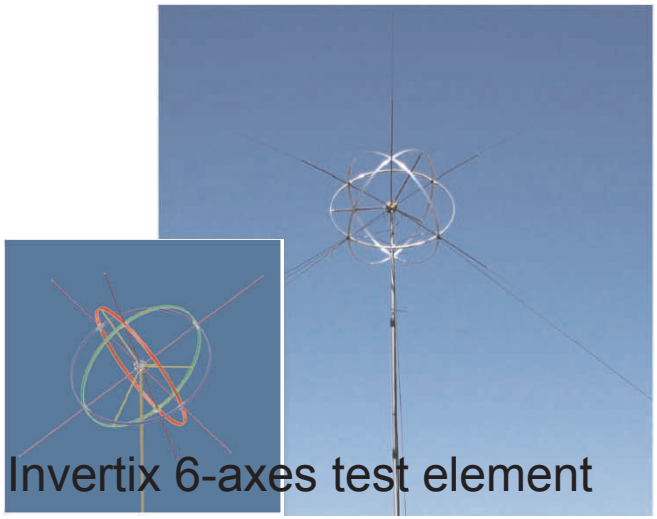


Image courtesy Invertix

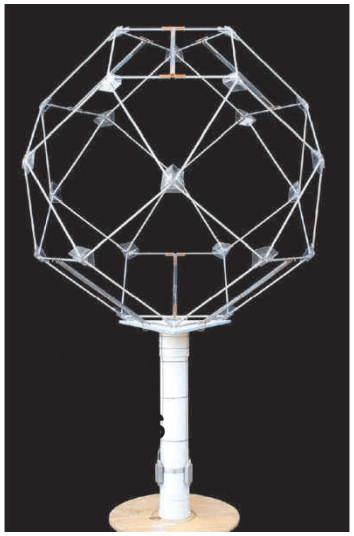
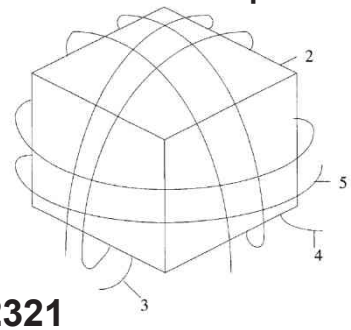
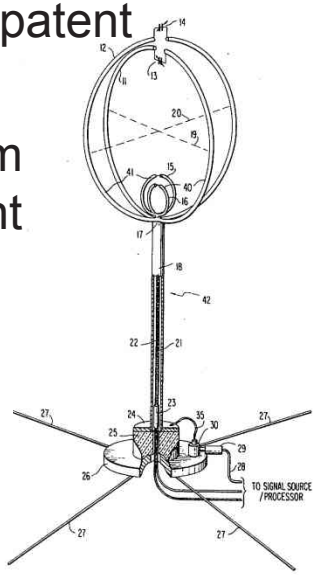


Image from DSTO-TR-2321

3-axes from DoC patent

3-axes from 2001 patent

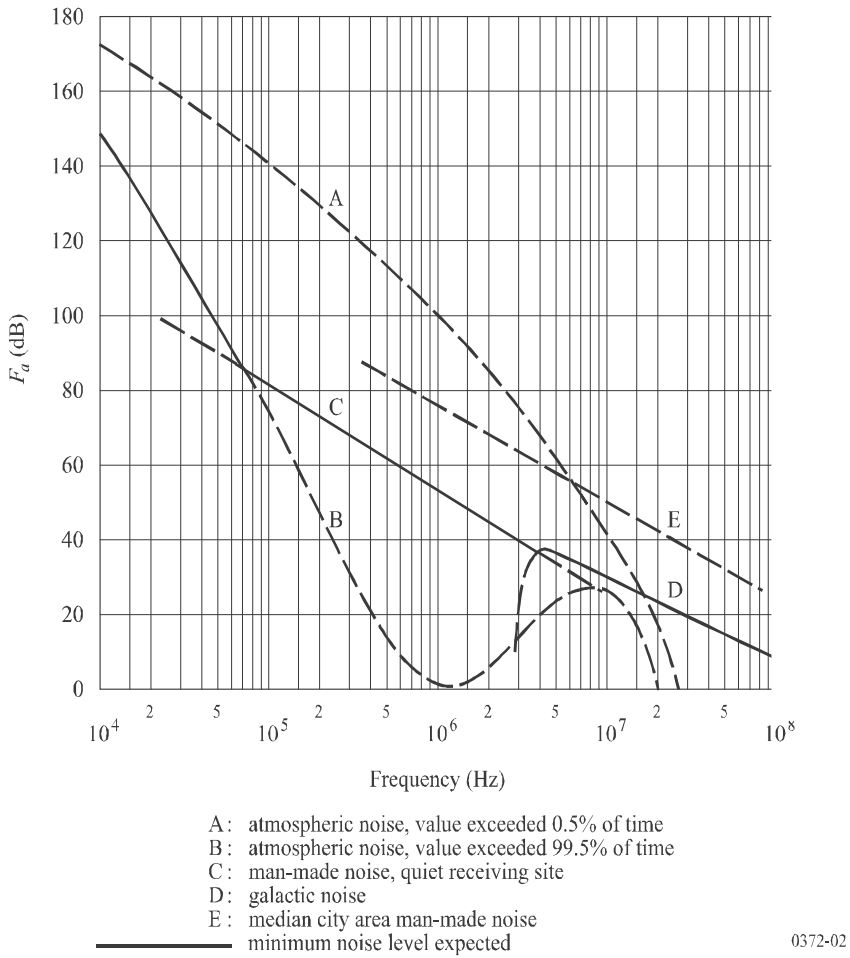




Advanced Signal Processing

- Goal is to enable smaller systems to detect more sources with better geolocation accuracy
- Exploit HF propagation physics in new ways
  - Understanding of noise has evolved significantly
  - Potentially applicable signal processing approaches have been developed
- Focus on:
  - Advanced noise suppression techniques
  - Efficient utilization of small arrays
- Performers will be provided GFI measured and simulated data

Signal Processing & HF Noise



- Many noise sources are structured
  - Directional
  - Temporal
  - Polarimetric
- Algorithms potentially enable “below noise” reception
  - Leverage noise and signal structure differences

Figure is from ITU P 372-10

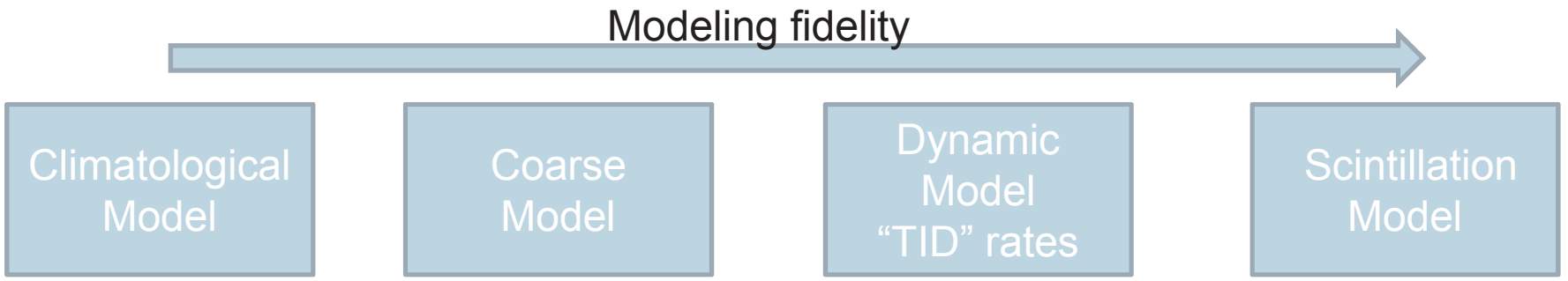
Other Signal Processing

- Small-array processing techniques
  - Localization with small HF arrays
  - Propagation mode isolation (e.g. mode super-resolution)
  - Combined with short temporal data segments
    - Critical for frequency hopping / spread spectrum sources
    - Limited sample sizes are below thresholds of many current techniques

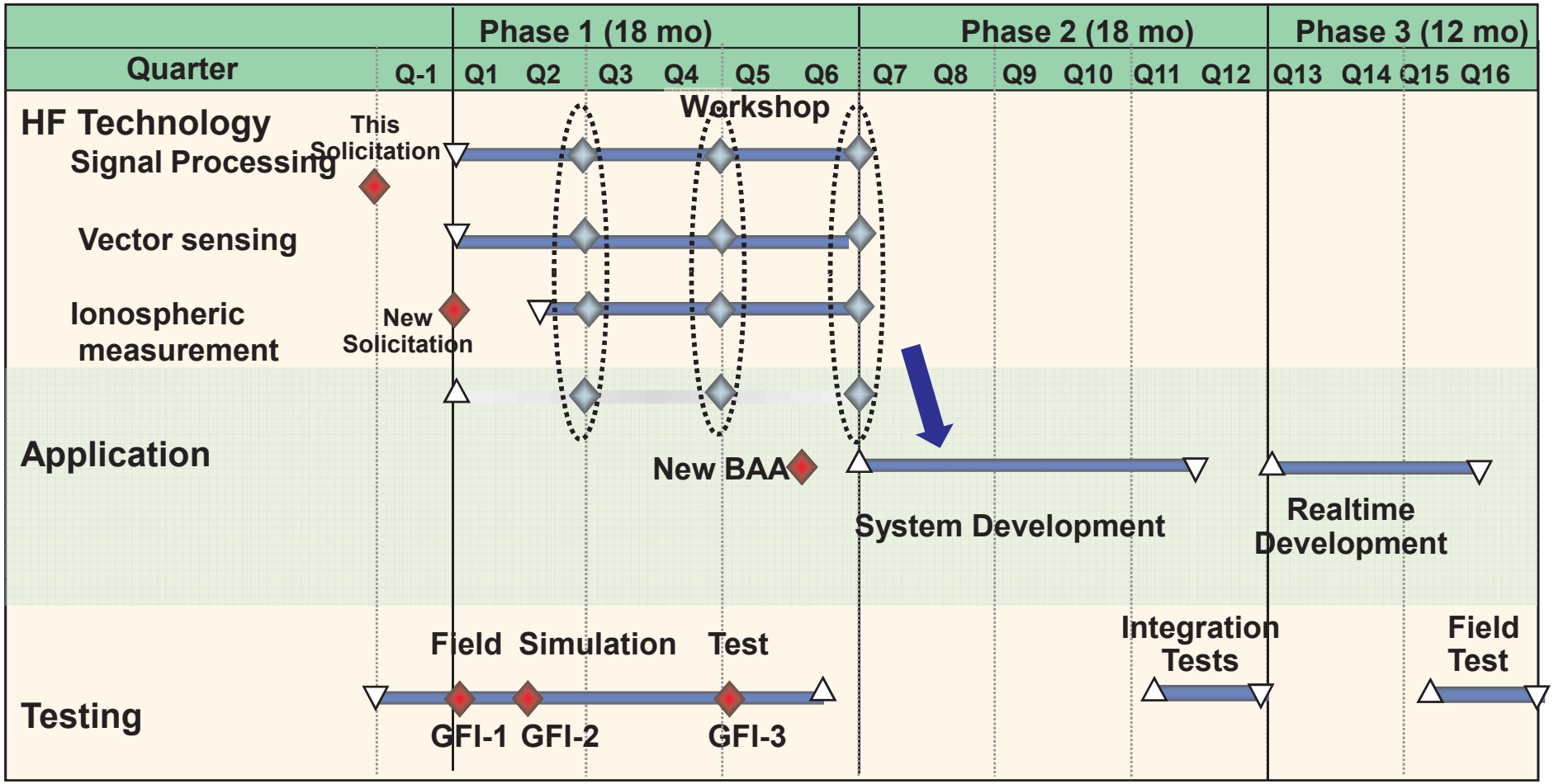
- Novel single-site signal detection and geolocation approaches
  - Novel/waveform-matched integration, demodulation and/or detection
  - Matched field multi-mode TDOA/FDOA/multi-lateration processing
  - Higher-dimensional cyclostationary processing

Ionospheric Measurement & Modeling

- Ionospheric understanding is required:
  - For accurate geolocation
  - For HF SkyWave, an ionospheric bottom-side profile is required
- Several measurement sources could enhance performance
- We don't currently know the ionospheric measurement limits/requirements
  - Ionosphere changes minute-to-minute & on TBD scale
  - Prior published studies were for long-range oblique paths, did not exploit polarized elements
  - Prior published studies discussed distance for coherence, not for angle-of-arrival
  - More accuracy is now desired



Schedule Overview



Sensor Technical Metrics (revised)

Parameter	Phase 1	Program Objective	
Angle-of-arrival accuracy	0.8 deg @ 30 dB SNR	0.1 deg @ 30 dB SNR	Accuracy of peak response. Includes cal. error.
Noise figure	<20 dB @8 MHz	<15 dB @ 20-30 MHz <20 dB @ 8-20 MHz <25 dB @ 3-8 MHz	1dB cable loss and receiver with 8dB NF
Operating Bandwidth	5-10 MHz	3-30 MHz	Instantaneous bandwidth (not tunable)
Gain	>-5 dBi	>0 dBi center band >-5 dBi 5-30MHz >-10dBi 3-5 MHz	Min. over 2π SR. Sum of all signals
Polarization sensing	Fully polarimetric	Fully polarimetric	
Polarization isolation	>20 dB	>30 dB	Two spatially orthogonal linear sources
Footprint	Single element	< 40 m in any dimension <15 m height	Smaller footprints desirable

Sensor Definitions and expected tests

- (standard definition) Polarization isolation is the difference in dB of received signal level between signals transmitted at primary and orthogonal polarization from a line-of-sight transmitter.

- Sensor test method: sensor set up in field. Line-of sight airborne source used as source signal.

- GFE receivers will be available if needed

Signal Processing Technical Metrics

Parameter	Phase 1 specification	Program Objective	
Signal Isolation*	40dB	60dB	Averaged over 5 minute period
Angle estimation	CRB + 5dB @ > 20 dB SNR	CRB+3dB @ > 20 dB SNR	CRB= Cramer Rao Bound
Detection threshold extension	10dB	15dB	New methods to enhance detection SNR for subsequent geolocation with particular signals

- * Signal Isolation defined as improvement in output SIgnal-to-Noise and Distortion (SINAD) over best single element SINAD for the following test cases:
  - A. Mode isolation case. Two strong temporally-coded sources, ionospherically propagated differing in ground distance. Stable mid-afternoon ionosphere verified through sounding and channel response characterization.
  - B. Source and lightning case. Temporally-coded source for desired signal. Local lightning interference.
  - C. Skywave and local source isolation case. Strong ionospherically-propagated source. Up to four spatially distributed local sources

During Phase 1, signal processing will be off-line with planning for later real-time operation

Ionospheric Technical Metrics

Parameter	Phase 1 specification	Phase 2	
Update rate			
Spatial sampling			
Layer heights			
Tilt			

- Unable to specify requirements at this time…
- Stay tuned for Phase 1B solicitation

Phase 1A: This Solicitation

- Innovative HF sensors
  - Develop and deliver prototype HF sensor element that can precisely determine angles-of-arrival of impinging signals (azimuth and elevation)
  - Demonstrate separation of multiple signals:
  - Demonstrate “small” single element footprint

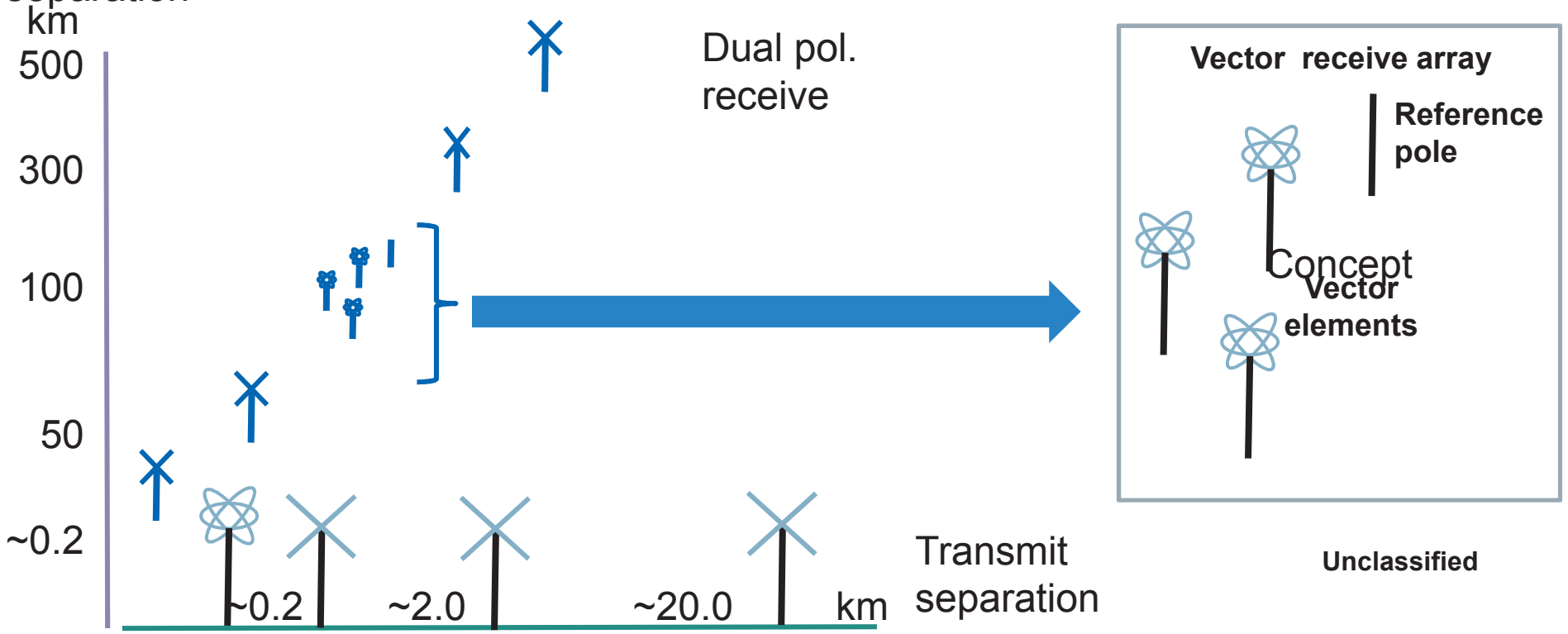
- Advanced signal processing techniques
  - Demonstrate small HF array signal selection enabling “below noise” reception using simulated and measured GFI data
  - Demonstrate propagation mode isolation (e.g. mode super-resolution) using simulated and measured GFI data
  - Derive system requirements for Phase 2

Phase 1 Data and Testing

- Performers will be provided GFI simulated & experimental data from initial data collection

- An experimental data collection & test will be planned later in Phase I
  - Data will allow for verification of results
  - Performers will have inputs into the experimental plan

Initial Data Collection Concept



- Goals:
  - Ionospheric temporal/spatial/polarization physics
  - Environmental background noise data
  - Vector antenna array data

Not in Scope

- Digital receiver development
- Line-of-sight methods of geolocation

Phase 1B: Future Solicitation

- Measurements will help to inform modeling expectations for:
  - Update rate
  - Spatial sampling
  - Layer heights
  - Tilt
  - Receive system and ionosonde requirements
- Anticipating possible solicitation early in Phase 1

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Preview of Phases 2-3

- Performance metrics will be determined based on the projected results of Phase 1
- System specifications will likely include parameters similar to the following
  - Geolocation accuracy at various ranges
  - Environmental conditions
    - Ionospheric conditions
    - Noise environment
  - Signal parameters
    - Modulation types
    - Signal duration
- Based on results of Phase 1, a new solicitation may be issued for Phase 2-3

Eligibility Information

- Other Government Agencies, Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), and any other similar type of organization that has a special relationship with the Government, that gives them access to privileged and/or proprietary information or access to Government equipment or real property, are not eligible to submit proposals under this BAA or participate as team members under proposals submitted by eligible entities
- Non-US organizations and individuals may be able to participate.
  - Must comply with Non-Disclosure Agreements, Security Regulations, Export Control Laws, etc. as appropriate
  - Specific guidance for non-US participation will be provided in the BAA

Proposal Guidance

- Your proposal should include a full discussion of the technical approach that will be used to meet the program goals.

- Programmatic issues to be addressed in the proposal:
  - Your team's current technical capabilities
  - Key resources needed (not currently available to your team), to include capital equipment and special expertise. The risk in acquiring these key resources, and mitigation strategies, should be indicated as well
  - A teaming plan along with the roles and responsibilities of each member of the research team
  - End of phase and some intermediate milestones are set, but it is expected that other intermediate milestones that are on the critical path of the proposed approach will be offered
  - A schedule of all milestones including a clearly charted description of the various risk mitigation strategies that will be undertaken to achieve program goals

Proposal Evaluation Criteria

- Overall Scientific and Technical Merit
- Effectiveness of Proposed Work Plan
- Relevance to IARPA Mission and HFGeo Program Goals
- Relevant Experience and Expertise
- Cost Realism

Evaluation criteria will appear in the BAA.

Security and Publication

- Phase 1, Enabling Technology development will be unclassified
- Security classification of later phases is to be determined
- US ITAR regulations may apply to work proposed for this program. IARPA is unable to waive compliance with ITAR regulations. If proposed work falls under ITAR it is the proposer's responsibility to ensure compliance.
- There is the possibility that some research results from this Program may require a pre-publication review if it is determined that the release of such information may result in the disclosure of sensitive information. Any award resulting from such a determination may include a requirement to obtain IARPA's permission before publishing any information on the research. A determination will be made based on the proposed work and any necessary provisions will be reflected in contract negotiations.

Additional Information

- Email dni-iarpa-baa-11-07@ugov.gov with additional questions
- HFGeo BAA will be posted on FedBizOpps website (www.fedbizopps.gov) and then noted on www.iarpa.gov
- Q&As will appear after the BAA is posted. See http://www.iarpa.gov/solicitations_hfgeo.html

Questions?