Receiving COSPAS-SARSAT Second-Generation Beacons with an RTL-SDR

A real French system beacon, an RTL-SDR receiver 80 km away, and an open-source decoder: from a wide burst in the waterfall to a verified identity and encoded position. Published IQ recordings let you repeat the experiment.

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A signal in the waterfall, and a message behind it

At the firmin relay station, about 80 km from a CNES system-beacon site near Toulouse, a Nooelec NESDR SMArTee v5 receives the 406 MHz band through an omnidirectional antenna. Among the familiar narrow beacon bursts is a much wider transmission: a second-generation COSPAS-SARSAT beacon, or SGB. The receiver is modest, but the processing required to recover its message is quite different from decoding a first-generation beacon.

That reception is the basis of dec406, my open-source FGB/SGB receiver and decoder. Its job extends from the complex IQ samples to the decoded beacon message: acquiring the carrier, synchronizing the spreading code, recovering the bits, checking and correcting the BCH code, and interpreting the message fields. It runs under Linux, is written in C, and is distributed under the MIT License.

The result can be tested independently. Two real IQ recordings from firmin are now public, including normal and self-test transmissions. A demonstration included with the software builds the receiver, downloads the recording and checks the decoded result.

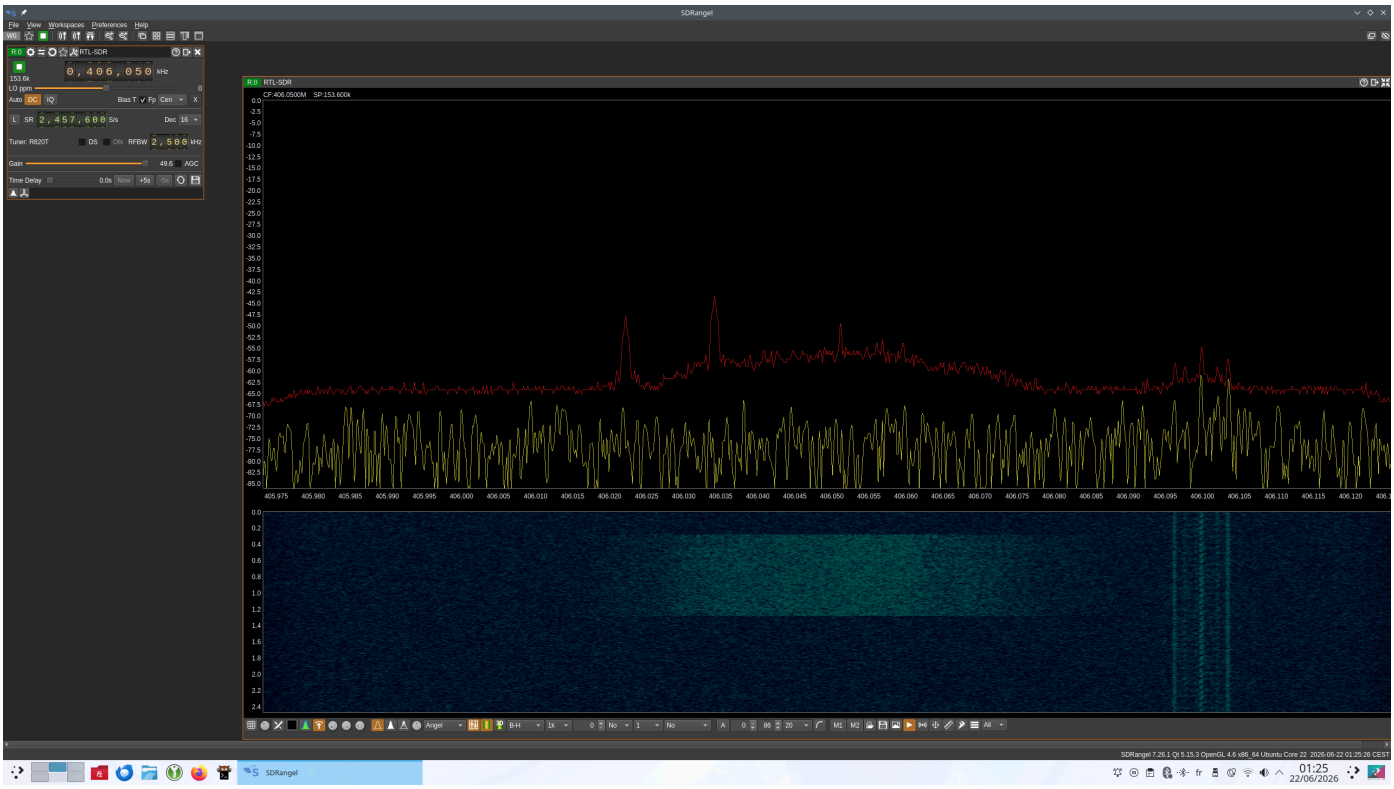


Figure 1. A real SGB burst in SDRangel. Its spread-spectrum waveform occupies much more bandwidth than an FGB transmission. Narrow lines visible nearby remain unidentified; they should not be interpreted as decoded beacons from this image alone. Image previously published in the F4KLO field report.

Why the second generation needs a different receiver

First-generation beacons use biphase-L phase modulation at 400 bit/s. Second-generation beacons, specified in C/S T.018, use direct-sequence spread spectrum (DSSS) and offset quadrature phase-shift keying (OQPSK), with a 300-bit/s data stream. Each I or Q branch uses 256 spreading chips per bit. The main lobe is 57.6 kHz wide between its first nulls, with roughly 50 kHz visible in the published captures.

Filtering this signal like a narrow FGB transmission will not recover its data. The receiver must align a locally generated spreading sequence with the received one and remove the spreading. Carrier frequency error, timing and phase must all be handled before the message can be validated. Normal and self-test transmissions also use different spreading sequences; the receiver must support both.

In dec406, processing starts directly from complex samples. The SGB chain removes DC, acquires the carrier through FFT correlation, removes the estimated frequency

offset, aligns the OQPSK branches and despreads the message. Preamble synchronization and phase processing lead to the BCH(250,202) decoder: 202 message bits protected by 48 parity bits. The BCH result helps resolve the candidate timing and phase choices.

These stages matter because a plausible-looking hexadecimal string is easy to print. A complete receiver must recover a consistent, verifiable message from an actual RF recording. That is the test the public samples are intended to make reproducible.

Reading a real self-test message

One firmin capture contains a French system beacon in self-test mode. The decoded result includes the following fields:

```
Frame Mode: Self-test
23 Hex ID: 9C77FFFA18CF00000000000
TAC Number: 65534
Serial Number: 8588
Country Code: 227 (France)
Type: System Beacon
Position: 43.56052 N, 1.48087 E
BCH validated: nerr=0
```

The TAC is the type approval certificate field, but the value here is a reserved system-beacon value, not the approval number of a commercial distress beacon. Country code 227 identifies France. The position is carried in the beacon message: the receiver has decoded the transmitted coordinates, rather than measured the beacon's location by direction finding or time-of-arrival processing.

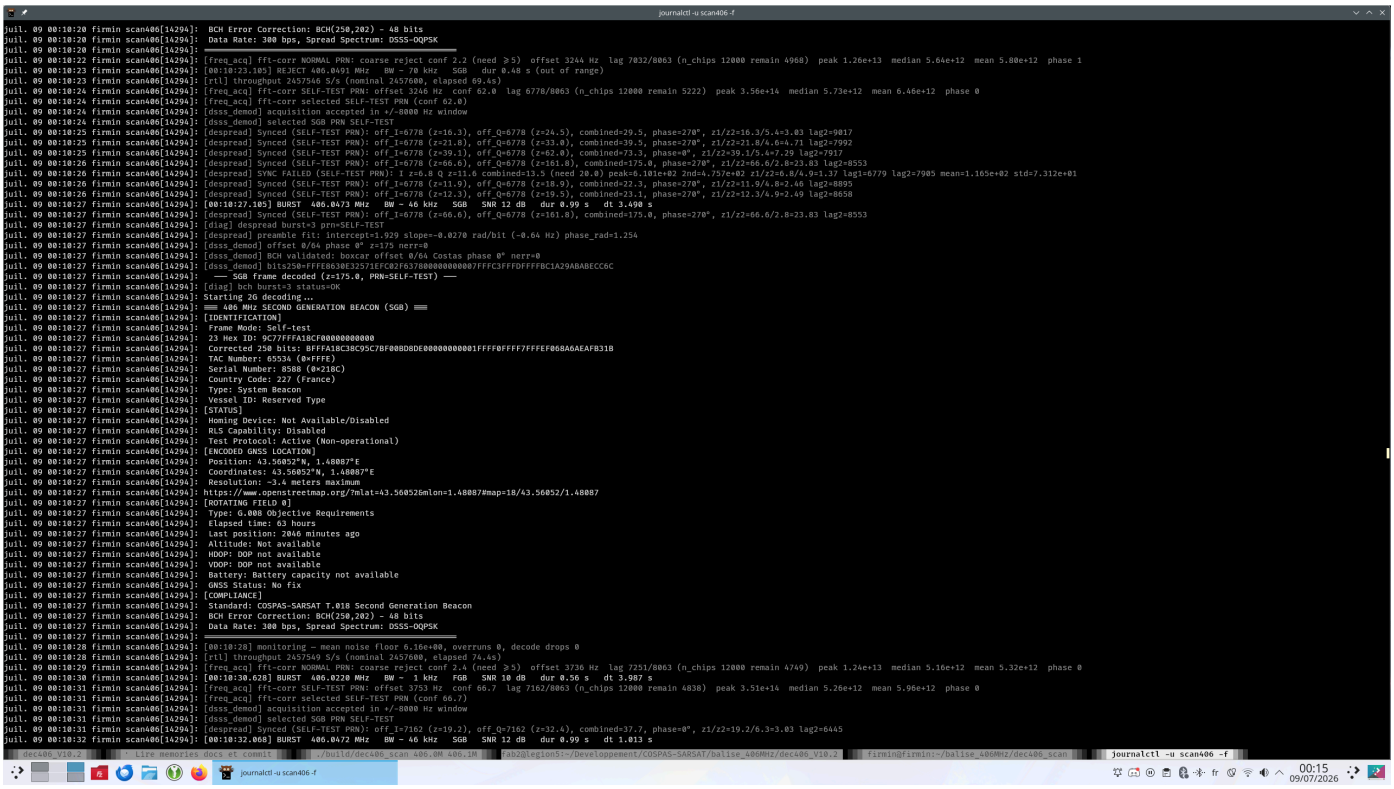


Figure 2. Real self-test reception at firmin. Acquisition, synchronization and BCH validation precede identification and position decoding. The 23-character identity is distinct from the complete protected message. Image previously published in the F4KLO report.

The complete message is represented by 63 hexadecimal characters:

```
BFFFA18C38C95C7BF00BD8DE00000000001FFFF0FFFF7FFFEF068A6AEAFB31B
```

This representation contains the 250-bit protected message plus two leading representation bits. In the published cross-check, the COSPAS-SARSAT full-message decoder recovered the same identity and position and recalculated exactly the same BCH parity. The separate IBRD identity decoder was also used to check fields of the normal-mode beacon's 23-character identity. Those are complementary checks: an identity-only decoder cannot validate the full received message.

An encoded position resolution of approximately 3.4 m is useful, but it is not a guarantee that every reported coordinate is within 3.4 m of the physical beacon. Resolution, GNSS accuracy and the freshness or availability of position data are separate properties.

Independent reception through MEOSAR at F4KLO

Local reception was followed by an independent test at the Radiotelescope du Parc de La Villette, station F4KLO. On 18 July 2026, Bernard F6BVP compiled and operated the decoder with an Airspy sampling at 2.5 MS/s. Instead of receiving the beacons directly at 406 MHz, the station received their retransmitted messages through the MEOSAR downlink near 1544 MHz.

This supplied a valuable change of receiver, site and propagation path. Two captures contained 23 decoded SGB messages from seven system or calibration beacons:

Country	Decodes	Beacons identified by TAC and serial number
United States	17	65533 / 10001; 65533 / 10002; 65532 / 4097
Cyprus	4	65534 / 10720; 65535 / 10648
Brazil	1	65535 / 1
Togo	1	65535 / 6711

All 23 messages passed BCH validation: 19 required no correction and four were validated after error correction. These observations span four countries on four continents. They are results from those two captures, not a universal reception-success percentage.

The Larnaca calibration beacon in Cyprus yielded an encoded position of 34.86539 N, 33.38373 E, corresponding to its site within a few metres. Again, this is recovery of the transmitted position. The amateur station is receiving and decoding the satellite downlink, not operating a MEOLUT multilateration system.

Repeat the experiment without waiting for a beacon

The simplest entry point is an offline replay. The published samples are three-second SigMF recordings in interleaved signed 16-bit IQ format (`ci16_le`), sampled at 2.4576

MS/s and centred on 406.050 MHz. The archive contains one normal-mode and one self-test burst with metadata.

With GCC, Make, curl, unzip and sha256sum installed on Linux:

```
git clone https://github.com/moricef/dec406.git
cd dec406
make demo-real-sgb
```

The command downloads the archive, verifies its SHA-256, compiles `dec406_iq` and runs the normal-mode recording through the full receive chain. It then checks the expected identity, country, position and zero-error BCH result. Processing time depends on the CPU; offline replay includes a sliding search through the recording.

```
Frame Mode: Normal
23 Hex ID: 9C77FFFE1A7F00000000000
TAC Number: 65535
Serial Number: 8615
Country Code: 227 (France)
Position: 43.56049 N, 1.48080 E
BCH validated: nerr=0
```

To process the extracted recording directly, use the signed-16-bit input option:

```
./build/dec406_iq sgb_firmin_20261026T211313Z_127s.sigmf-data -i -s 2457600
```

The IQ data are useful beyond this demonstration. Other receiver authors can feed the same samples into their own implementations and compare the recovered message, spreading mode and BCH results. This makes differences in receiver behavior easier to investigate than comparisons made on different signals at different times.

FGB reception, orbitography and live operation

The same project includes an IQ-direct FGB demodulator and a unified live scanner. The scanner detects bursts across the 406 MHz beacon band, classifies them by bandwidth and routes them to the appropriate receiver. SDR backends cover RTL-SDR, Airspy, PlutoSDR and HackRF. The offline SGB demonstration requires no SDR hardware.

Orbitography illustrates why protocol interpretation matters after a successful demodulation. The French FGB calibration beacon `9C6000000000001` carries UTC calibration data in national-use bits described by C/S T.006. Applying the usual long-message BCH-2 test to those bits would falsely report an error. dec406 instead displays their raw value and, for this beacon, a plausible BCD day and UTC time marked as unprotected. That qualification matters: an error in this field is not corrected by a BCH code.

Live operation also separates reception from alerting. Self-test, orbitography, ID-NOT-AVAIL, bench-test and isolated transmissions are filtered from the operational email-alert path. Successful decoding of a system beacon is a receiver validation, not evidence of a distress event.

> **Use the public recordings for experiments.** Do not radiate test transmissions on 406 MHz. Transmitter tests must use a confined, sufficiently attenuated connection or an appropriate protected RF environment. dec406 is an experimental receiving tool and does not replace the official COSPAS-SARSAT service or search-and-rescue procedures.

Source, recordings and field report

dec406 v10.2 is available as source code. The release was checked with a clean build of the principal tools, 94 codec tests, the synthetic SGB regression and a replay of the published real recording. Independent replays, additional receive-only captures and reproducible receiver comparisons are welcome.

- Source code and English/French documentation
- dec406 v10.2 release
- Real normal-mode and self-test IQ recordings

- Reproducible demonstration instructions
- F4KLO field report and public illustrations

Software and article: Fabrice Morel, F4MLV / ADRASEC 09. Independent MEOSAR reception: Bernard F6BVP and F4KLO, Radiotelescope du Parc de La Villette. This article adapts the public La Villette account with the current release and reproducible IQ demonstration.