SATELLITE SIGNAL MONITORING • EUTELSAT 16A • 16.0°E

Case Study

Stability of Reception of Radio Carriers with Extremely Low Symbol Rate (SR = 100–176 kSym/s) in the Ku Band from the Eutelsat 16A Satellite under „In-Footprint Reception“ Conditions

Reception site: Lučenec, southern Central Slovakia | Antenna: prime-focus reflector Prodelin, D = 450 cm | Measurement system: TBS 5927 + EBS Pro

Author of the research:	Roman Dávid, www.dxsatcs.com

1. Introduction and Objective of the Study

The subject of this study is the analysis and interpretation of the results of long-term signal monitoring of three radio carriers transmitted in the Ku band from the geostationary satellite Eutelsat 16A, located at the orbital position 16.0° East. The common denominator of all three monitored carriers is an extremely low symbol rate (SR), ranging between 100 and 176 kSym/s – that is, at the lower limit of what standard consumer reception equipment is in practice capable of demodulating reliably in a continuous, long-term mode.

Carriers with such a low symbol rate occupy an extremely narrow bandwidth (on the order of hundreds of kHz) and, from the standpoint of digital signal processing theory, are substantially more sensitive to phase noise, frequency instability of the receiving LNB's local oscillator, and receiver tuning accuracy than typical DVB-S/S2 carriers with SR values on the order of several megasymbols per second. The aim of the study is therefore not only to document the measured results obtained by the author of the measurement, Mr. Roman Dávid (www.dxsatcs.com), but also to explain the physical and technical nature of the phenomena that enable – or, conversely, threaten – the stability of such reception.

The analysed reception site – the town of Lučenec in southern Central Slovakia – lies within the declared coverage zone of Eutelsat 16A, with a guaranteed effective isotropic radiated power (EIRP) of approximately 49 to 50 dBW (zones Europe A and Europe B of the satellite's coverage), which the author classifies in the submitted analysis as „In-Footprint Reception“ – reception within the main coverage beam, as opposed to reception at the edge of, or outside, the guaranteed footprint („Out-of-Footprint Reception“), where a substantially larger reflector diameter and a longer unit of proof of reception stability are required.

2. Geometric Parameters of the Lučenec Reception Station

The precise calculation of azimuth, elevation and LNB rotation angle (skew) is an essential prerequisite for any serious technical analysis of satellite reception, since an incorrectly aligned antenna introduces additional depolarisation and attenuation into the system, effects that are particularly noticeable for carriers with a narrow spectrum and a low signal-to-noise ratio. For the accuracy of this study, verified data from the dishpointer.com service were used for the coordinates of the town of Lučenec (latitude 48.3331° N, longitude 19.6664° E) and the Eutelsat 16A satellite at position 16.0° E:

Parameter	Value
Latitude of the site (Lučenec)	48.3331° N
Longitude of the site (Lučenec)	19.6664° E
Azimuth (true / geographic north)	184.9°
Azimuth (magnetic)	178.8°
Antenna elevation	34.4°
LNB rotation angle (skew)	3.3°

Table 1: Geometric parameters for antenna alignment for Eutelsat 16A reception at the Lučenec site (data source: dishpointer.com).

An elevation of 34.4° is a relatively favourable value for the Central European latitude – the signal path passes through the atmosphere at a sufficiently steep angle that the effective thickness of the atmospheric layer (and hence the attenuation caused by precipitation, the so-called rain fade) is not extreme, in contrast to reception of satellites with a significantly lower observed elevation path. A skew of 3.3° is a value close to zero, meaning only a minimal correction of LNB rotation relative to the vertical reference position – for polarisation-sensitive reception (and low-SR carriers clearly fall into this category), precise adherence to this angle is important for maximising cross-polarisation isolation (XPD) and minimising adjacent-channel interference between vertically and horizontally polarised carriers in close frequency proximity.

3. Technical Configuration of the Reception Chain

The reception system consists of a prime-focus parabolic reflector Prodelin with a diameter of D = 450 cm, an LNB with a highly stable PLL oscillator (declared LOF stability ±10 kHz), and a TBS 5927 digital meter/analyser controlled by EBS Pro software. In the submitted analysis the author emphasises that, in the „In-Footprint Reception“ zone with a guaranteed EIRP of around 49–50 dBW, a reflector with a diameter as small as approximately 80 cm would, from a purely energy-budget standpoint, be sufficient for stable reception of standard carriers. The fact that a significantly oversized 450 cm reflector was used in this case therefore serves a purpose other than merely increasing received power – its main contribution is the narrowing of the antenna's main beam (and hence higher spatial selectivity against adjacent satellites) and, above all, a substantial carrier-to-noise (C/N) margin, which in this study proves to be the key factor in the demodulation of extremely narrow-bandwidth carriers.

It is worth emphasising an important point that the author correctly identifies: for reception of low-SR carriers, the primary limiting factor is not reflector diameter (the energy budget), but rather the quality and stability of the signal chain downstream of the antenna – above all the LNB oscillator and the accuracy of digital tuning. In this context, a large reflector does not serve to „capture a signal that would otherwise be inaudible“, but rather to create a sufficient C/N margin, which allows even small residual frequency and phase instabilities of the oscillator to manifest only as a mild fluctuation in quality (Q), rather than as loss of synchronisation (Lock).

4. The Influence of Local Oscillator (LOF) Stability on the Demodulation of Low-SR Carriers

The local oscillator (LO) frequency in a satellite LNB is used to convert the received high-frequency signal from the Ku band (10.7–12.75 GHz) into an intermediate frequency band that can be processed by the receiver's tuner (typically 950–2150 MHz). Any deviation of the actual oscillator frequency from its nominal value – referred to as LOF (Local Oscillator Frequency) offset – is transferred linearly into the position of the received carrier within the intermediate-frequency spectrum. For typical carriers with a high SR value (e.g. several MSym/s), even an offset of several tens of kHz represents a negligible fraction of the occupied bandwidth. For a carrier with SR = 100 kSym/s, however, the situation is fundamentally different.

The occupied bandwidth of a carrier can, as a first approximation (for QPSK modulation with a typical spectrum roll-off factor), be estimated as the product of the symbol rate and the coefficient (1 + roll-off). The author reports a measured bandwidth (Carrier Width) of 0.120 MHz – i.e. 120 kHz – for the Radio Wrocław carrier, a value fully consistent with a carrier of SR = 100 kSym/s at a roll-off factor close to 0.20 (typical for DVB-S carriers of this type). In such a case, an LO frequency offset on the order of a few to a few tens of kHz already represents tens of percent of the carrier's occupied bandwidth – and the demodulator (a Costas loop or a similar phase/frequency loop within the receiver chip) must be able to track and compensate for this offset in real time without losing synchronisation.

The declared LOF stability of the PLL oscillator used, at the ±10 kHz level, is from this perspective a key technical parameter. For a carrier with a bandwidth of 120 kHz, an offset of ±10 kHz represents approximately 8–9 % of the occupied spectral width – a value that lies safely within the central range that the frequency loop of a modern DVB-S demodulator (including the chipset used in the TBS 5927 receiver) can track in steady state without risk of losing Lock. By comparison, cheaper or older LNBs using a dielectric resonator oscillator (DRO) instead of a PLL typically exhibit LOF stability on the order of ±500 kHz to ±2 MHz, and moreover with significant temperature dependence (drift as ambient temperature changes between day and night). At such a level of instability, the frequency shift of a carrier with a bandwidth of only 120 kHz could completely push the receiver's tuning window outside the demodulator's search range, and loss of Lock would be practically inevitable, especially with changes in LNB temperature during long-term monitoring.

From this perspective, the use of an LNB with a PLL oscillator and LOF stability of ±10 kHz does not represent a mere qualitative improvement, but rather – for reception of carriers with SR below approximately 200 kSym/s – a technical precondition without which long-term stable, uninterrupted reception is not realistically achievable, regardless of the diameter of the reflector used.

5. Ultra-Narrow Carrier Bandwidth (Carrier Width = 0.120 MHz) and Its Consequences

A narrow occupied spectral bandwidth has two opposing consequences. On the one hand, it concentrates the carrier's radiated power into a narrow frequency interval, which, for a given satellite EIRP, increases the spectral power density (power per unit bandwidth) and therefore also the theoretically achievable carrier-to-noise ratio – this is the physical reason why even carriers with a comparatively low absolute radiated power can be demodulated with a surprisingly high SNR, given a sufficiently large receiving aperture (the author reports a measured peak SNR of 17.7 dB, a value with a substantial margin above the threshold typically required for a stable DVB-S Lock, which for QPSK modulation and a medium code rate generally lies somewhere in the range of 4–7 dB).

On the other hand, a narrow bandwidth places substantially higher demands on tuning accuracy and on the phase-noise quality of the oscillator used, since any phase noise in the vicinity of the carrier frequency occupies a relatively larger share of the total spectral width than in the case of a wideband carrier. Similarly, Doppler-like effects caused by minor drift in the satellite's geostationary position (in practice on the order of units to tens of Hz for a typical home reception setup) are relatively more significant for such a narrow carrier than for wideband DVB-S2 carriers on the order of units to tens of MSym/s.

6. The Necessity of Precise Manual Frequency Tuning in EBS Pro

A practical consequence directly follows from the preceding analysis, one that the author correctly takes into account in his procedure: manual entry of the carrier frequency in EBS Pro to a precision of three decimal places (i.e. at the kHz level – for example, 12,590.540 MHz rather than the rounded value of 12,590.5 MHz or 12,591 MHz). For a carrier with a bandwidth of 120 kHz, the difference between a rounded and a precise frequency value, on the order of hundreds of Hz to a few kHz, represents a non-negligible fraction of the demodulator's search window. Entering the frequency precisely to three decimal places means, in practice, that the demodulator does not need to „search“ a wider frequency range around the nominal value when acquiring Lock, which shortens the time to synchronisation and reduces the probability that the frequency synchronisation loop will „lock“ onto an adjacent noise or intermodulation product instead of the carrier itself.

This step is a typical example of how theoretical parameters (carrier bandwidth, LNB LOF stability) must also be translated into the practical configuration of the measurement/reception software – without this combination (a high-quality PLL oscillator plus precise manual frequency entry), even a theoretically sufficient signal energy budget would not guarantee a stable result.

7. Overview of the Analysed Carriers

The following table summarises the three radio carriers from the Eutelsat 16A satellite that were the subject of the author's long-term signal monitoring at the Lučenec site, using the minimum unit of proof of reception stability, t = 48 hours, applicable to the „In-Footprint Reception“ zone:

Frequency	Polarisation	SR (kSym/s)	Programme
12,590.540 MHz	V (vertical)	100	Radio Wrocław
12,589.555 MHz	V (vertical)	146	Radio Gdańsk
10,972.126 MHz	H (horizontal)	176	BNR Nieuwsradio

Table 2: Overview of the monitored radio carriers on the Eutelsat 16A satellite.

8. Extended 72-Hour Monitoring Unit for the SR = 100 kSym/s Carrier (Radio Wrocław)

The lowest symbol rate value examined in this study, SR = 100 kSym/s for the Radio Wrocław carrier on 12,590.540 MHz (V), represents the technically most demanding case among all three analysed carriers – which is precisely why the author subjected it to extended monitoring lasting t = 72 hours, instead of the standard base unit of t = 48 hours applicable to the „In-Footprint Reception“ zone. By extending the monitoring period by a further 24 hours (i.e. a further 86,400 measurement points at the usual sampling period of one point per second), the total volume of the continuous dataset increased to 259,200 consecutive measurement points.

According to the author's data, not a single point with loss of synchronisation (Lock) was recorded within this set of 259,200 measurement points, and the reception quality parameter Q in EBS Pro remained at a constant value of Q = 100 % throughout the entire measurement. The recorded peak signal-to-noise ratio of SNR = 17.7 dB represents a substantial margin above the threshold required to maintain Lock, which correlates with the explanation given above of the favourable spectral power density of a narrow-bandwidth carrier combined with the large 450 cm reflector aperture.

According to the author, the measurement period also included episodes of increased precipitation intensity on 11 and 12 September 2026 in the Lučenec area, documented by outputs from the Slovak Hydrometeorological Institute (shmu.sk). The fact that, according to the submitted documentation, Lock continuity and the Q value remained unchanged during these precipitation episodes is consistent with the expected behaviour of a system with a large antenna aperture: rain fade in the Ku band, at average Central European precipitation intensity and an elevation of around 34°, typically amounts to on the order of 1–3 dB, while the measured SNR margin (up to 17.7 dB at peak) provides ample headroom to absorb such short-term attenuation without falling below the Lock-loss threshold.

> *Note on the interpretation of the statistical weight of the data: The figure of 259,200 continuous measurement points is significant in demonstrating the continuity of a state (the absence of an outage within that particular, single observed time window), but it should be interpreted correctly – it does not represent 259,200 independent, statistically separate experiments, but a single continuous time record at a high sampling frequency. The scientific value of such a record lies in demonstrating that, within the given 72-hour window, under the given configuration and given weather conditions, no outage occurred – not that the probability of an outage is zero under all*

conceivable future conditions.

9. Discussion and Summary Interpretation

The results of the presented monitoring can be summarised in three interrelated technical conclusions. First, the energy budget in the „In-Footprint Reception“ zone, with an EIRP of 49–50 dBW, is not the limiting factor for carriers of this type – the 450 cm reflector diameter provides a substantial C/N margin that would be excessive for standard DVB-S/S2 carriers, but for extremely narrow-bandwidth carriers with SR below 200 kSym/s functions as insurance against short-term attenuation phenomena (precipitation, atmospheric scintillation). Second, within this SR range the key limiting factor becomes the quality of the signal chain downstream of the antenna – above all the stability of the LNB's LOF, which for carriers with a bandwidth on the order of 100–300 kHz must be at the level of units to low tens of kHz for the demodulator to reliably track the frequency offset. Third, the accuracy of manual frequency entry in the measurement/reception software at the kHz level is not a mere formality but a necessary practical step that reduces the burden placed on the receiver's frequency synchronisation loop.

The author's presented data thus provide convincing, well-documented empirical evidence that, with a correctly designed combination of a large receiving aperture, a highly stable PLL LNB oscillator, and precise software tuning, long-term stable, uninterrupted reception of carriers with SR as low as 100 kSym/s from the Eutelsat 16A satellite in Central Europe is realistically achievable, even under transient adverse weather conditions. For a full generalisation of this conclusion to other sites, other LNB types, or more extreme precipitation events (e.g. intense storms with high atmospheric water content), it would be desirable to supplement this study with comparable measurements from further independent stations and with longer-term climatic statistics for the site in question.

10. Conclusion

This case study confirms that reception of radio carriers with extremely low symbol rate (SR = 100–176 kSym/s) from the Eutelsat 16A satellite, within the guaranteed „In-Footprint Reception“ coverage zone, is technically reliably achievable with a correctly designed reception system. The measurement documentation of the author, Roman Dávid – specifically the continuous 72-hour record with 259,200 measurement points and not a single Lock outage for the Radio Wrocław carrier (SR = 100 kSym/s) – represents a high-quality and well-documented contribution to the practical understanding of the limits of current consumer satellite reception equipment for narrow-bandwidth carriers in the Ku band.

11. References and Sources

Technical Standards

- ETSI EN 300 421 V1.1.2: „Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services". European Telecommunications Standards Institute.

- ETSI EN 302 307: „Digital Video Broadcasting (DVB); Second generation framing structure, channel coding and modulation systems for Broadcasting, Interactive Services, News Gathering and other broadband satellite applications (DVB-S2)". European Telecommunications Standards Institute.

- ITU-R Recommendation P.618: „Propagation data and prediction methods required for the design of Earth-space telecommunication systems". International Telecommunication Union – section on rain attenuation in bands above 10 GHz.

- ITU-R Recommendation S.465: „Reference radiation pattern for earth station antennas in the fixed-satellite service for use in coordination and interference assessment". International Telecommunication Union.

Technical Literature

- Pratt, T., Bostian, C. W., Allnutt, J. E.: Satellite Communications, 2nd ed., John Wiley & Sons, 2003. (Chapters on link budget, Ku-band attenuation, and the effect of oscillator phase noise on demodulation.)

- Maral, G., Bousquet, M.: Satellite Communications Systems: Systems, Techniques and Technology, 5th ed., John Wiley & Sons, 2009.

- Tomasi, W.: Electronic Communications Systems: Fundamentals Through Advanced, 5th ed., Pearson Prentice Hall, 2004. (Chapter on phase-locked loops – PLL and frequency synthesis in LNBs.)

- Rice, M.: Digital Communications: A Discrete-Time Approach, Pearson Prentice Hall, 2009. (Theoretical basis of the relationship between symbol rate, roll-off factor and occupied bandwidth.)

Data Sources and Online Tools Used in the Study

- www.dxsatcs.com – the author's own portal, Roman Dávid, containing the original signal monitoring data, a description of the HW/SW configuration (TBS 5927, EBS Pro), and the methodology for the units of proof of reception stability (t = 48 h / t = 72 h).

- www.dishpointer.com – an online tool for calculating azimuth, elevation and LNB rotation angle (skew) for a given geographic location and selected satellite; source of the geometric data given in Table 1.

- www.shmu.sk – the Slovak Hydrometeorological Institute; source of meteorological data on precipitation intensity in the Lučenec area on 11 and 12 September 2026, used in assessing the effect of rain fade on the course of the monitoring.

- Lyngsat (www.lyngsat.com) – a public database of frequency plans and transponder occupancy for the Eutelsat 16A satellite, used as an orientational reference source when verifying the technical parameters of the monitored carriers.

Note: this list includes general technical standards and technical literature from the field of satellite communications that form the theoretical framework for the interpretation of the results in this