

# THE PRESIGNAL EM SENTINEL

A Camera-Free Long-Duration Electromagnetic Monitoring Node for Geological  
Plasma Discharge Research

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## ABSTRACT

We describe the Presignal EM Sentinel — a camera-free, solar-powered, continuously operating electromagnetic monitoring node designed for long-duration deployment at geological plasma discharge candidate sites. The instrument integrates ten independent sensor channels covering the ULF magnetic, atmospheric electric field, ground conductivity, ionizing radiation, atmospheric ion density, ozone, infrasound, groundwater conductivity, GPS timing, microseismic, broadband radiofrequency, and optical emission spectrum domains. The design is derived from the Geological Pathway Diversity Model (GPDM) framework, which classifies six geological mechanisms producing atmospheric plasma discharge and four state variables governing discharge probability. The EM Sentinel is designed to continuously monitor all GPDM-relevant channels simultaneously, building the multi-year site-specific baseline required for statistically meaningful correlation analysis between geological state variables and observed discharge events. The complete instrument deploys for approximately \$516 USD in commercially available components, operates on 20W of solar power, and requires no specialist installation. All data is GPS-timestamped and uploads via WiFi to the Presignal anomaly intelligence dashboard. This preprint provides complete component specifications, assembly guidance, deployment protocol, scientific rationale for each sensor channel, and network configuration for multi-site correlation research. The EM Sentinel is the electromagnetic backbone of the Presignal global monitoring network and is released under CC BY 4.0 for open scientific use.

**Keywords:** geological plasma discharge, earth lights, aerial plasma phenomena, ULF monitoring, electromagnetic field monitoring, APP detection, GPDM, ball lightning, Hessdalen, citizen science instrumentation

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## 1. INTRODUCTION

Anomalous light phenomena — persistent luminous orbs, recurring earth lights, earthquake lights, and related aerial plasma phenomena (APP) — have been documented at specific geological sites worldwide for centuries. Despite substantial observational records and peer-reviewed theoretical frameworks proposing geological electrical mechanisms as the origin of these phenomena, systematic multi-channel instrumented monitoring of candidate sites remains rare. The primary obstacle has been the cost and complexity of deploying research-grade electromagnetic monitoring equipment in remote field conditions for extended periods.

The Geological Pathway Diversity Model (GPDM) — published on EarthArXiv as Preprint 12638 (Carter, 2026a) — classifies six geological mechanisms capable of producing atmospheric plasma discharge: p-hole/Freund charge carrier mechanism, piezoelectric discharge, triboelectric discharge, electrochemical natural battery mechanism, radon and dusty plasma pathway, and seismoelectric/hydroelectric discharge. The model proposes four state variables governing discharge probability: stress rate (V1), charge carrier density (V2), atmospheric state (V3), and circuit geometry (V4). Each mechanism produces a characteristic electromagnetic

signature detectable by specific sensor types prior to, during, and following a discharge event.

The EM Sentinel was designed specifically to monitor all GPDM-relevant channels simultaneously, continuously, and automatically — producing the long-duration site-specific baseline that distinguishes genuine geological discharge signatures from environmental noise and enables statistically testable correlations with external forcing variables including solar activity, tidal stress, and regional seismicity.

The instrument is also directly relevant to the electroball plasma model proposed by Galán Santos and Koren (2024) in the Journal of Scientific Exploration, whose experimental proposals for in-situ characterization specify electromagnetic field meters, Geiger counters, spectrometers, barometers, and hygrometers as the minimum instrument set. The EM Sentinel channel selection provides all of these instrument types in a single integrated package.

This preprint provides the complete technical specification of the EM Sentinel as an open-access instrument design for use by the scientific community, citizen science investigators, and field researchers working in the geological plasma discharge domain.

## 2. SCIENTIFIC RATIONALE FOR CHANNEL SELECTION

The EM Sentinel channel selection is derived directly from the GPDM pathway and variable structure. Channels are classified by detection role: **Primary Detection** channels produce the core event signature that constitutes scientific evidence of a discharge event; **State Variable** channels quantify the geophysical conditions at the moment of any event, enabling GPDM pathway classification; and **Background/Baseline** channels provide the long-duration environmental context required to distinguish genuine anomalies from noise. All three roles are required for a scientifically publishable result.

Sensor Channel	GPDM Role	Detection Role	Pre-Event Signal	Event Signature	Scientific Value of a Positive Reading
ULF Magnetometer 0.01–12 Hz	Pathway 1 (p-hole) primary	<b>PRIMARY DETECTION</b>	Elevated pulse frequency	Unipolar pulse >100 pT, 1–30 sec	Distinguishes geological discharge from lightning (which produces bipolar signature). A confirmed unipolar pulse correlated with other channels is the single strongest publishable indicator.
Electric Field Meter EFM	All pathways / V3	<b>PRIMARY DETECTION</b>	Sustained elevation >500 V/m	Sudden collapse from peak — discharge occurring	EFM collapse is the highest-confidence real-time discharge indicator. Captures the charge release event directly. Galán Santos & Koren (2024) identify EFM as essential for electroball characterization.
Ground Conductivity Stakes	Pathway 1 (p-hole) primary	<b>PRIMARY DETECTION</b>	Slow multi-day rise	Sustained voltage >20mV differential	Direct measurement of p-hole surface current — the specific charge carrier proposed by Freund (2011). A sustained differential correlated with ULF activity constitutes direct pathway evidence.
RTL-SDR 500kHz–1.7GHz	Pathway 3 (triboelectric RF)	<b>PRIMARY DETECTION</b>	None	Broadband burst 120–1500 kHz	Captures the radiofrequency emission signature of discharge events. Broadband burst correlated with ULF and EFM events provides multi-domain electromagnetic confirmation.

AMS AS7341 Spectral Sensor	Optical emission fingerprint	<b>PRIMARY DETECTION</b>	None	Wavelength signature of plasma mineral composition	Captures optical emission spectrum at the moment of any visible discharge without requiring a camera. Galán Santos & Koren (2024) note many electroballs are invisible at visible wavelengths — the AS7341 captures emission regardless of visual brightness. Emission spectrum identifies plasma mineral composition, providing geological pathway indicator from optical data alone.
Geiger Counter + SBM-20	Pathway 5 (radon/dusty plasma)	<b>STATE VARIABLE</b>	Radon elevation	Saturation or Forbush Decrease	Quantifies ionizing radiation environment at time of event. Elevated CPM correlated with discharge activity supports Pathway 5 (radon/dusty plasma). Forbush Decrease correlated with NASA DONKI CME catalog links event to solar forcing.
Gerdien Ion Counter	Variable 3 (atmospheric state)	<b>STATE VARIABLE</b>	Ion count elevation	>1000 ions/cm <sup>3</sup> sustained	Quantifies atmospheric ionization state at time of event. Required for V3 classification in GPDM. Elevated ion density correlated with discharge activity provides atmospheric state evidence for pre-event charge accumulation.
MQ131 Ozone Sensor	All pathways (corona byproduct)	<b>STATE VARIABLE</b>	Background rise	>80 ppb — active corona discharge	Ozone is a direct chemical byproduct of corona discharge. Detection above threshold provides chemical confirmation of discharge activity independent of EM channels. Corroborating evidence across EM + chemical domains strengthens publishability.
ICS-40618 Infrasound Mic	Variable 1 (stress rate)	<b>STATE VARIABLE</b>	None	Tonal signal 4–8 Hz — geological stress acoustic	Captures sub-audible geological stress acoustic emissions. A 4–8 Hz tonal signal correlated with ULF pulse activity provides acoustic confirmation of geological stress — the physical mechanism driving discharge probability.
ADXL355 Accelerometer	Variable 1 (microseismic)	<b>STATE VARIABLE</b>	None	Micro-seismic burst correlated with ULF	Captures microseismic activity at the deployment site. Correlation between micro-seismic bursts and ULF pulse events provides mechanical-to-electromagnetic coupling evidence — the core physical claim of the p-hole pathway.
TDS/EC Water Probe	Pathway 6 (seismoelectric)	<b>BACKGROUND/BASELINE</b>	60-day conductivity drift	Anomaly >15% from 30-day baseline	Groundwater conductivity is a 60-day precursor indicator for Pathway 6. Slow drift correlated with later discharge activity provides the longest-lead precursor signal in the instrument stack — potentially the most valuable data for earthquake light prediction research.

NEO-6M GPS + SNR Proxy	Variable 1 (ionospheric TEC)	<b>BACKGROUND/BASELINE</b>	None	SNR degradation — ionospheric disturbance	GPS satellite SNR degradation provides a low-cost proxy for ionospheric TEC disturbance — a known precursor to large discharge events. Cross-correlation with USGS seismic catalog and NASA DONKI CME catalog contextualizes events within space weather forcing.
Bosch BME280 (Temp/Humidity/Pressure)	Variable 3 (atmospheric state)	<b>BACKGROUND/BASELINE</b>	None	Continuous environmental logging	Provides the atmospheric state record required to rule out weather-driven false positives in EFM and ion counter readings. Essential for distinguishing geological charge accumulation from thunderstorm-driven EFM elevation.

## 2.1 Event Capture Hierarchy

Not all threshold crossings produce equivalent scientific output. The following hierarchy defines what constitutes a publishable event vs. background data, based on the number and type of channels active at the time of a reading:

Event Class	Channel Combination	Scientific Status	What You Have in Hand
Class A — Full Confirmation	ULF unipolar pulse + EFM collapse + ground stake elevation + RTL-SDR burst, simultaneous within 500ms	Publishable multi-domain electromagnetic discharge event	Four independent EM channels confirm a single discharge event. Pathway classification possible. Suitable for submission to geophysics or atmospheric physics journal with baseline context.
Class B — Strong Evidence	Any two Primary Detection channels simultaneous + one State Variable elevated	Strong evidence — requires corroboration	Dual-domain EM confirmation with geophysical state context. Publishable as a case report with appropriate caveats. Strengthens significantly with multiple occurrences at same site.
Class C — Candidate Event	Single Primary Detection channel threshold crossing + ozone or ion count elevated	Candidate event — insufficient alone	Single-channel EM + chemical corroboration. Not independently publishable but valuable for statistical analysis across a long deployment. Multiple Class C events with consistent state variable patterns constitute a dataset.
Class D — Background Data	State variable or baseline channels only — no Primary Detection threshold crossed	Essential scientific infrastructure	The baseline record that makes Class A–C events meaningful. Without Class D data, no anomaly can be distinguished from normal site variation. A 12-month Class D record is a scientific contribution in its own right for an unmonitored candidate site.

## 3. COMPLETE COMPONENT SPECIFICATION

All components are commercially available globally. Temperature ratings are verified against manufacturer datasheet specifications. Alibaba sourcing reduces component costs by 40–60% for bulk orders at equivalent specification.

Component	Cost USD	Temp Rating	Category	Notes
Raspberry Pi Zero 2W	\$15	0°C to +70°C	Core controller	Brain of system. Runs all logging software, manages WiFi upload, controls GPIO.
Samsung PRO Endurance 128GB microSD	\$22	–25°C to +85°C	Storage	Continuous write rated — essential. Standard cards fail within months of continuous logging.
Bosch BME280 Temp/Humidity/Pressure	\$10	–40°C to +85°C	Environmental	Temperature, humidity, barometric pressure — GPDM Variable 3 atmospheric state monitoring. Required to rule out weather false positives.

u-blox NEO-6M GPS module	\$10	−40°C to +85°C	Timing + proxy	Precise UTC timestamping for cross-channel correlation. Satellite SNR proxy for ionospheric TEC disturbance.
DIY ULF coil (ferrite rod + LT1677 op-amp + MCP3208 ADC)	\$35	−40°C to +85°C (op-amp rated)	Primary EM	2000 turns 0.2mm wire on 10cm ferrite rod. Primary discharge detection channel. Wind, conformal coat, mount horizontal N-S.
DIY Gerdien tube ion counter + brushless fan	\$45	Fan: −30°C rated	Ion density	Positive and negative air ion density. State Variable 3. Brushless fan draws air continuously through tube.
Boltek EFM-100 Electric Field Meter	\$200	Heater mitigated below −10°C	Primary EM	Most reliable EFM option. EFM collapse is the highest-confidence real-time discharge indicator. DIY alternative at \$50 with reduced accuracy.
CAJOE RadiationD Geiger + SBM-20 tube swap	\$25	SBM-20: −40°C	Radiation	Stock tube works to 0°C. SBM-20 rated to −40°C — mandatory cold climate swap. Pathway 5 state variable.
ICS-40618 MEMS infrasound microphone	\$10	−40°C to +85°C	Acoustic	Sub-20 Hz geological acoustic. State Variable 1 stress rate. Mount inside enclosure with port tube to exterior.
ADXL355 3-axis accelerometer	\$20	−40°C to +125°C	Seismic	Microseismic ground vibration. State Variable 1. Mount to enclosure base plate — rigid coupling to ground essential.
MQ131 ozone sensor	\$15	−20°C to +50°C	Atmospheric	Corona discharge chemical byproduct. Chemical confirmation channel independent of EM readings. Requires 48-hour burn-in.
Copper ground stakes x2 + differential amplifier circuit	\$5	Unlimited	Primary EM	30cm copper rods, 1.5m apart, perpendicular to nearest fault line. Direct p-hole surface current measurement — Pathway 1 primary evidence.
TDS/EC water probe	\$12	−10°C to +60°C	Pathway 6	60-day precursor monitoring channel. Slow conductivity drift is the longest-lead precursor indicator in the instrument stack.
AMS AS7341 11-channel spectral sensor	\$15	−40°C to +85°C	Optical emission	Plasma emission fingerprint without camera. Captures optical signature even for electroballs invisible at visible wavelengths (Galán Santos & Koren, 2024). Identifies mineral composition of plasma.
RTL-SDR V4 dongle	\$30	−40°C to +85°C	Broadband RF	500 kHz–1.7 GHz. Primary RF emission detection channel. 120–1500 kHz range most relevant for triboelectric discharge.
20W flexible solar panel	\$30	−40°C to +85°C	Power	Primary power. 20W sufficient for continuous ~3W average draw of EM Sentinel.
LiFePO4 20Ah battery + BMS	\$60	Discharge: −20°C to +60°C	Power	MANDATORY chemistry. Never substitute LiPo or Li-ion. Safe below freezing.
Victron SmartSolar MPPT 75/10 charge controller	\$65	−30°C to +60°C	Power	Victron specifically — reliability proven in remote deployments.
5W PTC ceramic heater + MOSFET switch	\$12	Self-regulating	Thermal management	Mandatory for deployment below −10°C. Pi controls via GPIO from BME280 reading.
5V buck converter LM2596	\$5	−40°C to +85°C	Power regulation	Steps 12V battery to 5V rail for Pi and sensors.
IP67 ABS weatherproof enclosure	\$35	−40°C to +85°C	Housing	Paint white or reflective wrap — reduces internal temperature 15–20°C in summer.
Silica gel desiccant x4 + conformal coating	\$15	N/A	Weatherproofing	Replace desiccant monthly. Conformal coat all circuit boards before sealing.
Miscellaneous: wire, terminals, standoffs, grommets	\$15	N/A	Hardware	22 AWG wire throughout. Stainless steel hardware only — no galvanized with copper stakes.

TOTAL	~\$516 USD	—	—	Alibaba sourcing reduces to ~\$200–250 at volume. DIY EFM saves additional \$150.
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**LiFePO4 battery chemistry is mandatory. LiPo and Li-ion batteries are unsafe below –20°C, cannot be charged below 0°C without active thermal management, and must not be substituted in field deployments. LiFePO4 is heavier but thermally stable and purpose-built for remote autonomous operation.**

#### 4. DEPLOYMENT PROTOCOL

##### 4.1 Site Qualification

The GPDM Field Operations Manual (Carter, 2026b) provides a complete five-step site qualification protocol. In summary: the candidate site must show at least one documented geological pathway mechanism in the local geology, have a historical record of anomalous light observations, not be fully explained by conventional atmospheric or astronomical phenomena, have accessible groundwater or surface water within 5 km, and be free of major artificial electromagnetic interference sources within 1 km.

##### 4.2 Physical Deployment

Orient the ULF coil horizontally in the North-South direction, away from metallic structures. Deploy ground stakes 1.5 meters apart perpendicular to the nearest documented fault line. Deploy the water EC probe in the nearest accessible surface water or groundwater at consistent depth. Mount the solar panel at optimal angle for site latitude with unobstructed sky exposure. Seal the enclosure with fresh desiccant. Orient the AS7341 spectral sensor toward the primary observation zone.

##### 4.3 Calibration and Baseline Establishment

Run the node indoors for a minimum of 48 hours before field deployment to verify all channels are returning readings within expected baseline ranges. Allow 30 days of continuous field operation before any anomaly assessment — the baseline must be established before deviations from it are meaningful. The water EC probe requires 60 days of baseline before precursor analysis is valid. The MQ131 ozone sensor requires a 48-hour burn-in period before calibrated readings are available.

##### 4.4 Data Upload and Dashboard Integration

Configure WiFi credentials and dashboard API endpoint in config.json before deployment. Data uploads automatically when WiFi connectivity is available. The node queues readings locally on microSD during connectivity gaps and uploads in batch on reconnection. Contact jubecrew@gmail.com for Presignal dashboard integration once 30 days of clean baseline data is established.

#### 5. SCIENTIFIC VALUE OF LONG-DURATION DEPLOYMENT

The primary scientific value of the EM Sentinel lies not in single-event detection but in the depth of continuous baseline it produces. The following table summarizes the difference in scientific output between short and long deployments, and specifically what a researcher would have in hand after each period if a genuine discharge event occurred during that window.

Channel	1 Week Output	6 Month Output	1 Year Output + Positive Event
ULF Magnetometer	Raw readings — no context for site normal	Seasonal baseline establishing. Diurnal variation mapped. Kp correlation emerging.	Full seasonal cycle. Unipolar pulse events statistically separable from background. If an event occurred: pulse amplitude, duration, and repetition rate compared against 12-month baseline — publishable anomaly profile.

Electric Field Meter	Fair-weather baseline only	Storm elevation vs. geological elevation patterns beginning to separate.	Full storm season captured. Geological EFM elevation distinguishable from weather-driven by pattern signature. If an event occurred: pre-event elevation curve and collapse timestamp constitute direct discharge documentation.
Ground Conductivity Stakes	mV readings — no trend visible	Slow multi-day rise patterns separating from diurnal variation.	Lunar tidal correlation testable. Pre-seismic buildup identifiable against baseline. If an event occurred: stake differential at time of event provides p-hole surface current magnitude — direct Pathway 1 evidence.
Geiger Counter	Background CPM — no solar events captured	Forbush Decrease events beginning to accumulate for CME correlation.	Seasonal radon variation mapped. Full Forbush Decrease catalog correlated with NASA DONKI. If an event occurred: CPM at time of event characterizes radiation environment — Pathway 5 indicator or elimination.
AS7341 Spectral	Ambient light baseline only	Seasonal ambient light variation mapped. Night-time background established.	Full emission baseline. If an event occurred: optical emission spectrum at moment of discharge identifies plasma mineral composition — geological pathway indicator from optical data alone, without ground sampling.
Water EC Probe	Starting conductivity — no precursor window possible	60-day precursor window operational. First slow-drift anomalies detectable.	Seasonal groundwater chemistry variation mapped. If an event occurred: 60-day conductivity record preceding event is the longest-lead precursor dataset in the stack — potentially the most valuable data for earthquake light prediction research.
RTL-SDR Broadband RF	Local RF noise floor established	Persistent interference sources mapped and filterable.	Clean RF baseline with known interference eliminated. If an event occurred: broadband burst at discharge frequency provides RF emission profile — third independent EM domain confirmation alongside ULF and EFM.
Ozone + Ion Counter (Chemical/ Atmospheric)	Baseline chemical environment only	Seasonal ion density variation and weather correlation established.	Weather-driven ozone and ion baselines fully characterized. If an event occurred: ozone and ion count at time of event provide chemical confirmation of discharge independent of EM channels — cross-domain corroboration.

## 5.1 What a Publishable Dataset Looks Like

A Class A event (Section 2.1) occurring after a minimum 6-month baseline deployment produces the following data package for peer review:

Data Component	Source Channels	Evidential Role
12-month site baseline record	All channels continuous	Establishes what is normal for this specific site. Without this, no anomaly can be distinguished from background.
Pre-event state variable record (30 days preceding)	Geiger, ion counter, water EC, GPS SNR, BME280	Documents the geophysical conditions building toward the event. Enables GPDM pathway classification based on which state variables were elevated.
Event electromagnetic signature (millisecond-resolution)	ULF, EFM, ground stakes, RTL-SDR	The core evidence. Multi-domain EM confirmation within 500ms window. Unipolar vs. bipolar signature distinguishes geological from lightning source.
Event chemical signature	Ozone, ion counter	Chemical corroboration of discharge activity independent of EM readings. Cross-domain confirmation.
Event optical emission spectrum	AS7341	Mineral composition fingerprint of plasma at moment of discharge. Geological pathway indicator from optical data alone.
Post-event return-to-baseline record	All channels	Documents how long elevated conditions persisted after the event. Enables comparison with pre-event state variable trajectory.

## 6. NETWORK CONFIGURATION

The EM Sentinel's scientific value scales with the number of simultaneously operating sites. A single node establishes a site-specific baseline. Multiple nodes enable cross-site correlation — the primary test of the GPDM prediction that discharge events cluster around elevated Variable 1 conditions regardless of site location.

Configuration	Nodes	Total Cost USD	Scientific Output
Single site baseline	1	~\$516	Site qualification, 12-month baseline, tidal and solar correlation, water EC precursor window. Minimum configuration for a Class A publishable event.
Dual site correlation	2	~\$1,032	Cross-site correlation — tests whether events at two sites are correlated with the same Variable 1 conditions. A correlated pair of Class B events at two sites approaches Class A evidential weight.
Hessdalen full package	2 EM Sentinels + 1 Field Node v2.0	~\$3,822	Long-duration EM baseline at two positions plus triggered camera acquisition. Dual-node ULF triangulation enables source localization. Adds visual and IR documentation to EM dataset.
Regional network	5	~\$2,580	Multi-site correlation across a geological region. Tests whether discharge events cluster around shared Variable 1 conditions — the GPDM framework's primary falsifiable prediction.
Global pilot network	10	~\$5,160	Eight primary GPDM sites covered. Cross-site correlation during Kp storms and CME events. First global APP monitoring dataset.

## 7. RELATIONSHIP TO PUBLISHED FRAMEWORKS

### 7.1 GPDM Framework

The EM Sentinel was designed as the primary monitoring instrument for the GPDM framework (Carter, 2026a). Every sensor channel maps directly to a GPDM pathway mechanism or state variable as documented in Table 1. The EM Sentinel does not merely detect anomalies — it generates the continuous multi-channel dataset required to classify which GPDM pathway mechanism is active at a given site and to test the framework's falsifiable predictions.

### 7.2 Electroball Framework

Galán Santos and Koren (2024) identify specific instrument types for in-situ electroball characterization: electromagnetic field meters, Geiger counters, IR and thermal cameras, spectrometers, barometers, hygrometers, and thermometers. Their experimental proposals further note that the majority of electroballs are transparent or invisible at visible wavelengths and that detection requires infrared cameras or polarized filters — a finding with direct design implications. The EM Sentinel addresses this in two ways: the AS7341 spectral sensor captures optical emission signatures independent of visible brightness, acquiring a plasma mineral fingerprint even when no visible discharge occurs; and the RTL-SDR captures broadband RF emission from discharge events that produce no visible output at all. The complete EM + optical emission + RF stack ensures that sub-visual discharge events leave a multi-channel scientific record even without camera hardware. Camera documentation of visible events is addressed by the Presignal Field Node v2.0 (Carter, 2026c).

## 8. CONCLUSIONS

The Presignal EM Sentinel provides a complete, open-access, low-cost instrument design for long-duration electromagnetic monitoring of geological plasma discharge candidate sites. At approximately \$516 USD in commercially available components, the instrument is accessible to individual researchers, citizen science networks, and university research groups without specialized procurement.



The ten-channel simultaneous monitoring architecture, continuous 24/7 solar-powered operation, automatic data upload, and GPS-precision timestamping make the EM Sentinel, to our knowledge, the most comprehensive single-instrument package currently available for GPDM-framework-based APP site monitoring. The event capture hierarchy in Section 2.1 and the publishable dataset framework in Section 5.1 define precisely what data a deployed instrument produces at each level of geophysical activity — from background baseline through full multi-domain discharge confirmation. This structure ensures that every day of deployment produces scientific value, and that any genuine discharge event produces a dataset with a defined evidential weight for peer review.

The complete technical specification is released under Creative Commons Attribution 4.0 International (CC BY 4.0) for open scientific use, modification, and distribution. Researchers wishing to contribute data to the Presignal global monitoring network or collaborate on multi-site correlation studies are invited to contact the author.

## 9. LIMITATIONS

The EM Sentinel design carries several constraints that users should consider before deployment. All sensor thresholds and trigger values in this specification are derived from theoretical GPDM pathway parameters and published electroball literature — they have not yet been validated against a confirmed geological plasma discharge event at an instrumented site. Baseline calibration periods of 30–60 days are required before anomaly assessment is meaningful, making the instrument unsuitable for short-duration deployments. The MQ131 ozone sensor operates outside its rated temperature range below  $-20^{\circ}\text{C}$  and above  $+50^{\circ}\text{C}$ , limiting cold-climate utility without supplemental enclosure heating. The DIY ULF coil and Gerdien ion counter are constructed from commodity components and have not been independently calibrated against research-grade equivalents; absolute sensitivity figures should be treated as estimates. WiFi-dependent data upload means connectivity gaps will produce batch uploads rather than real-time streaming, and sites without any WiFi access require alternative data retrieval planning. Environmental electromagnetic interference from power lines, vehicles, or nearby structures within 1 km will elevate baseline noise and may produce false threshold crossings in single-channel assessments.

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