Decoding satellite telemetry

I was intrigued to see the 'Decoding telemetry from satellites' competition (<u>https://www.hamsatsa.co.za/2022/04/16/decoding-telemetry-from-</u><u>satellites-competition/</u>) come up, linked with the very helpful satellite manual that ZR6TG has put together

(http://www.satellitemanual.com/telemetry.html). I have yet to complete a satellite QSO (although I've been able to listen in to some), and the only data I've downloaded from the birds was some SSTV footage from the ISS last December. This looked to be just the inspiration I needed to nudge me along.

The competition found me at a busy time, and I didn't think that I'd be able to construct an antenna and get an SDR up and running. I therefore gave some thought as to practical options that might work for me.

I recalled logging onto a WebSDR last year and listening to a conversation (in Afrikaans, as it happened) taking place through the Es-Hail (QO-100) satellite. The competition calls for amateurs to 'receive and decode telemetry from any amateur satellite in orbit', and a WebSDR should enable me to do just that. A quick search on http://websdr.org/ got me to the Qatar-OSCAR 100 Narrowband WebSDR

(<u>https://eshail.batc.org.uk/nb/</u>). A helpful article on Radio Club HF5L's website (<u>https://hf5l.pl/en/eshail-2-or-qo-100-for-beginners/</u>) confirmed that there were CW beacons on 10 489.500 MHz and 10 490.00 MHz.

I wasn't entirely as to whether obtaining and decoding these transmissions would fall into the scope of the contest. They certainly are transmissions, in fact retransmissions, since they are generated at the Es-Hail control centre, but these CW transmissions are in Morse *code*, after all. Also, they're referred to as telemetry beacons in a very interesting article on Github (https://github.com/happysat/Es-Hail-2-Oscar-100/blob/main/README.md#Telemetry beacon_). In any event, I would try.

So, I set the controls on the WebSDR to listen to the lower beacon (see screen shots below), and made recordings of the transmitted code. Recording using the laptop microphone resulted in an overly soft result; using a mobile phone provided a better result, and the best was that obtainable directly from the WebSDR itself (not surprisingly).

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I then re-tuned to the upper beacon, and repeated the exercise (see screenshots below).



Now that I had the audio files, it was time to attempt to decode them. Not being Morse proficient (and with no chance of becoming so before the end of the contest) I went looking for a software decoding option. I'd heard of CW Skimmer, so downloaded (<u>http://www.dxatlas.com/CwSkimmer/</u>) and installed it. After some playing it became clear to me that it was designed for higher purposes than just decoding audio files, so I looked for alternatives. Next it was the turn of MRP40 (<u>http://www.polar-</u> <u>electric.com/Morse/MRP40-EN/LoadPRM-EN.html</u>), but that again seemed unnecessarily complicated for my intended use. The Github site already mentioned had a link to fldigi (<u>https://sourceforge.net/projects/fldigi/files/fldigi/</u>), so I thought I would try that next, and hope for a more user-friendly experience. Installation was quick, and there's a beginner's guide at <u>https://www.sbarcnm.org/documents/fldigi%20beginner%27s%20guide.p</u> <u>df</u>, with more comprehensive information available at <u>http://www.w1hkj.com/FldigiHelp/</u>.

I quickly worked out how to generate Morse code using the program, but getting it to decode my audio files proved a little more problematic. Frustration ensued, as I could get the programme to 'listen to' the beacons (see screen shot below), but no decoding was taking place. Or if it was, I couldn't find it.



I even sent a recording of the transmissions to a local Elmer who had been very helpful to me in the past, but he told me that his Morse wasn't yet up to the task.

Time to try something else. Like the middle beacon, transmitting telemetry using PSK. This is transmitted on 10 489.750 MHz (<u>https://www.sdr-radio.com/EsHail-2</u>), no longer on 10 489.800 MHz (<u>https://www.dk3wn.info/wp/satelliten/qo-100/</u>).

I downloaded AO40Rcv (<u>http://www.moetronix.com/ae4jy/ao40rcv.htm</u>), downloaded some audio files of the telemetry beacon from the WebSDR, and got to work.

This worked well, and I was amazed at how much data was readily available from the beacon. Reports were available on the satellite's status:



Navigation indicators:

+=+=+=+=+=+=+=+=+=+==+==+=+=+=+=+=+=+=
SEU Sensor Mode: Spin Magnet Sys: OFF
Magnet Pwr: OFF M-SOLL: 105
EARTH SENSORS
Sensitivity:600.00 mV Pointing: Side
Edge: Positive Lock Range: 116
ES-R Upper> MA:110 Orbit:121(mod256)
ES-R Lower> MA:032 Orbit:111(mod256)
ES1 spin Cnt: 104 Update Flag1 101
ES2 spin Cnt: 114 Update Flag2 032
SPIN SUN SENSORS
SS1 cnt:108 SS2 cnt:032 Threshold: 1.80 V
SS-Flags: 111 Spin Count Raw: 114 SEU: 26.69 RPM
Sun Angle: 33.54 deg.
3 - A X I S S U N S E N S O R S
Omni Up-X: 82.79 deg. Up-Y: 82.79 deg.
Omni Down-X: 82.79 deg. Down-Y: 82.79 deg.
U//D Z: Below Y-X Plane
ELECTRONIC PROPULSION UNIT
Configuration: #75
Tank Pressure: 1.36 Bar Motor Pressure: 4.63 Bar
Motor Voltage:-223 98 V Motor Current: 3 36 B
Set Current: 6.57 h Flow(analog): 100 Flow Pater 22
Set Current. C.S/A Flow(analog). 100 Flow Rate: 32
Wheel I Deven OFF Concile 442 14 DEV
wheel I Power: OFF Speed: -443.14 RPM
wheel 2 Power: OFF Speed: -565.61 RPM
Wheel 3 Power: ON Speed: -107.23 RPM Sync: NO

Power status:

----- S T A T U S ------Batteries: Main On Charger: OFF Aux Heater: OFF Solar Array Release Unit: OFF ----- V O L T A G E S ------Main Bat: 13.53V Aux Bat: 16.16V 28V Bus: 5.48V Bat Voltage Offset: 21.72V ----- C U R R E N T S ------
 Total Bat:
 -6.94A
 EPU:
 3.66A
 Main Bus:
 15.22A

 28v-S:
 3.24A
 BCR:
 11.23A
 SEU:
 [110]
 ----- BATTERY CHARGE REGULATOR #1-----I SA-6: 9.42A BCR-1 Array Voltage Offset: 31.60V
 Part TERY
 CHARGE

 Vin:
 7.64V
 10V-C1:
 4.68V

 ISA-4:
 10.63A
 ISA-5:
 10.53A

 BCR-2
 Array Voltage Offset:
 31.70V
 REGULATOR # 2 -----I 10v-C1: 1.35A ----- BATTERY CHARGE REGULATOR #3------Vin: 10.02V 10V-C2: 3.69V I SA-2: 11.14A I SA-3: 9.21A BCR-3 Array Voltage Offset: 29.70V ----- T X P O W E R ------V-Tx:[032] U-Amp:[032] I-10v-S:[032] S1-A/mix:[032] CS X-Tx:[#28] Out X-Tx:[032] I-28v-S: 1.04A S2 Pwr:[032] Helix X Tx: 6.05mA I-K-Tx:[032]

Temperatures:

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HP1+X-Y: 10.04
HP3+X: -48.61
               ----- S / C F R A M E ------
                                                Side2: 2.13
               Bottom: -3.14 Back: 5.43
Top: 2.13
               S Ant: 2.13
Side4: -1.82
                ----- T A N K S ------
MMH B3: -3.80
NH3 B2: -48.61
                Helium: 7.40
               ---- BATTERIES ------
Main B2: 6.74
               Main B4: 3.45
                               Main B6: -48.61
               Aux B5: -3.14
Aux B1: 5.43
           ----- SOLAR PANELS----

        Panel 1: -4.46
        Panel 2: 3.45
        Panel 3: 3.45

        Panel 4: 5.43
        Panel 5: -3.80
        Panel 6: -0.50

                                Panel 6: -0.50
           ----- BATTERY REGS-----
BCR 1: -48.€1
               BCR 2: 5.43
                               BCR 3: 3.45
                SEU: -21.59 EPU: 2.79
               - T R A N S M I T T E R S -----
                U Tx: 3.45 U PA: 1.47
X Tx: 90.58 TWTA X Tx: 90.58
               ---- R E C E I V E R S ------
U&V: 6.74
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& even a message from the control centre:

K HI de Qatar-OSCAR 100 (DK0SB)

L HI de Qatar-OSCAR 100 (DKOSB) Transponder is open for general use since 2019-02-14. Enjoy the Narrow Band (NB) and Wide Band (WB transponders. Follow the guidelines and keep transmitter power below beacon.

For more information visit: http://amsat-dl.org/ QO-100 was brought to you by Es'hailSat, QARS and AMSAT-DL. Good Luck and Good DX via the first geostationary P4-A satellite M HI de Qatar-OSCAR 100 (DKOSB) 2020-02-14: Celebrating 1 year of QO-100 New bandplan with extended transponder range active now. New beacons (and new LEILA ground station) currently experimental. New beacon frequencies: CW now F1A on 10489500 Middle Beacon AMSAT PSK 10489750 Experimental Beacon 10490000 currently also FIA CW N HI de Qatar-OSCAR 100 (DKOSB) In order to coordinate potential emergency communications during the actual or any other crisis, the following frequency will be assigned as international emergency frequency on QO-100 NB Transponder: Downlink: 10489.860 MHz Uplink: 2400.360 MHz SSB channel: max. 2.7kHz bandwidth All users on QO-100 are encouraged to monitor

All users on QO-100 are encouraged to monitor this frequency, but keep it clear for emergency traffic!

What's next? Perhaps time to start looking at setting up my own QO-100 station (<u>https://hf5l.pl/en/eshail-2-or-qo-100-for-beginners/</u>)? Or perhaps I'll build a turnstile or egg-beater antenna and start hunting for more telemetry, this time without needing a WebSDR. I'll decide next week!

Gary Cundill ZS1GAR

Annexure: an interesting phenomenon

While listening to the beacon, I suddenly heard a whistle, rapidly changing in tone. The time corresponded to the slanted line that can be seen on the waterfall below.

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I later saw a similar slanted line (see below) on the waterfall, although I didn't hear anything as it didn't cross the frequency I was listening to.

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+ +++					-	+							
CW LSB USB	squelch autonotch	-107.1 dB; peak -1	05.5 dB;		><	\diamond							
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I wonder what would generate such a transmission?