Rent-a-GEO

Phase 4 Space

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Abstract

An opportunity to rent communications capacity on a Geosynchronous satellite has been offered to Open Research Institute. The rate is $2000 a month on EchoStar 9 for the remaining 4* years of service life for 1MHz of bandwidth.

This rental enables advanced digital communications research and development for amateur radio while also increasing emergency communications coverage for the continental United States, parts of Canada, and parts of Mexico.

The motivation for this proposal is to advance the amateur radio arts and to improve emergency communications capability in the radio amateur satellite service.
The problem directly addressed by this proposal is the lack of geosynchronous amateur radio research and development options for the continental United States, Canada, and Mexico. This rental provides a reliable test bed with a cooperative supplier using current satellite technology. Renting the capacity and building ground stations that use a real link to a real spacecraft will produce enormous open source hardware and software results.

The approach in this proposal is divided into phases.

Uplink Development Phases

First, contract to rent capacity for the remaining years of the satellite's service life.
Second, build uplink stations in close cooperation with the satellite operator. These stations will use hardware approved by the operator. Some of the uplink hardware and software will be proprietary.
Third, use the uplink station design to build Amateur Radio Access Points (ARAPs). See the System Block Diagram chapter for an overview of uplink, downlink, and ARAP architecture.

ARAPs are portable and flexible digital devices. They aggregate any amateur band that they are configured to receive. They prepare the collected amateur radio signals for digital retransmission. In this case, a satellite uplink. ARAPs are open source hardware and software. Once this third phase equipment is tested and functional, ARAPs will available for for integration into emergency communications systems and educational institutions. They will be available for general amateur use within the ARAP footprint.

This fourth phase involves a large commitment to communicate with a wide variety of institutions and organizations. Open Research Institute commits to this process.

Downlink Development Phases

First, rent capacity for the remaining years of the satellites's service life.
Second, design, build, and test the individual receiving stations that anyone can use to receive the traffic on the capacity rented. Stations must comply with the downlink protocol. Since this is DVB-S2/X, all work leverages Phase 4 Ground research and development. This proposal greatly benefits from and contributes towards the success of the Phase 4 Ground project.
Third, distribute the designs and support those that build and use them. This phase involves a large commitment to communication with a wide variety of receiving stations. Open Research Institute commits to this process.

No internet access is required for this communications system to work. While traffic can and should be streamed over the internet, successful communications does not depend upon the internet being operational. This is a fundamental requirement of a resilient emergency communications resource.

ARAPs must be portable so that they can be moved to a new location quickly and easily.

All results from this program will be published with one exception. We expect that some of the required hardware from the satellite operator must remain proprietary. This is expected to be certain details of the uplink modem.

Two major types of results are expected.

First, operational best practices learned while using a geosynchronous satellite in an amateur radio context. Commercial use and amateur use have significant differences. Results and reports and best practices will greatly help the radio amateur satellite service in efforts to achieve higher earth orbits. Knowing best communication practices before designing a dedicated amateur radio payload will improve the likelihood of successful missions. These results from direct operational experience with a digital payload are expected to be used internationally.

Second, a large amount of open source hardware and software designs, test results, and code is expected to be published as it is created. This is also expected to be used internationally for the advancement of the radio arts. The heart of this system is a high performance reconfigurable polyphase filter bank. This is a powerful, portable, and re-usable design. It has inherent modularity and flexibility and lends itself to machine learning, cognitive radio, and offers an opportunity for practical application of adaptive channel width protocols.

The implications of this project are significant. They are in line with Phase 4 Ground and Phase 4 Space, Virginia Tech's Phase 4B, and ARISS AREx Lunar Gateway. Moving to higher amateur radio orbits will be much easier and more successful if the results of this project are accessible to the general public.

This project is proposed and managed by Open Research Institute. All are welcome to participate in this project, as long as they abide by the developer and participant policies and the Open Research Institute code of conduct.

All of these policies can be found on the Open Research Institute website. Open Research Institute is a 501(c)(3) dedicated to open source research and development for amateur radio.

Research Questions

Some starting points for academic research include but are not limited to the following.

1) What operational best practices should amateur operators use for digital geosynchronous satellites? The lessons learned from QO-100 are built upon and expanded with this project.

2) What station designs for amateur receiving stations for geosynchronous microwave band communications can be recommended based on the technical results achieved with this opportunity?

3) What are the trade-offs between simplicity, capability, and portability in an amateur radio context using the advanced techniques proposed in this project? There are fundamental differences between commercial and amateur communications and equipment. This project allows for a formal study of communications metrics and modes.

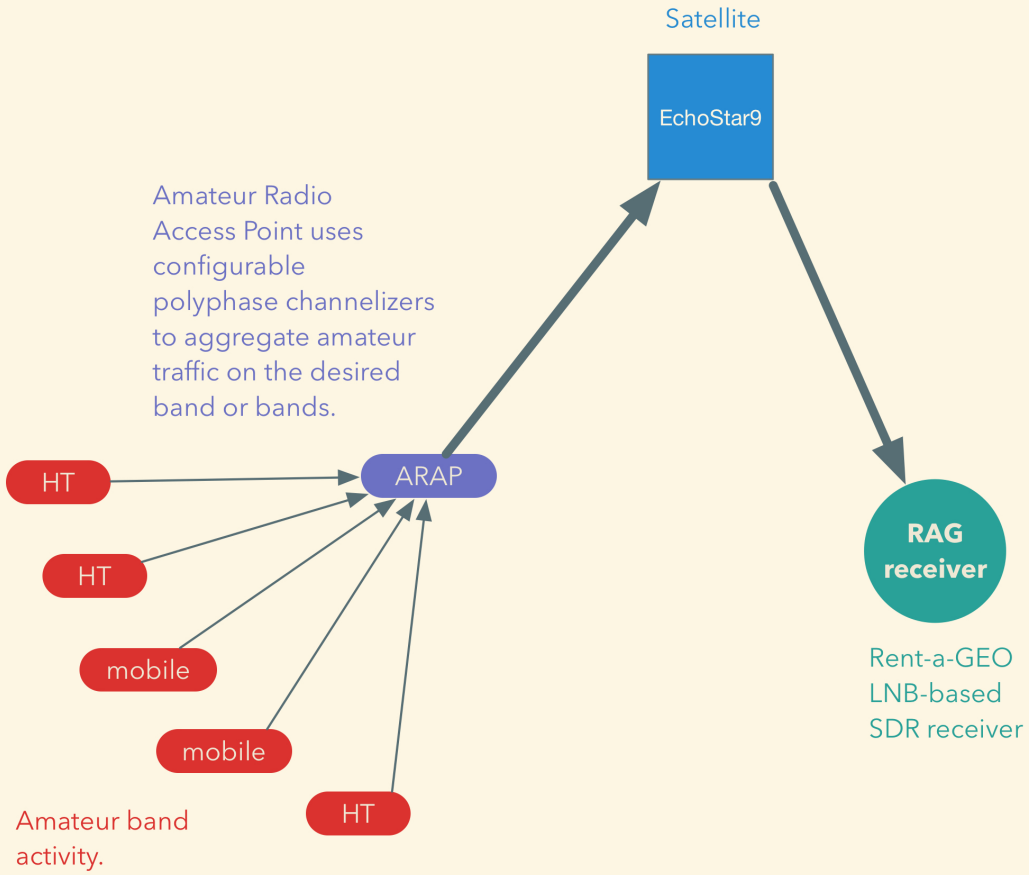
4) What are the advantages gained by machine learning, cognitive radio, and adaptive polyphase filter bank architectures in the amateur context?

System Block Diagram

Rent-a-GEO Frequencies

ARAP Receive	ARAP Uplink	EchoStar 9 Downlink
Configurable!	Defined upon rental	~12GHz, defined upon rental

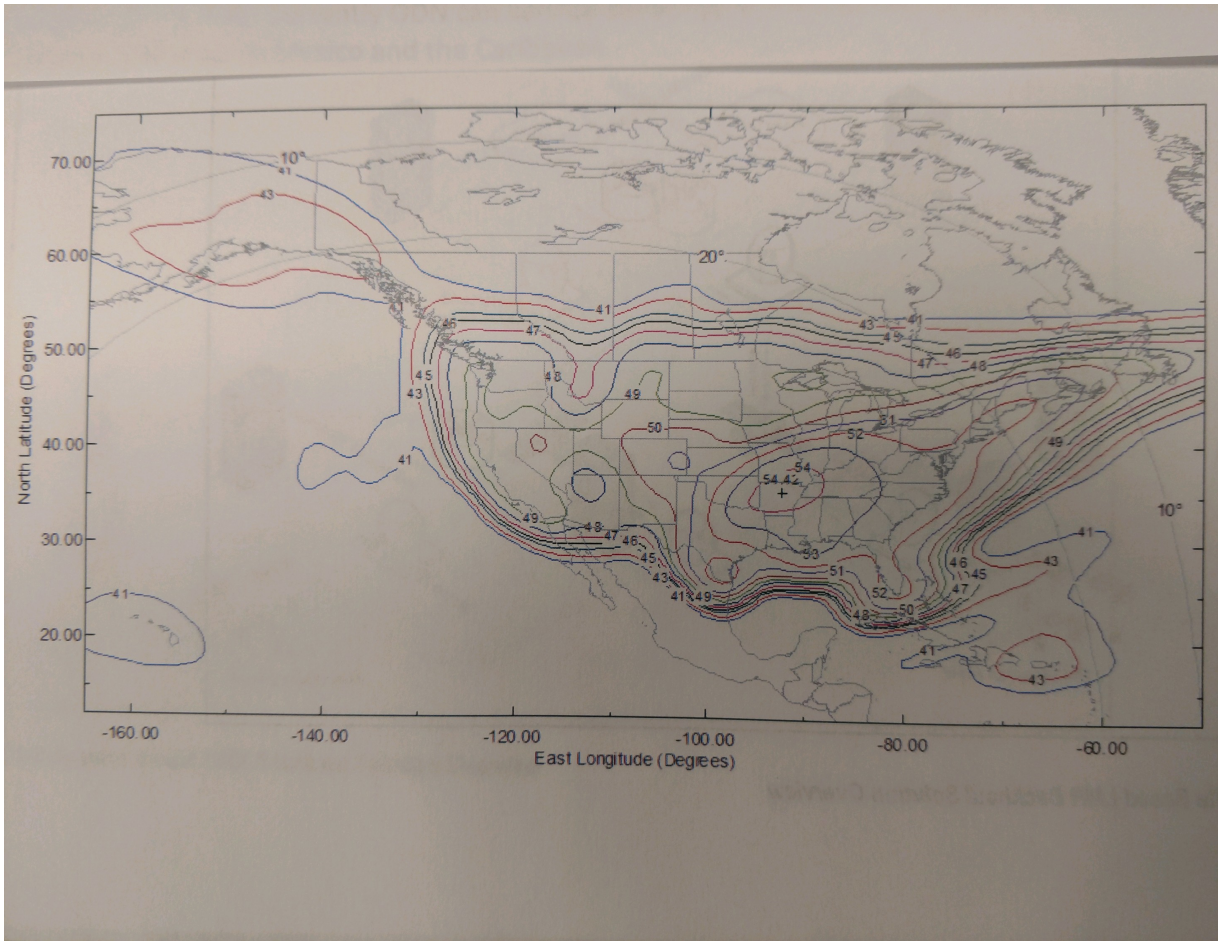
Rent-a-GEO System Block Diagram

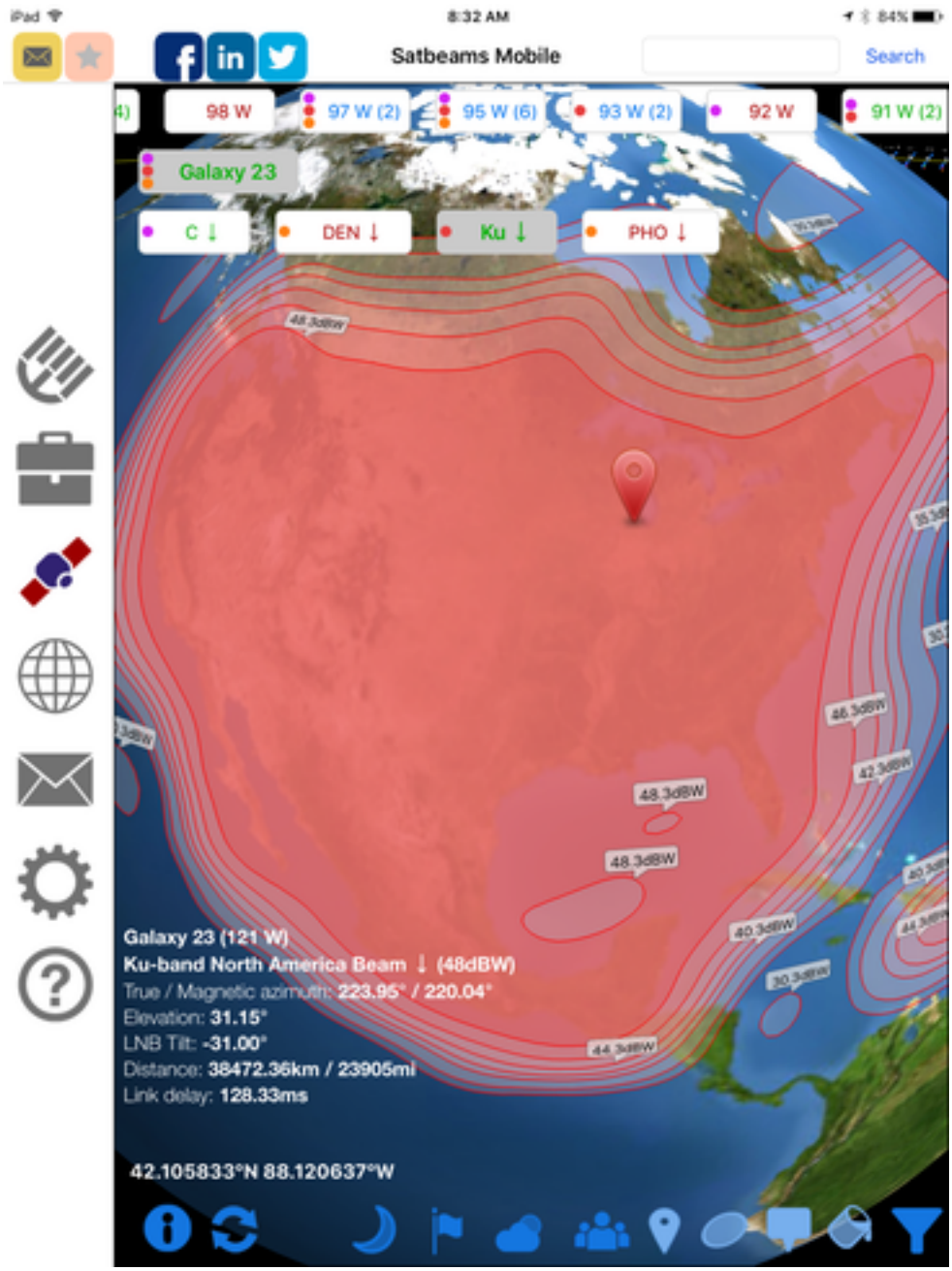


Document Info Block

TITLE	CREATED BY	VERSION	DATE
rent-a-geo-system-block-diagram	Michelle Thompson http://johnscullen.com	1.1	Sep 28, 2019

Footprint of EchoStar 9

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48.3dBW
42.3dBW
40.3dBW
44.3dBW
Galaxy 23 (121 W)
Ku-band North America Beam ↓ (48dBW)
True / Magnetic azimuth: 223.95° / 220.04°
Elevation: 31.15°
LNB Tilt: -31.00°
Distance: 38472.36km / 23905mi
Link delay: 128.33ms
42.105833°N 88.120637°W

Work Plan

June 2020

1. Proposal re-submitted
2. Authors available for questions

If Funding Proposal Successful, Work Commences

1. Pay for satellite capacity. If contract cannot be negotiated for any reason, all funds immediately returned.
2. Test satellite capacity and satellite link characteristics. Publish results.
3. Build and test uplink earth station. Publish all non-proprietary results.
4. Design, build, and publish a working receiver reference design in GNU Radio and make it available for deployment to amateur SDR equipment.
5. Build and test Amateur Radio Access Point. Publish all results.
6. Commence and continue recursive feedback-redesign loop for receiver function, user experience, and user interface. Publish results.
7. Publish final report upon end of service life of the satellite.

Budget

Line Item	Amount
Satellite capacity rental $2000 a month for 48 months*.	$96,000
Earth station prototype build, development. RF compliance testing with vendor.	$5,000
ARAP station development, prototype build quantity of at least 5 units.	$25,000
GNU Radio reference design development, one floating Vivado licenses for RFNoC.	$4,295
GNU Radio reference design development, DVB-S2/X compliance test equipment.	$8000
Total	$138,295

*This proposal was originally circulated and published on the Open Research Website in October 2019. Costs have decreased due to the steadily decreasing number of months available between now and end of life of EchoStar 9.