Subject	**Amateur Transponders on Geosynchronous and Geostationary Satellites**		
Society	**RSGB**	Country:	**United Kingdom**
Committee	**C5**	Paper Number	**LA17_C5_14**
Author	**Trevor Hawkins M5AKA**		

1. Introduction

Orbiting Satellites Carrying Amateur Radio "OSCARs" have existed for more than 55 years but there have not, up to now, been any that have been deployed into circular high earth orbits. These are often referred to as Phase 4 spacecraft. Information on two exciting opportunities is provided.

2. Background

Orbital Characteristics

- **Geosynchronous Orbit:** A geosynchronous orbit (GSO) is an orbit around the Earth with an orbital period of one sidereal day, intentionally matching the Earth's sidereal rotation period (approximately 23 hours 56 minutes and 4 seconds). This synchronization of rotation and orbital period means that, for an observer on the surface of the Earth, an object in geosynchronous orbit returns to exactly the same position in the sky after a period of one sidereal day. While it can provide coverage of more than 1/3rd of the globe it is not 24-hour continuous coverage. Some tracking will be required, but even a fixed dish antenna will provide coverage for many hours a day.

- **Geostationary Orbit:** This is a particular type of geosynchronous orbit, a circular orbit 35,786 kilometres inclined above the Earth's equator and following the direction of the Earth's rotation. A satellite in this orbit appears to ground observers to be motionless at a fixed position in the sky. A satellite in geostationary orbit can provide communications across more than 1/3rd of the globe. For example, a satellite at 25.5 degrees east could link countries as far apart as Brazil and Thailand.

Signal Delay

For a satellite in geostationary orbit there will be a round-trip signal delay of between 240 and 280 milliseconds depending on the ground station location within the coverage area. Additional delays will arise from any digital signal processing within the satellite.

Frequency considerations

A limiting factor on hosted payloads is the amount of room available on the Earth facing side of the satellite for mounting amateur radio antennas. There is unlikely to be sufficient space for antennas in the 1 260 MHz and lower frequency bands. Additionally, the maximum size of antenna on the satellite is restricted by the desire to illuminate all the visible diameter of the

Earth.

Meeting these physical constraints necessitates the use of frequencies between 2 - 12 GHz for both the uplink and downlink. There are Amateur-satellite Service allocations in this part of the spectrum at 2.4, 5 and 10,45 GHz.

The high noise floor on both 2,4 GHz and 5 GHz in urban areas from the large number of Wi-Fi and other licence exempt devices presents severe challenges to receiving satellite downlinks in cities. The weak signal from the satellite might be significantly below the noise floor.

The problem of Wi-Fi interference was highlighted by the Digital ATV transmitter on the International Space Station – HamTV. It had originally been planned to operate in the 2,40 – 2,45 GHz Amateur-satellite Service allocation but the interference level made it impossible for ground stations to receive the signal and an alternate frequency had to be used.

With the increasing usage of the 5 GHz spectrum for terrestrial use, the 10,45 – 10,50 GHz allocation appears to be the most suitable for the reception of satellite downlinks in urban areas.

Deployment options

The high cost, considerably more than $30 million, of launching a satellite to geostationary or geosynchronous orbit is beyond the scope of the amateur community. An alternative approach is for an amateur payload to be hosted on a commercial or governmental satellite. These satellites generally have an abundance of solar power available, which can enable the use of higher power transponders than are traditionally used in amateur satellites.

The amateur community is fortunate in to have the opportunity for amateur radio payloads on Qatar's geostationary satellite Es'Hail 2 and a geosynchronous satellite being built by Millennium Space Systems in California.

3. Es'hail 2 Geostationary Opportunity

Qatar's Es'hail 2 satellite is planned to launch in 2018 into a geostationary slot at 25,5 degrees East. It will carry two "Phase 4" amateur radio transponders operating in the 2,4 GHz and 10,45 GHz bands.

- A 250-kHz bandwidth linear transponder intended for narrow band operations e.g. SSB/CW
- An 8 MHz bandwidth transponder for experimental digital modulation schemes and DVB amateur television.

Anticipated Equipment Requirements for Es'Hail 2 are:

2.4 GHz Uplinks:
Narrow band transponder
- 2 400,050 – 2 400,300 MHz

- Right-hand circular polarisation
- 32,5 dBW EIRP e.g. 10 watts PEP to 22,5 dBi gain antenna such as a 75 cm dish
- Typical operating modes SSB, CW

Wide band DATV transponder uplink:

- 2401.500 - 2409.500 MHz
- Right-hand circular polarisation
- 53 dBW EIRP e.g. 100 watts PEP to a 33 dBi gain antenna such as a 2,4 m dish
- Typical operating mode DVB-S2

10 GHz Downlinks: These will typically need a 60 - 75 cm dish, although 90 cm is recommended for rainy areas at edge of the coverage area such as Brazil or Thailand

Narrow band downlink:

- 10 489,550 -10 489,800 MHz
- Vertical polarisation

Wide band downlink:

- 10 491,000 – 10 499,000 MHz
- Horizontal polarisation

4. Millennium Space Systems Geosynchronous Satellite Opportunity

AMSAT are developing a hosted payload for a USA geosynchronous spacecraft to be located over North America. The transponder will use digital modulation schemes with Frequency Division Multiple Access (FDMA) for uplinks and a Time Division Multiple Access (TDMA) downlink.

Unlike traditional bent-pipe transponders, which amplify and frequency-convert from uplink to downlink, there is no analogue signal path from uplink to downlink. Instead, there is a multi-mode, multi-channel digital receiver bank and a single digital transmitter. A digital processing system forwards data from the multiple uplink receive channels to the single channel downlink transmitter.

The 10 MHz bandwidth uplink can support more than 100 individual FDMA carriers from individual ground stations. The downlink will be a 10 MHz bandwidth DVB-S2X based multiplex.

Several types of modes and ground stations can be used for the DVB-S2X Phase 4B transponder:

- Low speed data, equivalent to traditional RTTY or PSK-31
- Single channel digital voice with 10 kHz bandwidth
- Multi-channel wideband terminal with 100 kHz bandwidth capable of carrying trunked narrow band channels and/or higher speed IP packet flows. This can act as an Amateur Radio Access Point that can aggregate traffic from multiple VHF/UHF repeaters.
- High data rate with up to 1 MHz of bandwidth for DATV

The proposed frequency plan is:

- Uplink: 5 655.0 – 5 665.0 MHz
- Downlink: 10 455.0 - 10 465.0 MHz

Conclusion

This paper describes two upcoming projects which will effectively provide more than 10 MHz additional spectrum for long range amateur communication. This capability will be available to amateurs using small antennas and quite simple microwave equipment. It demonstrates:

- The need to fully protect this spectrum for such use
- Tremendous opportunities for amateur communications and development

Overleaf – Annex for coverage plots

Es'Hail 2 will be at geostationary at 25,5 degrees East, directly over Region-1 (2,4 GHz up, 10,4 GHz down)

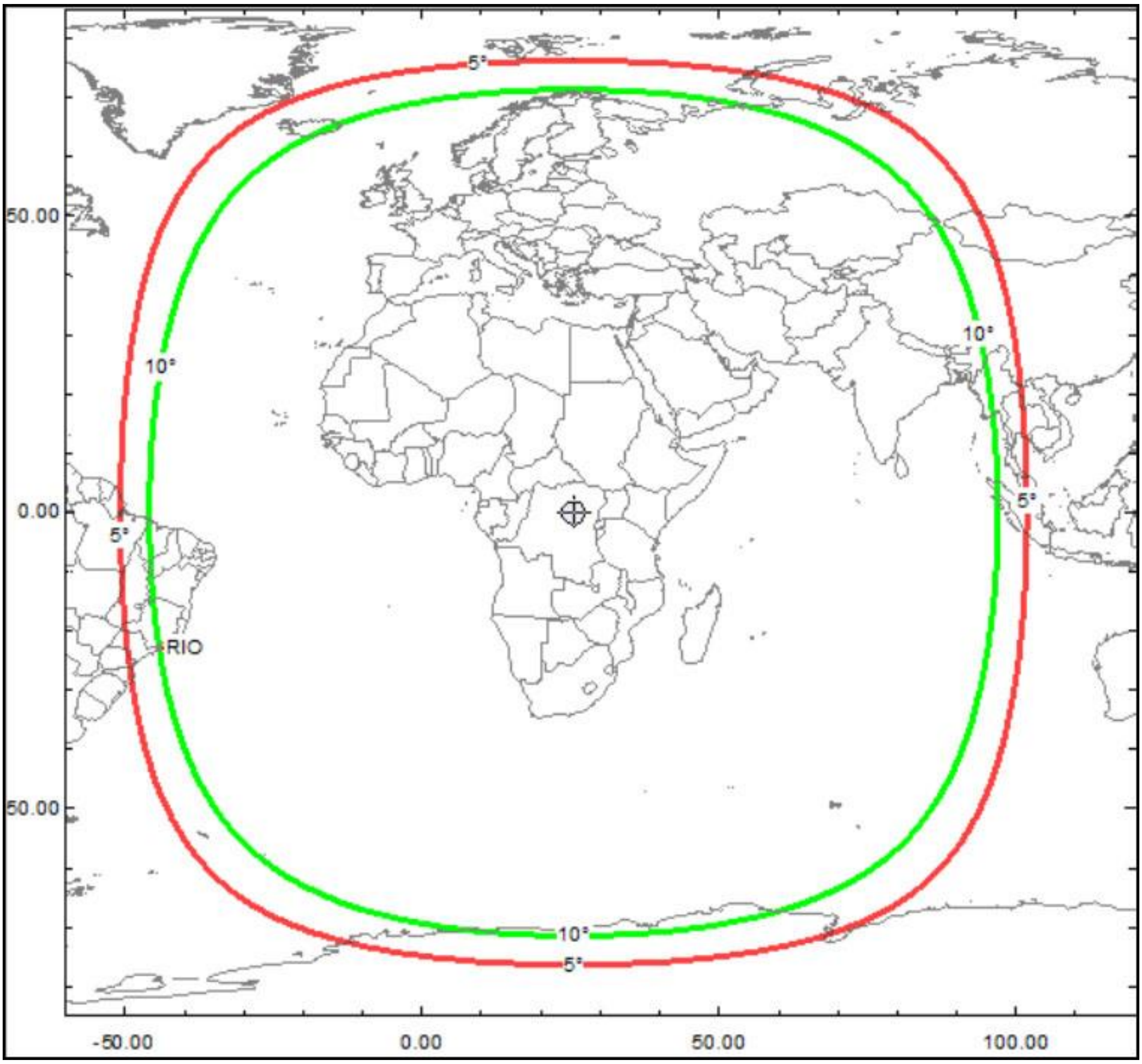

Fig 1 Expected coverage area of Es'Hail 2

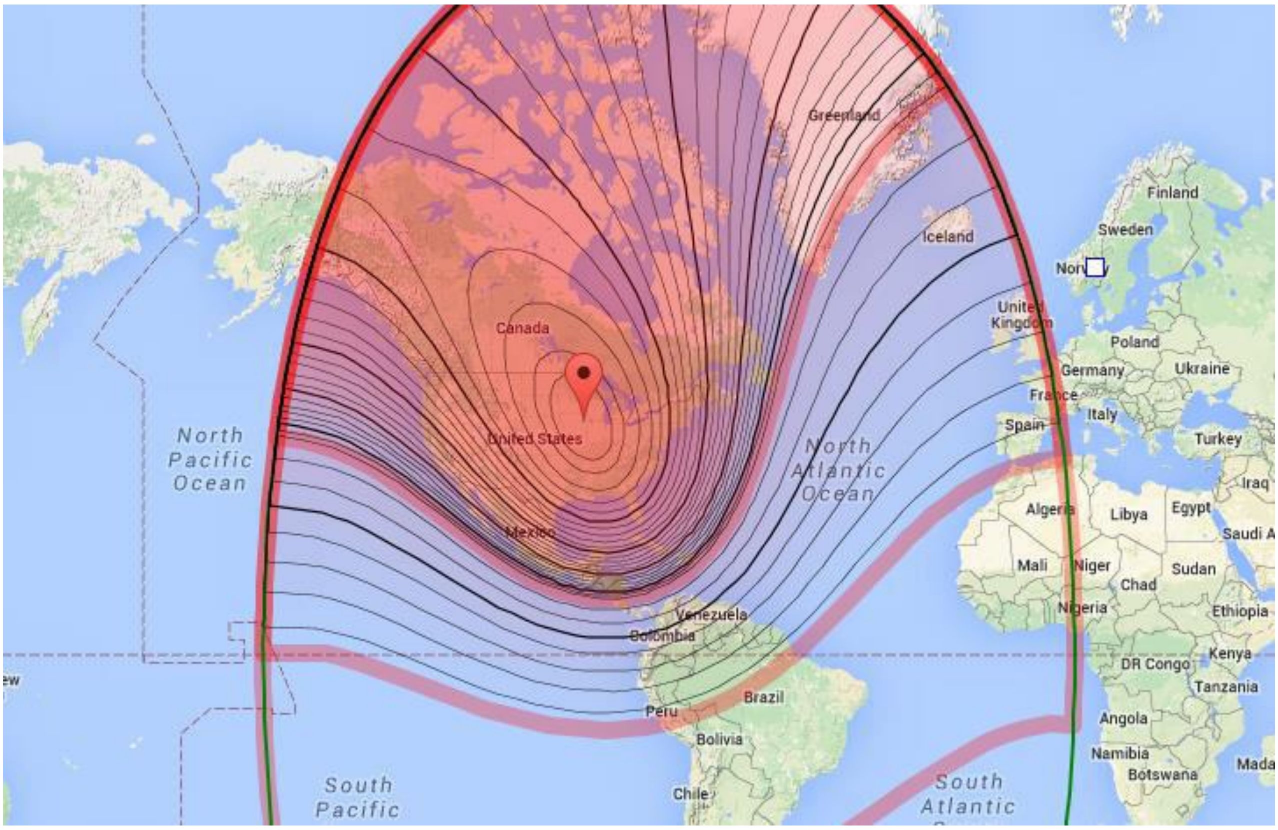

Fig 2: Typical coverage area of a geosynchronous satellite located at 74° west - Credit NX5R

Final detail for the AMSAT transponder coverage remains to be confirmed (5,6 GHz up, 10,4 GHz down)