

AMSAT GOLF

A PRESENTATION TO THE NORTH TEXAS MICROWAVE SOCIETY

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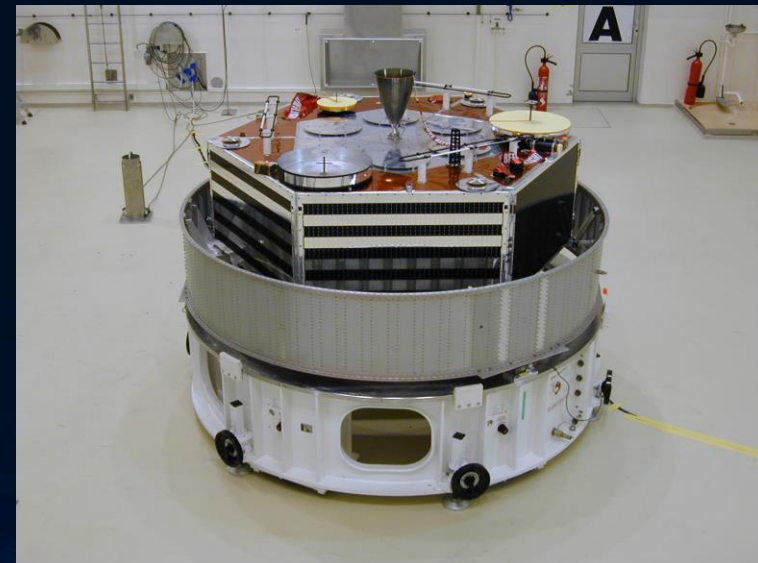
Quick background

- AMSAT founded in 1969
 - Continuing the work of Project OSCAR (1961)
 - Orbiting Satellite Carrying Amateur Radio
 - Many successful (and a few not-so-successful) satellites in orbit
 - AO-7 launched in 1974, oldest satellite still in limited operation
 - > 4000 members as of Oct 1st, 2023
 - Sister organizations in many other countries
 - AMSAT-UK, AMSAT-DL, AMSAT-SA, etc.



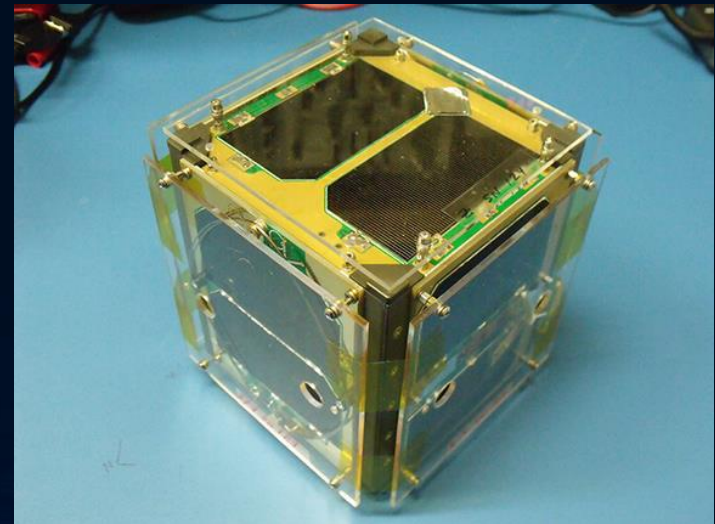
Growing Ambitions

- First satellites
 - “Shoe-box” sized
 - Weight/size not the driving factor, usually
 - Many rides were free/cheap – high-risk or AMSAT “knew someone” looking for ballast.
- Bigger is better?
 - AO-40 weighed in at 4,758 kg (10,489 lb)
 - Antennas galore (L, S, C, X, V, U, and K bands)
 - .. and that arcjet thruster!



Incredible Shrinking Satellites

- Cubesat form-factor
 - 1U == 100mm x 100mm x 100mm
 - Necessary due to rising costs (at the time) of launches
 - Enabled by consumer electronics leveraging surface-mount technology (SMT)
- FOX-1A (AO-85)
 - First of the AMSAT Cubesats
 - UHF/VHF cross-band FM repeater
 - Coiled piano-wire antennas



Current AMSAT Fleet

- AO-91 (aka Fox-1B, aka RadFxSat)
- AO-92 (aka Fox-1D)
 - Carrier-operated FM repeater
 - No tone required but may cut off on weak carrier
- AO-109 (aka Fox-1E aka RadFxSat2)
 - Very low power linear transponder
 - Very low power BPSK-1200 telemetry
 - Telemetry receivable with a big antenna
 - Usable with FT₄ and CW

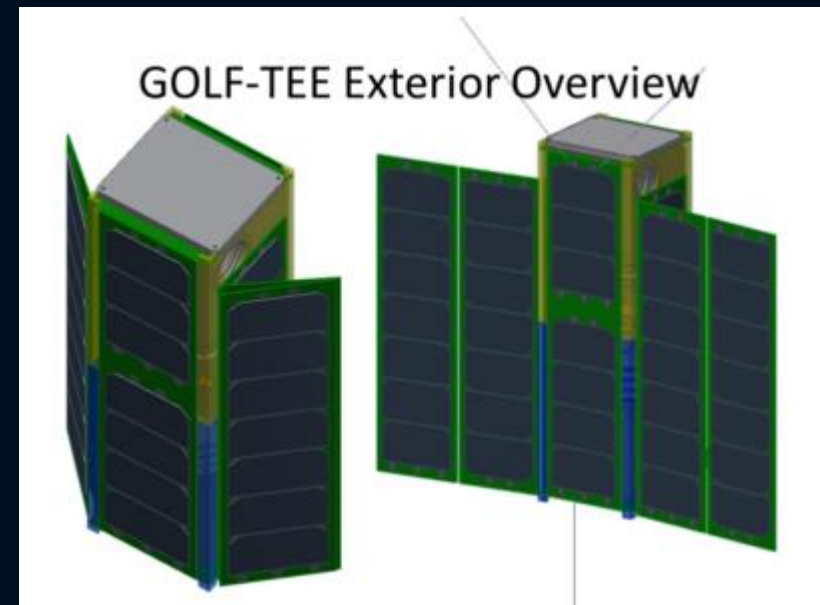


Microwave Ambitions

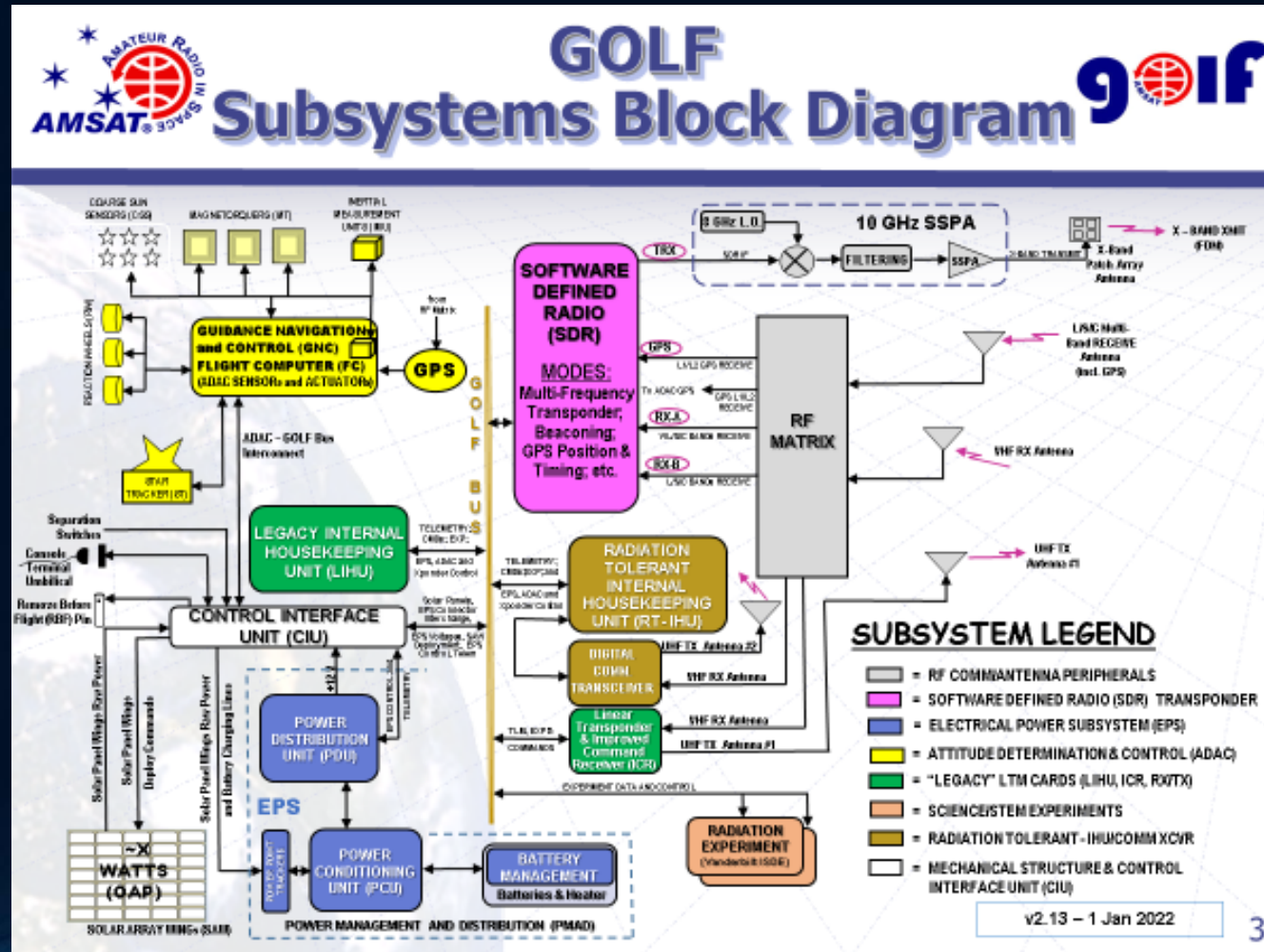
- Since the earliest AMSAT satellites
 - AO-7: 13-cm (2.4 GHz) beacon, but never activated due to band-plan changes.
 - AO-10: 23-cm (1.2 GHz) transponder -> 70-cm downlink
 - AO-40: Many bands from 2m to 24GHz!
- Cubesats are no exception
 - AO-92 (Fox-1D) L-band "downshifter"
 - 23-cm converter fed into 70-cm uplink of transponder
 - Experimental add-on which didn't require an extra antenna or hardware mods

Greater Orbit Larger Footprint (GOLF)

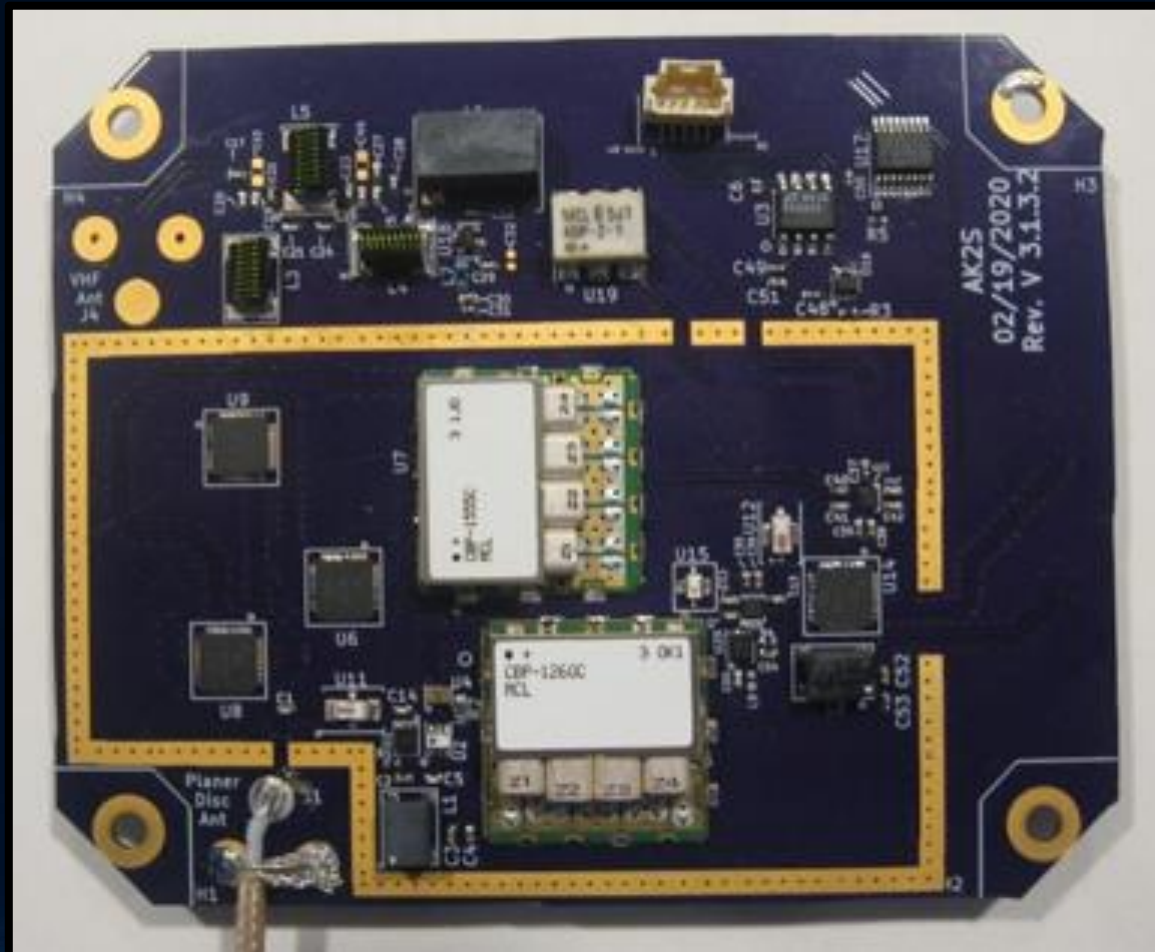
- Successor to the Fox series of Cubesats
- Larger 3U (30x10x10 cm) footprint
- First two satellites in series
 - GOLF-Tee
 - Technology demonstrator
 - LEO
 - GOLF-1
 - Enhanced capabilities
 - LEO, but possibly MEO/HEO
 - Orbital debris regulations went into effect. It's crowded up there!



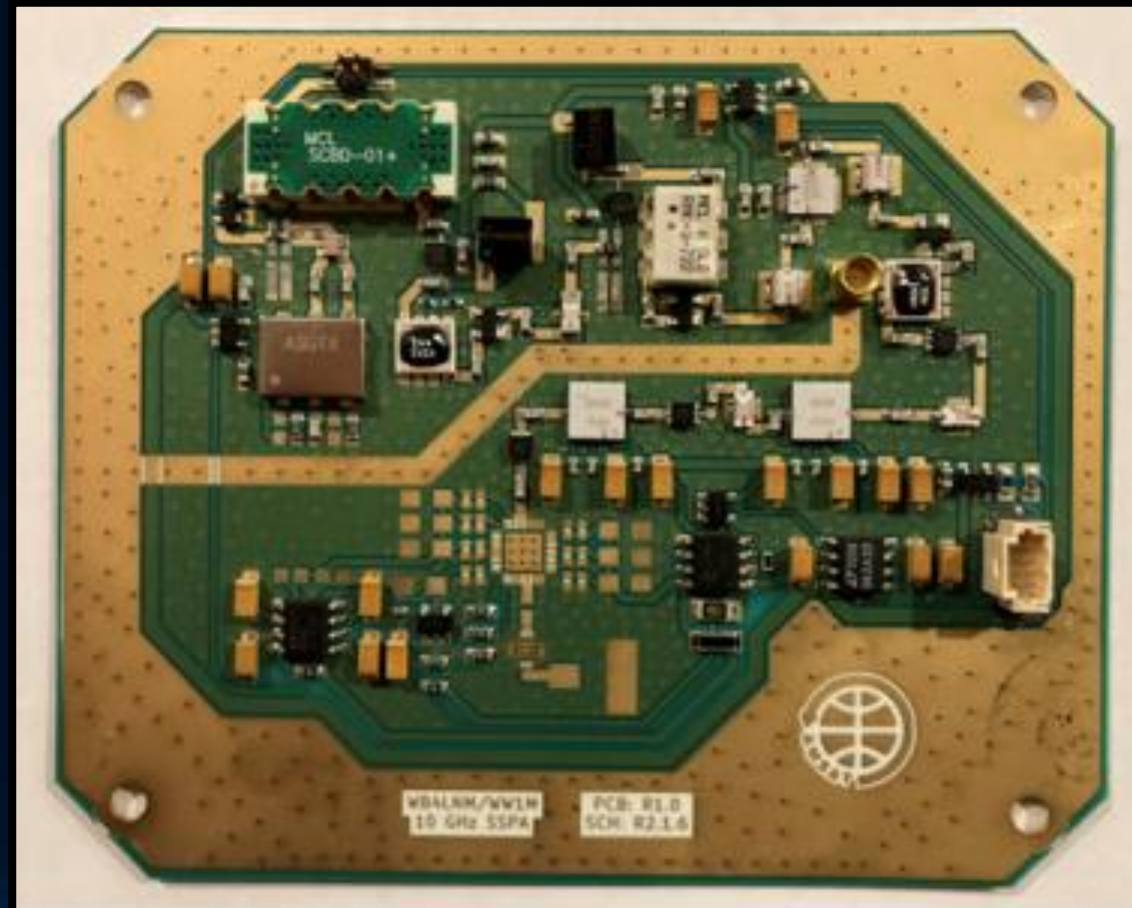
GOLF Satellite Architecture



RF Matrix

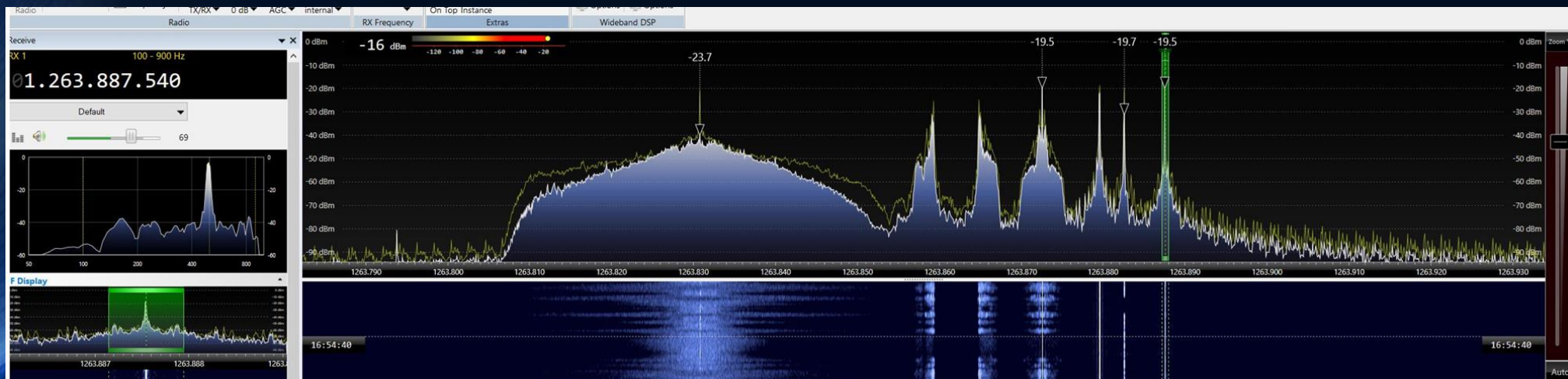


10 GHz SSPA



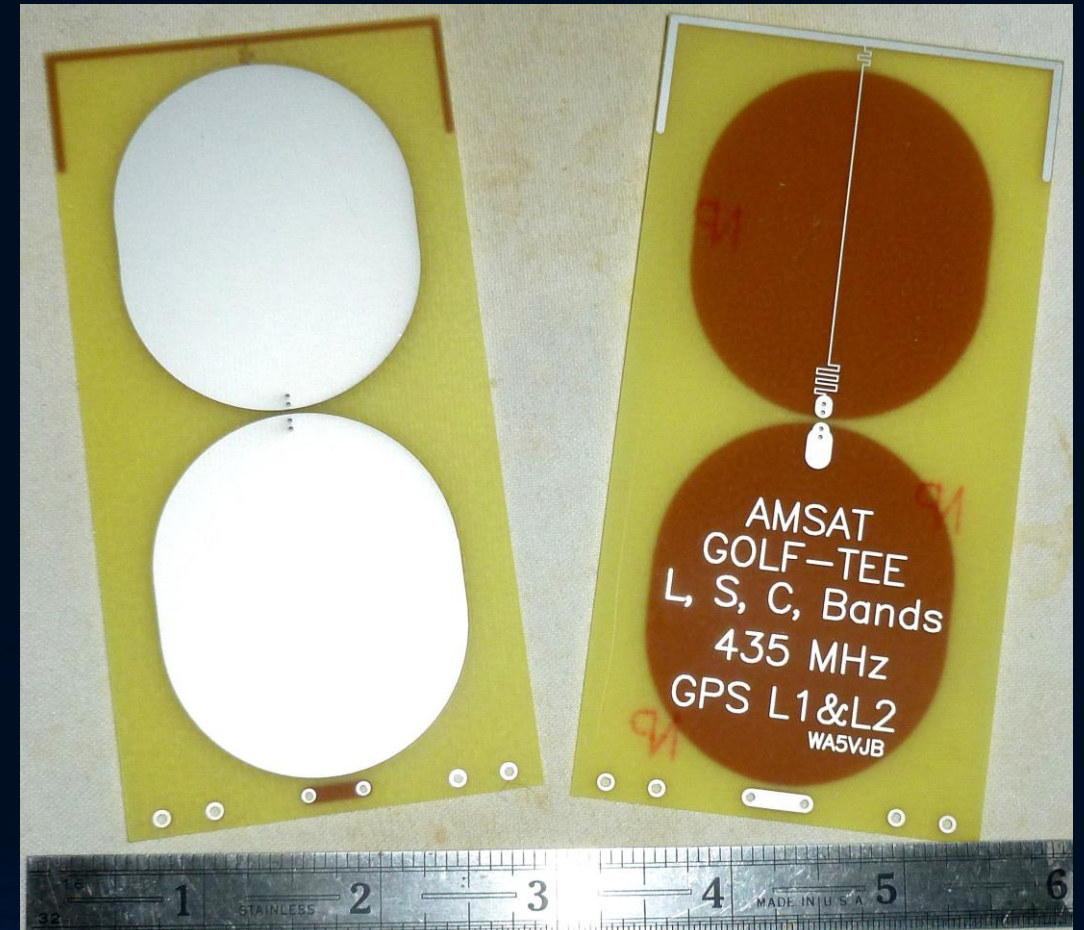
GOLF SDR

- Enables many simultaneous uplink bands
- Single 10GHz downlink signal generated by Ettus E310
 - Centered around 10.4 GHz. Peak power into the array is about 1 watt.
- On Golf-Tee, used primarily for engineering data
 - Future missions (Golf-1, etc.) plan to open this downlink up for user traffic



GOLF Multi-band Antenna

- Designed by Kent Britain (WA5VJB)
 - He's the expert on this, not me. 😊
- Requires ADCS to point at Earth
 - Attitude Determination and Control System



Ground Station for GOLF

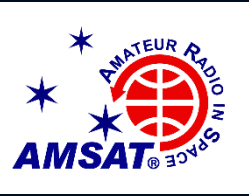
- The usual VHF/UHF capabilities
- X-band downconverter
 - Cheap models available from the EU ("FreeSat" services)
 - Kent may have some to sell – no, I don't get a commission
- On Golf-1 and follow-on satellites
 - Uplink capabilities in microwave bands (1.2GHz, 2.4GHz, ...)



Figure 2: Completed dual-band feed – July 2019

Future Directions

- Spectrum is money
 - Commercial interests will continue to ask for more, including our allocations
 - Prime example: 3.3 – 3.5 GHz band
 - We must utilize what we have and show our need to keep it!
- Microwave is easy (sorta...?)
 - Antennas are small
 - Horn-type feeds simplify pointing in exchange for lower gain
 - Consumer devices are driving the use of uW bands → Cheap ICs and modules



Thank You

- Questions?

