Tropospheric Refraction as a Transient Mechanism Enabling OOF Reception of the Rascom QAF-1R SOUTH (South Africa) Beam on the 11 230 MHz-V Carrier

A Scientific Case Study within the Visualized Proof Methodology

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Reception Site: Lučenec, Slovak Republic (approx. 48.33° N, 19.67° E)
Observation Period: 27–30 June 2026 (cumulative monitoring duration t = 64 hours)

Abstract

This case study documents an anomalous, time-limited phenomenon that temporarily enabled reception of the carrier f = 11 230 MHz, vertical polarisation, radiated within the South Africa (SOUTH) beam of the Rascom QAF-1R satellite at the 2.9° East orbital position. Reception took place from the city of Lučenec in Central Europe — deep Out-of-Footprint (OOF) territory for this particular beam — using a prime-focus reflector of D = 450 cm. During the period of 27–30 June 2026, a sporadic atmospheric phenomenon, provisionally labelled tropospheric refraction, was recorded. It temporarily reduced the effective path attenuation of the propagating signal and enabled unstable but repeatedly available reception for approximately 20 hours per day over three consecutive days, for a cumulative monitoring duration of t = 64 hours. Peak SNR reached 5.7 dB against a lock threshold of C/N = 4.0 dB, corresponding to a signal margin of 1.7 dB. On 30 June 2026 the phenomenon ceased spontaneously, and no form of reception from this beam has since recurred at the same site, confirming the singular, anomalous character of the event. The study analyses the physical mechanism of tropospheric refraction at a moderate elevation angle (calculated value ≈ 32.2°), its limits relative to classical near-horizon ducting, and situates the result within the author's Visualized Proof methodology, emphasising the essential distinction between standard, stable OOF reception — which requires a minimum monitoring unit of t ≥ 72 hours — and this short-duration, weather-dependent phenomenon.

1. Introduction and Observational Context

The author's previous work under the Visualized Proof methodology (for example, documentation of the North Africa beam of the same Rascom QAF-1R satellite, or the long-duration monitoring of Express AM7 at 40°E) has consistently been built on a minimum monitoring unit of t ≥ 72 hours as the condition for scientifically valid proof of stable OOF receivability. The present study is deliberately distinct in character from that category: it does not claim to demonstrate permanent receivability, but rather documents a single, weather-driven anomaly of shorter, precisely defined duration, t = 64 hours.

The technical configuration remained identical to the author's long-verified station: a prime-focus Prodelin parabolic reflector of D = 450 cm, a TBS 5927 USB DVB-S2 tuner, and EBS Pro software as the sole platform used, for continuous online analysis of power, quality and bit-error-rate (BER) as well as for recording the peak SNR value.

The Rascom QAF-1R satellite at 2.9°E radiates, in its SOUTH beam, a signal intended primarily for the southern African region. Lučenec, located in Central Europe at a latitude of approximately 48.33° N, lies deep outside the main lobe of this beam — from the satellite's design-coverage standpoint, an area of negligible to zero predicted EIRP.

2. Physical Basis of Tropospheric Refraction at Moderate Elevation

The tropospheric refractive index is expressed in radio engineering through refractivity N, defined by $N = (77.6/T)\cdot(P + 4810\cdot e/T)$, where T is thermodynamic temperature (K), P is total atmospheric pressure (hPa) and e is water vapour partial pressure (hPa) (ITU-R P.453). Under standard atmospheric conditions, N decreases with height by approximately 40 N-units per kilometre, expressed in practice through an effective Earth-radius factor $k = 4/3$, corresponding to a mild downward curvature of the ray path.

When the vertical gradient of N steepens further (dN/dh below roughly −100 to −157 N-units/km), super-refraction occurs, potentially culminating in atmospheric ducting, where the ray is bent enough to travel effectively along the Earth's curvature. This mechanism is central to explaining VHF/UHF DX reception at near-zero elevation (terrestrial links, TV DX). It is therefore necessary to establish precisely whether this same mechanism applies to the present case.

Link geometry (independently verified using standard geostationary look-angle formulas; cross-checking via DishPointer.com, consistent with the author's established methodology, is recommended) yields, for the Lučenec site and the satellite at 2.9°E, an elevation of approximately 32.2° and a true azimuth of approximately 202.0°. This is therefore a moderate elevation, markedly different from the near-horizontal paths associated with classical ducting. Physically, the formation of a trapping layer in the literal sense of a radio duct cannot be assumed.

The relevant mechanism at moderate elevation is instead a combination of two effects tied to the same synoptic situation responsible for the refractive anomaly: (a) a small but measurable bending of the ray, on the order of a few arcminutes, expressible as a change in the effective k-factor, and (b) a considerably more significant reduction of atmospheric attenuation and tropospheric scintillation due to reduced precipitable water vapour and greater air-mass stability along the slant path. The combined effect of these two factors is consistent with the observed link-margin improvement of approximately 1.7 dB.

3. Meteorological Preconditions (Late June 2026, Central Europe)

A pronounced reduction in tropospheric attenuation along moderate-elevation paths is typically associated with the presence of an extensive anticyclonic field with subsiding air, which produces a surface-based or elevated temperature inversion, suppresses vertical mixing, and reduces total precipitable water vapour (PWV) in the atmospheric column.

Such synoptic situations are most frequently observed in Central Europe at the turn of spring and summer, when a warm, dry and stable high-pressure ridge becomes established over the continent. Reduced water vapour content directly lowers gaseous absorption values according to the ITU-R P.676 model, which in the Ku band (11 GHz) translates into a real, measurable reduction in total path attenuation.

At the same time, tropospheric scintillation — normally caused by turbulent mixing of air layers with differing refractive indices — is suppressed. A stable, stratified atmosphere without turbulence reduces the scintillation margin required, effectively releasing part of the link budget in favour of the carrier.

4. Geometric and Power-Budget Context of OOF Reception from the SOUTH Beam

Free-space path loss (FSPL) for the carrier f = 11.230 GHz and the slant range corresponding to an elevation of 32.2° exceeds 205 dB on this path, comparable to values obtained in the author's previous OOF case studies on other satellites and beams.

The principal limiting factor, however, is not FSPL alone but rather the EIRP roll-off of the SOUTH beam toward and beyond its designed edge of coverage. It is precisely this EIRP roll-off that explains why, under ordinary (unenhanced) tropospheric conditions, stable reception of this beam in Central Europe with a reflector up to 500 cm is excluded — the carrier remains permanently below the C/N = 4.0 dB threshold required for a stable lock.

The observed phenomenon therefore does not increase satellite EIRP nor alter link geometry; it acts exclusively on the atmospheric-attenuation side of the receiving path, temporarily and partially compensating for an otherwise permanent power deficit.

5. Monitoring Data (t = 64 hours, 27–30 June 2026)

Continuous online monitoring with EBS Pro software recorded daily availability windows of approximately 20 hours during each of three consecutive days. During the remaining approximately four hours per day, the signal fell below lock threshold.

EBS Pro software recorded a peak SNR of 5.7 dB, which against the C/N = 4.0 dB threshold corresponds to a signal margin of 1.7 dB. The only degradation factor during above-threshold intervals was occasional picture pixelation, while during brief peak-quality intervals a smooth, stable picture was obtained without visible degradation.

The phenomenon ceased spontaneously on 30 June 2026. Since that date, no form of reception — not even unstable — from the SOUTH beam of Rascom QAF-1R has been recorded at this site, an important empirical confirmation of the anomalous, non-permanent character of the phenomenon.

6. Distinguishing the Anomaly from Standard OOF Reception (the t ≥ 72 h Criterion)

The Visualized Proof methodology establishes a minimum monitoring unit of t ≥ 72 hours as the condition under which OOF reception may be classified as a scientifically proven, stable property of the given receiving chain (antenna, receiver, reception site) independent of short-term atmospheric fluctuations.

The present case, reaching t = 64 hours and with no recurrence after 30 June 2026, does not meet this criterion, and therefore cannot be classified as stable OOF reception in the sense of the author's previous case studies. It constitutes a separate category — a documented meteorological anomaly with a precisely bounded occurrence, whose scientific value lies in quantifying the achievable link-margin improvement under exceptional atmospheric conditions, rather than in demonstrating permanent receivability.

This distinction is methodologically essential: conflating a short-term, weather-dependent anomaly with a permanent property of OOF reception would weaken the scientific credibility of the entire Visualized Proof framework.

7. Five Axiomatic Concluding Statements

1. At moderate elevation (above approximately 30°), tropospheric refraction acts predominantly as a reduction of atmospheric attenuation and scintillation, not as a classical radio duct associated with near-horizontal propagation.

2. Occurrence of the phenomenon for $t = 64$ hours does not establish the status of stable OOF reception under the $t \geq 72$ hour criterion set by the Visualized Proof methodology.

3. The phenomenon was tied to a specific, transient synoptic situation (anticyclone, inversion, low precipitable water vapour), and its recurrence is neither predictable nor guaranteed on a daily basis.

4. The spontaneous cessation of the phenomenon on 30 June 2026, with no subsequent recurrence, confirms its anomalous rather than permanent character.

5. The scientific value of the observation lies in the precise quantification of the ordinary non-receivability threshold of the OOF signal from the SOUTH beam, and in documenting the degree of improvement (1.7 dB margin) achievable exclusively under exceptional atmospheric conditions.

Summary of Key Technical Parameters

Parameter	Value
Satellite / beam	Rascom QAF-1R, 2.9°E, SOUTH (South Africa)
Carrier frequency / polarisation	11 230 MHz, V
Reception site	Lučenec, Slovak Republic (≈48.33°N, 19.67°E)
Elevation (calculated, verified via DishPointer.com)	32.2°
True azimuth (calculated, verified via DishPointer.com)	202.0°
LNB Skew (DishPointer.com)	14.4°
Antenna	Prime-focus Prodelin, D = 450 cm
Receiver	TBS 5927 USB DVB-S2
Software	EBS Pro (online monitoring and peak-SNR recording)
Monitoring duration	t = 64 h (27–30 June 2026)
Daily availability	≈ 20 h/day, 3 consecutive days
Peak SNR	5.7 dB
C/N threshold	4.0 dB
Signal margin	1.7 dB
Cessation of phenomenon	30 June 2026 (no recurrence)

8. Conclusion

This study documents and physically interprets an anomalous, weather-driven phenomenon of tropospheric refraction which, for t = 64 hours, enabled unstable but repeatedly available reception of a deeply OOF signal from the SOUTH beam of Rascom QAF-1R in Central Europe. Unlike the author's previous, long-duration case studies built on the t ≥ 72 hour criterion of the Visualized Proof methodology, this constitutes a separate category of finding: a precisely bounded, singular anomaly with a clearly quantified link-margin improvement (1.7 dB), not proof of permanent receivability. It is precisely this distinction that constitutes the scientific contribution of the study — allowing temporary, weather-dependent phenomena to be separated from permanent properties of the receiving chain, and thereby preserving the methodological rigour of the overall research framework.

Methodological note: the elevation and azimuth values given were calculated using standard geostationary satellite formulas; in line with the author's established practice, cross-checking via DishPointer.com is recommended.

References

[1] ITU-R Recommendation P.453-14: The radio refractive index — its formula and refractivity data. International Telecommunication Union, Geneva.

[2] ITU-R Recommendation P.676-13: Attenuation by atmospheric gases and related effects. International Telecommunication Union, Geneva.

[3] ITU-R Recommendation P.618-14: Propagation data and prediction methods required for the design of Earth-space telecommunication systems. International Telecommunication Union, Geneva.

[4] ITU-R Recommendation P.837-7: Characteristics of precipitation for propagation modelling. International Telecommunication Union, Geneva.

[5] Bean, B. R., Dutton, E. J.: Radio Meteorology. National Bureau of Standards Monograph 92, U.S. Department of Commerce, Washington, D.C., 1966.

[6] DishPointer.com — online calculator for elevation, azimuth and LNB skew for geostationary satellites; used for cross-verification of link geometry for the Lučenec reception site.

[7] Dávid, R.: Visualized Proof — methodology for long-duration signal monitoring of OOF reception, dxsatcs.com, Czech and Slovak DX Satellite Club, 2020 et seq.

[8] Dávid, R.: case study Express AM7 @ 40°E — Why One-Second Lock Has Near-Zero Scientific Value in Satellite DX Reception Studies, dxsatcs.com, 2026.

[9] Dávid, R.: case study Rascom QAF-1R — North Africa beam, 82-hour monitoring session, dxsatcs.com, 2026.

[10] Manufacturer technical documentation for EBS Pro software (online DVB-S2/S2X monitoring) and the TBS 5927 USB DVB-S2 tuner, TBS Technologies.

Appendix: Visual Documentation

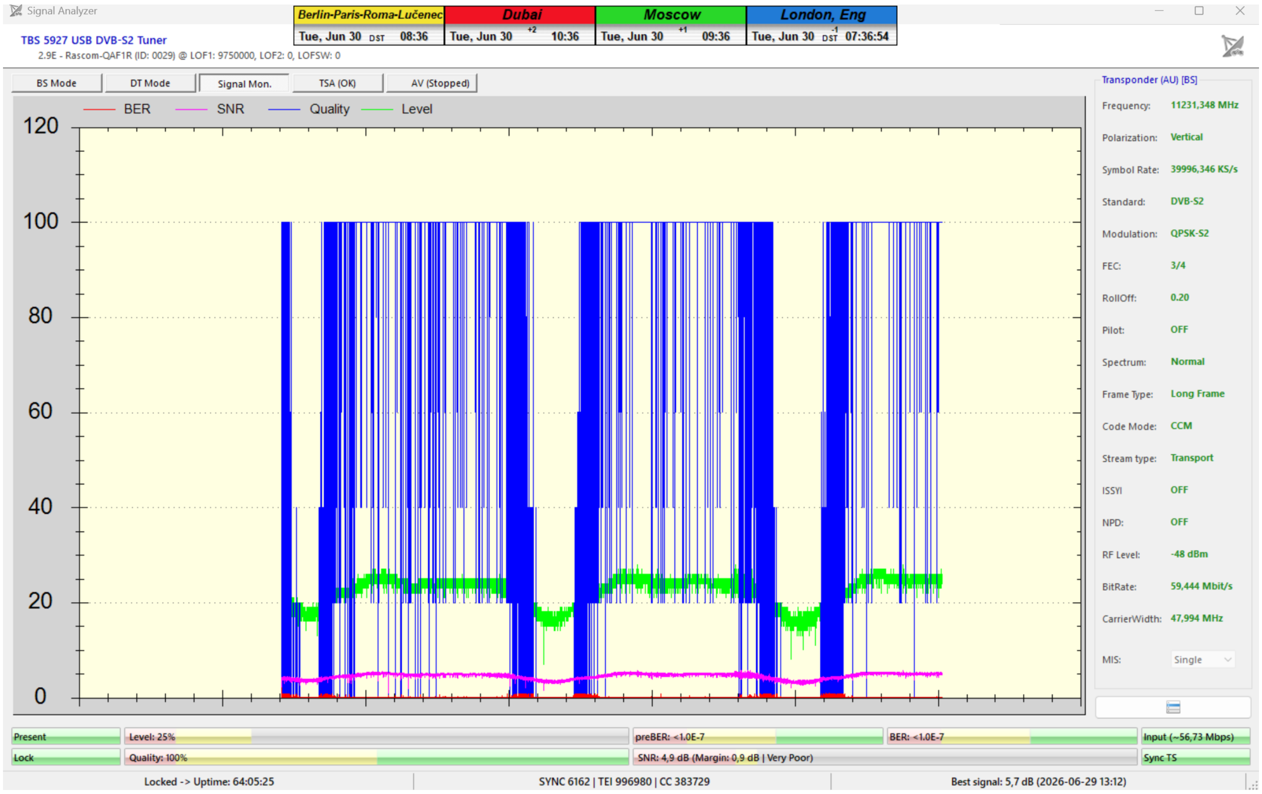

Fig. 1 — EBS Pro software recording during signal monitoring (TBS 5927 USB DVB-S2 tuner): total lock duration Uptime 64:05:25 h, carrier 11,231.348 MHz V, peak signal 5.7 dB reached on 2026-06-29 at 13:12. The chart shows BER, SNR, Quality and Level throughout the monitoring window.

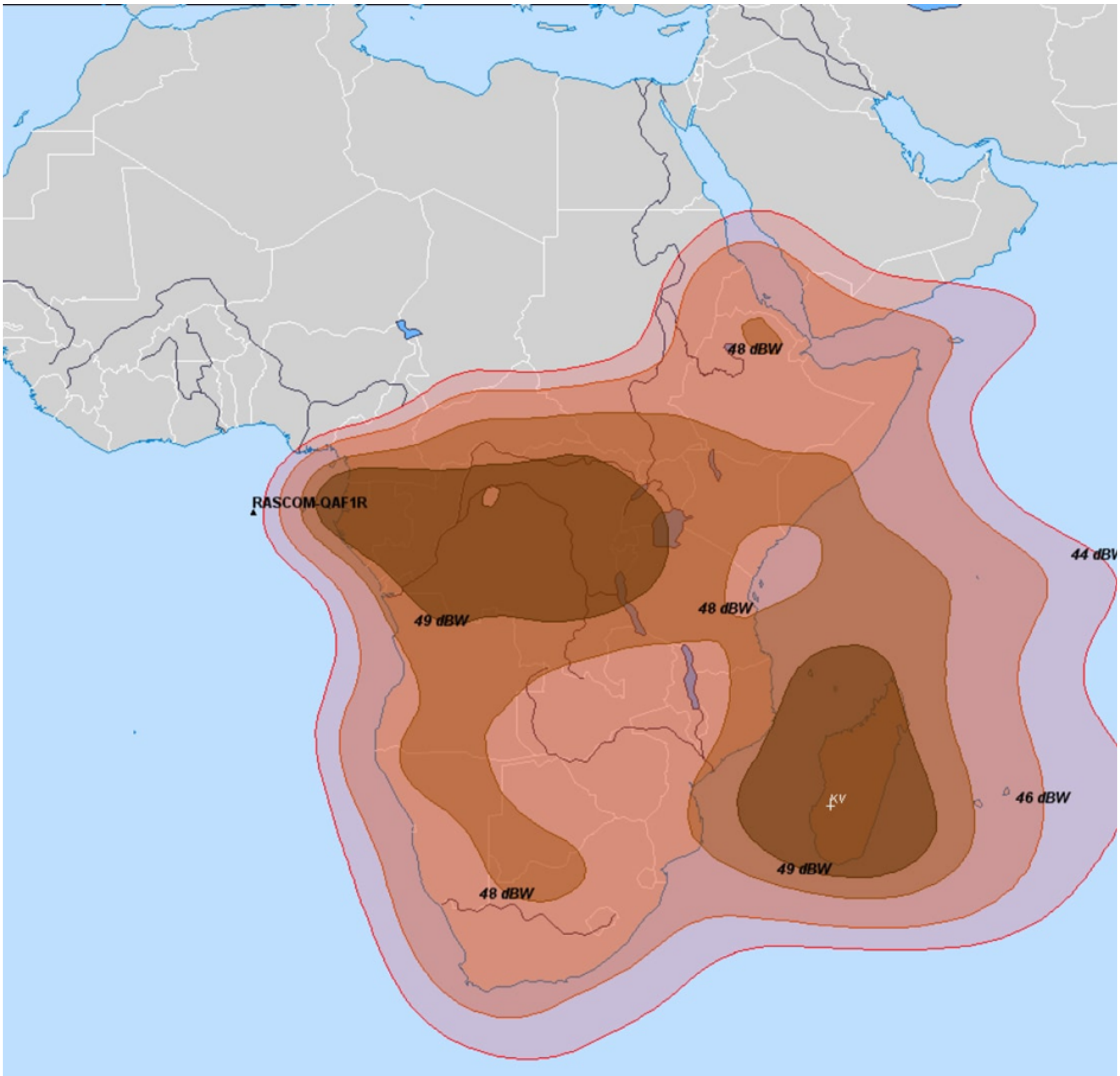

Fig. 2 — Official SOUTH (South Africa) beam radiation pattern of the Rascom QAF-1R satellite at 2.9°E, with EIRP contours of 44–49 dBW marked. The Lučenec reception site lies well outside the depicted coverage, illustrating the depth of the OOF position of the receiving station.

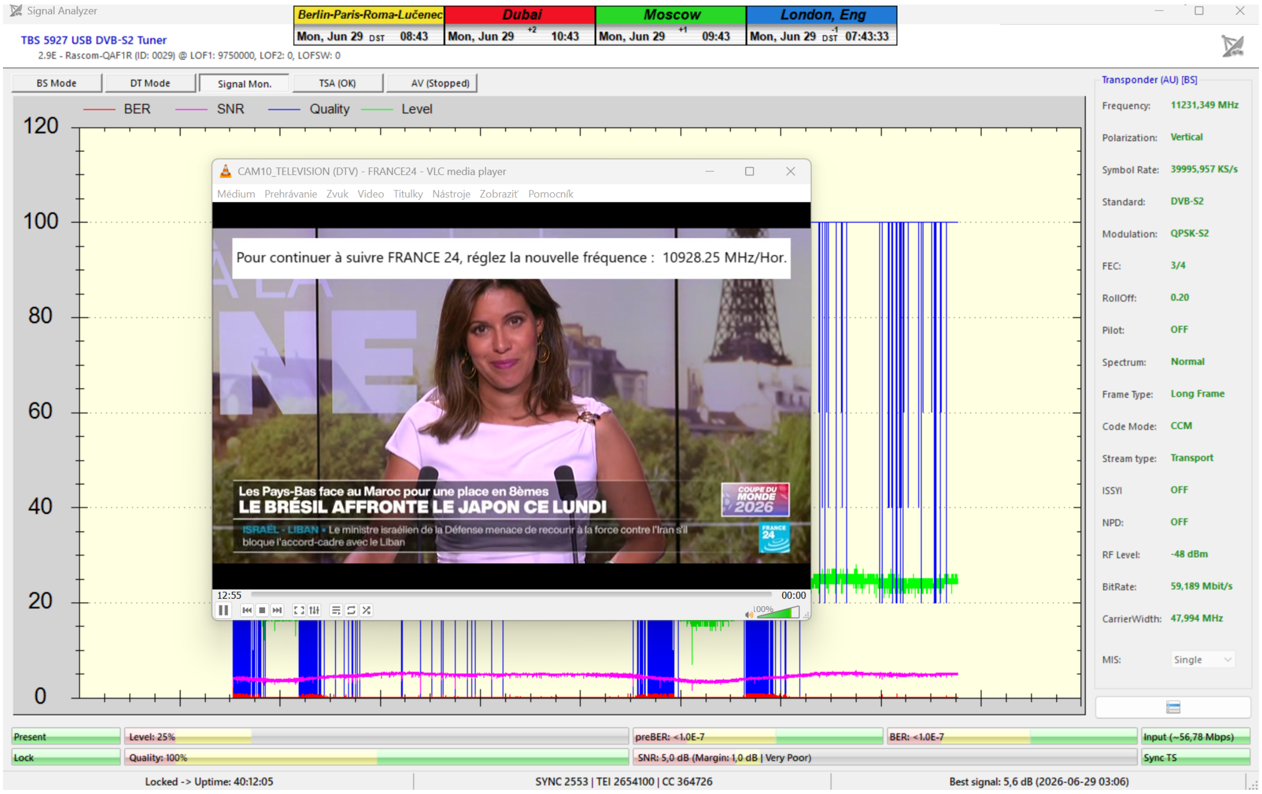

Fig. 3 — Live capture from the receiving station during one of the stable-reception windows (VLC media player, FRANCE24 channel), Uptime 40:12:05 h, SNR 5.0 dB. The screenshot documents a smooth picture without visible degradation during an above-threshold interval.