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USA

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Greetings all,

Please confirm Open Research Institute's interest in the futureGEO project.

Please find attached:

1. A short Draft Proposal (maximum of 2 pages) outlining:
  - a) The organization's potential contribution to futureGEO.
  - b) Lessons learned from previous missions such as QO-100 or others.
  - c) Ideas for specific payload elements, experiments, technologies, or educational outreach.

2. Indication of involvement in the upcoming Workshop:

- a) The first futureGEO Workshop will be held on 19 September 2025, during the AMSAT-DL Symposium and Bochumer Weltraumtage (19–21 September) at the Bochum Observatory, Germany:

Yes, in person

- b) Please indicate if you are interested in giving a presentation and/or contributing to technical and strategic discussions:

Yes

3. Forum Participation:

- a) Would your organization like to take an active role in the futureGEO online forum for ongoing collaboration and idea exchange? The forum will be accessible at <https://forum.amsat-dl.org> for registered users in a closed area.

Yes

4. Contact Details:

- a) Please include the name, email, institutional affiliation, and mailing address of your primary contact person.

Michelle Thompson CEO ORI

Direct: [abraxas3d@openresearch.institute](mailto:abraxas3d@openresearch.institute)

Include Board of Directors: [board@lists.openresearch.institute](mailto:board@lists.openresearch.institute)

Include executive leadership: [ori@openresearch.institute](mailto:ori@openresearch.institute)

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Here are Open Research Institute's answers to the questionnaire kindly sent 21 May 2025.

## Organization Overview

Open Research Institute (ORI) is a US 501(c)(3) non-profit organization dedicated to advancing open source digital radio space and terrestrial communication systems.

Founded to democratize access to advanced communication technologies, ORI has established itself as a leader in technical and regulatory open source digital radio development. We are the organization that obtained clarity for public domain communications satellite work being free of ITAR and EAR. Details can be found at <https://github.com/OpenResearchInstitute/documents/tree/master/Regulatory> in the ITAR\_EAR folder.

## 1. Primary Area of Expertise

Open Research Institute's primary expertise lies in open source digital signal processing and software-defined radio systems for space communications. Our core competencies include the following.

**Digital Communication Protocol Development:** Design and implementation of modern, efficient protocols optimized for satellite and terrestrial environments. Work in all projects and categories can be found at <https://github.com/OpenResearchInstitute>

**Modem Architecture:** Our modem module approach implements useful modularity for FPGA digital communications design. All of the components are available free to the general public at no charge from ORI GitHub. Modularity is achieved through combining the building block repositories as submodules in an integrated design. Please see [https://github.com/OpenResearchInstitute/pluto\\_msk](https://github.com/OpenResearchInstitute/pluto_msk) for one example of an integrated modem module design for minimum shift keying.

**Open Source Hardware/Software Integration:** Creating complete, reproducible communication systems with full design transparency.

**Microwave Systems:** Development of high-frequency communication solutions for next-

generation satellite applications means microwave. The vast majority of our work is microwave or above.

Educational Technology Transfer: Bridging the gap between cutting-edge research and practical amateur radio implementation is our core mission.

## 2. Previous Work Experience

The volunteers at ORI have extensive experience in all of the areas in the questionnaire.

### a) Hardware and Software Development - Extensive Experience

- Complete open source transceiver designs from baseband to RF
- FPGA-based digital signal processing implementations
- Microcontroller and embedded Linux system development
- Multiple payloads in orbit in amateur and commercial settings

### b) Transponder Development and Design - Significant Experience

- Phase 4 Ground transponder development and testing (Interlocutor, Postlocutor, and Locutus projects)
- Regenerative transponder architecture design (Haifuraiya project)
- DVB-S2/S2X downlink implementation and optimization
- Opulent Voice uplink protocol implementation and optimization

### c) Software Defined Radio (SDR) Systems - Core Expertise

- GNU Radio flowgraph development and optimization
- Custom SDR hardware design and implementation
- Real-time signal processing algorithm development
- Multi-platform SDR software architecture (Linux, Windows, embedded)

### d) High Frequency (HF), VHF/UHF, and Microwave RF Design - Advanced Capabilities

- 10 GHz amateur band transverter design and implementation (phae 4 ground)
- 5/10 GHz dual band feed design published, implemented, and tested
- 24 GHz and higher frequency system development
- 10/24 GHz dual band feed design published, implemented, and tested
- Phase-locked loop and frequency synthesis systems experience
- Opulent Voice at VHF/UHF has flown twice with the RockSat-X NASA program.
- High radiation resistance HF antenna design (Dumbbell project)

### e) Antenna Design - Comprehensive Experience

- Dish antenna optimization for EVE communications for DSES (photogrammetry for RMS results)
- Phased array antenna system development (Kerberos at 915 MHz, 5 GHz patch)
- Feed horn design for microwave applications (5/10 and 10/24)
- Antenna modeling and simulation using industry-standard tools (Dumbbell project)

f) Launched Satellite Missions - Active Participation

- Successful collaboration with multiple CubeSat missions including ORSAT, CATSAT, and FOX.
- Commercial launched satellite experience by ORI members includes Globalstar, Viasat, L3 Harris, Millenium Space Systems, Velastra and others.
- Technical advisory roles for multiple satellite communication systems since 2019.

g) Ground Stations or Networked Reception Systems

- We have experience with SatNogs and Globalstar Ground Stations.
- We have experience with IS-95, 4G LTE, 5G NTN, and several other networked, mesh, and ad-hoc receiver systems.

h) Link Budget Planning and Simulation Professional Capability

- Advanced link budget modeling software development through MATLAB and Python Jupyter Notebooks.
- Statistical analysis of satellite communication performance achieved by understanding the modeling and simulation environment, and performing those functions through MATLAB and Python Jupyter Notebooks
- Real-world validation and correlation with operational systems has been achieved by ORI volunteers (multiple commercial project experiences, Remote Labs testing, and the ongoing EVE project)

### 3. Resources and Capabilities ORI Can Contribute

a) Laboratories and Test Facilities: Available through ORI Remote Labs

- Digital signal processing development (FPGA-centric) provided by Remote Lab West ([https://github.com/OpenResearchInstitute/documents/tree/master/Remote\\_Labs](https://github.com/OpenResearchInstitute/documents/tree/master/Remote_Labs))
- Antenna test ranges and measurement facilities are available to us in San Diego, CA through volunteer-provided resources

b) Environmental Testing Facilities: Limited Direct Access

- Collaborative arrangements with local university testing facilities
- Industry partnerships potentially possible for thermal-vacuum testing
- Vibration testing through aerospace industry contacts
- EMC/EMI testing facility access (not free to us, but available at a discount)

c) Ground Stations: In Development

- Ground station design is Interlocutor (<https://github.com/OpenResearchInstitute/interlocutor>)

d) Hardware and Software Development Tools: Professional-Grade Capabilities

- FPGA development tools (Xilinx Vivado full license, MATLAB full license, zc706, zcu102, PLUTO SDR, SR-1)
- RF simulation software (all MATLAB toolboxes available)
- Software development infrastructure (Remote Lab West CHONC virtual machines provide any OS connected to any test equipment or development platform we have)
- 3D printing and mechanical prototyping capabilities (on-site 3D printers, CNC, Voltera circuit

printer, and lathe)

e) Students and Educational Resources: Academic Partnerships

- University collaborations for student development (University of Puerto Rico)
- Graduate student research projects (Northwestern University, San Diego State University)
- Educational curriculum development (in progress)
- Training workshops and technical conferences (offered throughout the year)

#### 4. Legal Status and Public Presence

a) Legal Status: Registered 501(c)(3) Non-Profit Organization

- California-headquartered charitable organization
- Federal tax-exempt status
- Board of directors governance structure
- Transparent financial reporting and accountability
- Ethical operation is the highest priority and this is ensured through an enforced code of conduct and developer and participant policies that clearly communicate how and why ORI is a safe place to volunteer

b) Public Presence: Comprehensive Digital Presence:

- Website is <https://openresearch.institute>
- Active Twitter (X), LinkedIn, FaceBook, YouTube channels
- Technical Forums: include GitHub repositories and issue trackers, mailing lists, Slack workspace
- Documentation: Extensive technical and project documentation on GitHub and on the website
- Publications: Regular conference presentations are made. Technical papers generally published through ARRL QEX. At least four articles will be in QEX for 2025. ORI publishes a newsletter roughly monthly called The Inner Circle. Archive available <https://www.openresearch.institute/newsletter-subscription/>

#### 5. Space Agency Collaboration Experience

- NASA: Advised NASA on open source communications satellite regulatory relief. ORI has repeatedly inquired about opportunities. We applied for two NASA SBIR grants and made the final round for one of them. NASA seems devoted to commercial crew, and has very limited attention for amateur radio in space outside of astronauts on the ISS communicating with students at school-based events.
- Commercial Space: We were heavily involved with the Millennium Space Systems Phase 4B payload development. Many volunteers have professional commercial space backgrounds at a variety of companies.
- International Amateur Satellite Organizations: working with Libre Space Foundation, Open Source Satellites (UK), IARU, JAMSAT, AMSAT-CANADA (defunct), AMSAT-UK and AMSAT-DL have all been very good collaborative experiences.
- Academic Institutions: University research partnerships with space programs at University of Puerto Rico, Portland State University, University of Arizona, and Virginia Tech.

- Industry: Formal technical advisory role at Velastra.

Note: While ORI has not previously worked directly with ESA, our technical leadership has extensive European connections and we actively seek international collaboration opportunities. Our volunteers come from all over the world and our first regulatory task was to certify that open source communications satellite work was free of ITAR and EAR. This was done in order to restore international amateur radio satellite collaboration.

## 6. Technical, Educational, and Scientific Goals for futureGEO

### Primary Technical Objectives

#### 1. Open Source Payload Architecture Development

- Design and implement a fully open source software-defined payload architecture
- Create modular, reconfigurable communication systems that can be updated in-orbit
- Develop standardized APIs enabling third-party application development
- Demonstrate containerized applications running on space-qualified Linux systems

#### 2. Next-Generation Protocol Implementation

- Our goal here would be to offer and optimize Opulent Voice, a modern digital communication protocol, for GEO satellite environments. Opulent Voice delivers high-fidelity voice at 16 kbps with integrated voice, text, control, and data communications using standard Internet protocols (TCP, IP, UDP, RTP). The voice quality is substantially higher than anything in amateur radio at this time.
- Implement adaptive coding and modulation based on real-time link conditions, using machine learning if necessary.
- Create seamless integration between amateur and professional communication standards and advance the radio arts whenever and wherever we can.

#### 3. Ground Segment Democratization

- Design cost-effective, open hardware ground station solutions such as Interlocutor. Interlocutor is deployed on a Raspberry Pi and delivers Opulent Voice protocol frames over Ethernet to an SDR, computer, or any other device that can understand Ethernet. This allows remote operation and the use of a very broad class of modems and computers.
- Require the user interface to be accessible to people with visual, hearing, mobility, and cognitive challenges
- Develop software packages enabling existing amateur equipment to access new payload capabilities
- Implement cloud-based ground station networks for global access (enabled by our Ethernet interface)

### Educational Mission Goals

#### 1. STEM Education Enhancement

- Provide remote access to advanced ground stations for personal and professional development through open source work. ORI already provides very similar access to development stations

through Remote Labs. The test benches are available 24 hours a day 7 days a week. When Interlocutor ground stations are added to Remote Labs, then this will indeed provide remote access to a functional ground station.

- We help train the next generation of space communication engineers through the carrying out of frameworks such as developed through the IEEE IWRC process. ORI was a participant in IWRC 2023 and carries forward the aims and purposes of personal and professional development through open source project involvement.

## 2. Knowledge Transfer and Documentation

- We publish all designs, software, and documentation under open source licenses approved by the Open Source Initiative. All of our work has always been available to the general public at no cost through our GitHub website.
- Continue to create detailed technical tutorials and educational materials. Please see our github and youtube channels for examples.
- Continue to establish mentorship partnerships that connect students with industry professionals
- Continue to document lessons learned for future mission development

## Scientific Research Objectives

### 1. Advanced Communication Research

- Continue to investigate AI/ML applications in satellite communication optimization. Our article on AI/ML RTTY communications receivers will be in QEX soon, and we expect to produce more work in this area. We know how to use machine learning in the radio frequency environment and look for opportunities to demonstrate successfully application of this particular technology.
- Research adaptive beamforming and interference mitigation techniques.
- Study propagation characteristics at millimeter wave frequencies.
- Continue to develop new modulation and coding schemes optimized for satellite channels, such as Opulent Voice.

### 2. Technology Demonstration

- We believe "it doesn't work until it is shown to be working over the air". This guiding principle is how we carry out our work.
- Prove feasibility of commercial-grade open source space systems.
- Demonstrate cost-effective approaches to advanced satellite payloads.
- Validate open development methodologies for space applications.
- Create reference implementations for future amateur satellite missions.

## Long-Term Vision

ORI sees futureGEO as a crucial stepping stone toward a future where advanced satellite digital communication capabilities are accessible to educators, researchers, and amateur radio operators worldwide. Our goal is to help create a sustainable, open ecosystem that continues to evolve and serve the global amateur radio community for decades to come.

ORI is committed to making futureGEO a technical success that demonstrates the power of open

source development while advancing the state of the art in amateur satellite communications. We bring unique technical capabilities, educational mission alignment, and a proven track record of delivering complex open source communication systems.

Anshul Makkar, Director ORI

Keith Wheeler, Secretary ORI

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Matthew Wishek, Director ORI