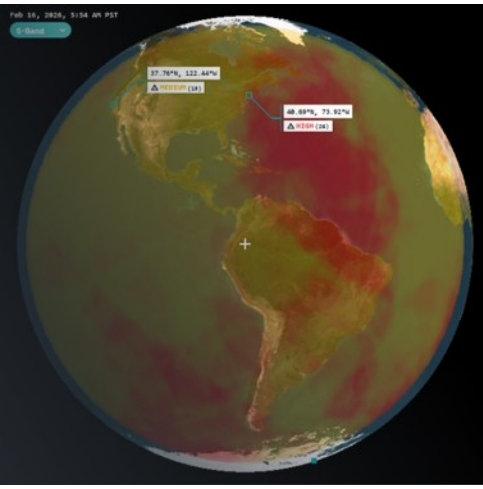
VEGA

SPECTRUM FORECASTING

Predict when and where spectrum congestion will impact your link up to 7 days in advance.



Capability Overview

Predict when and where spectrum congestion will impact your link up to 7 days in advance.

The Vega API provides an interference forecasting service. It models all 15,000+ active satellites—their orbits, their frequencies, their beam patterns. It calculates where and when transmissions will overlap and then tells you before it happens.

No new hardware. No infrastructure changes. Just an API call that returns the interference events heading your way. Your planning systems can ingest it. Your mesh networks can route around it. Your operators can explain predicted disruptions to customers in advance—instead of investigating after the fact.

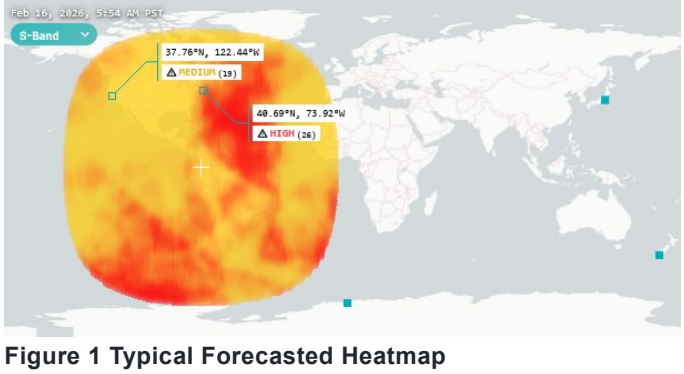


Figure 1 Typical Forecasted Heatmap

Operational Use Cases

We forecast band-specific satellite co-visibility density across the globe for your frequencies and translate it into a congestion risk index. This enables the following operational use cases.

Pre-Emptive Network Control

For high-throughput satellites or LEO constellations, forecasting becomes a scheduling input—not just a diagnostic tool. If an operator does know that a beam is likely to experience elevated interference, they can act before their customers feel it. When congestion risk spikes in one frequency band or geographic region, operators can respond dynamically by:

- Increase margin or adjust coding and modulation (ACM thresholds)
- Shift traffic, users, or carriers to alternate beams or bands
- Rebalance gateways and move capacity to cleaner windows
- Delay non-critical transfers and reschedule downlinks
- Reduce spectral density during overlap windows

Today, most operators react after Eb/N0 drops. Forecasting lets them act before their customers feel it.

Risk and Anomaly Management

If an operator can show a forecasted interference window before a performance dip, they can protect themselves contractually, shorten root-cause time, and demonstrate due diligence. When noise rises unexpectedly, the first question is always: “Is this internal or external?” If the operator already has a forecast showing high probability of adjacent satellite overlap then they can:

- Attribute degradation to documented external overlap
- Provide timestamped evidence to customers
- Reduce mean time to resolution (MTTR)—thus diagnostic time and costs

Forecasting turns interference from speculation into documented evidence.

Commercial Opportunities

If an operator knows which beams are predictably clean, they can:

- Price premium uptime
- Offer guaranteed performance tiers
- Monetize congestion avoidance

Additionally, if they know when spectrum is idle, they can lease it (see Vega's Spectrum Marketplace).

For Your Team

Operations: Proactive scheduling and capacity control—instead of reactive firefighting

Engineering: Clear external attribution—fewer unexplained anomalies to chase

Customer Success: Expectation setting and documented answers before customers ask

Leadership: Measurable uptime improvement and additional revenue opportunities

Technical Methodology

Vega's interference forecasting system combines orbital mechanics, spectrum allocation data, and geospatial analysis to predict when and where satellite interference will occur. Our system is transparent, validated, and built on industry-leading tools.

High-Level Architecture

Data sources (TLEs, Frequency Slots, Frequency Observations, Frequency Used, Satellites) flow into a Database and Data Lake, are filtered, then processed through a per-tracked-satellite pipeline, see Figure 2.

Step 1: Real-Time Orbital Tracking

Every forecast starts with accurate orbital data. We pull Two-Line Element (TLE) sets from authoritative sources, which are updated daily and propagated forward in time using industry-standard orbital mechanics accounting for atmospheric drag, zonal harmonics (J2), and solar radiation pressure.

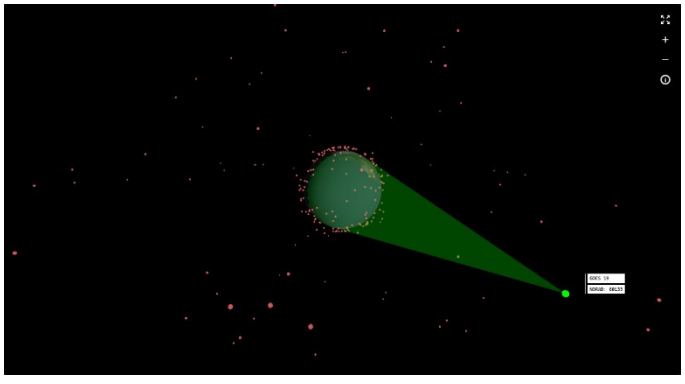


Figure 3 Customer Satellite (green) with Interferers (red)

Step 2: Frequency Conflict Identification

Not all satellites interfere with each other—only those operating in overlapping frequency bands. We map satellites to their frequency allocations using regulatory databases and public filings.

Our system cross-references these sources to identify which satellites share spectrum with your tracked assets. Only confirmed frequency overlaps or recorded usages are flagged as potential interferers.

Step 3: Coverage Analysis

Once we know which satellites could interfere, we calculate their ground coverage footprints:

- **Field of Regard Cones** — Each satellite's entire field of regard is modeled as a cone projecting tangent to Earth's surface
- **Geospatial Tessellation** — Earth's surface is divided into equal-area cells using a nested HEALPix process that enables flexible resolution
- **Timestep Analysis** — Coverage is computed for every minute out seven days totaling 10,080 epochs per analysis

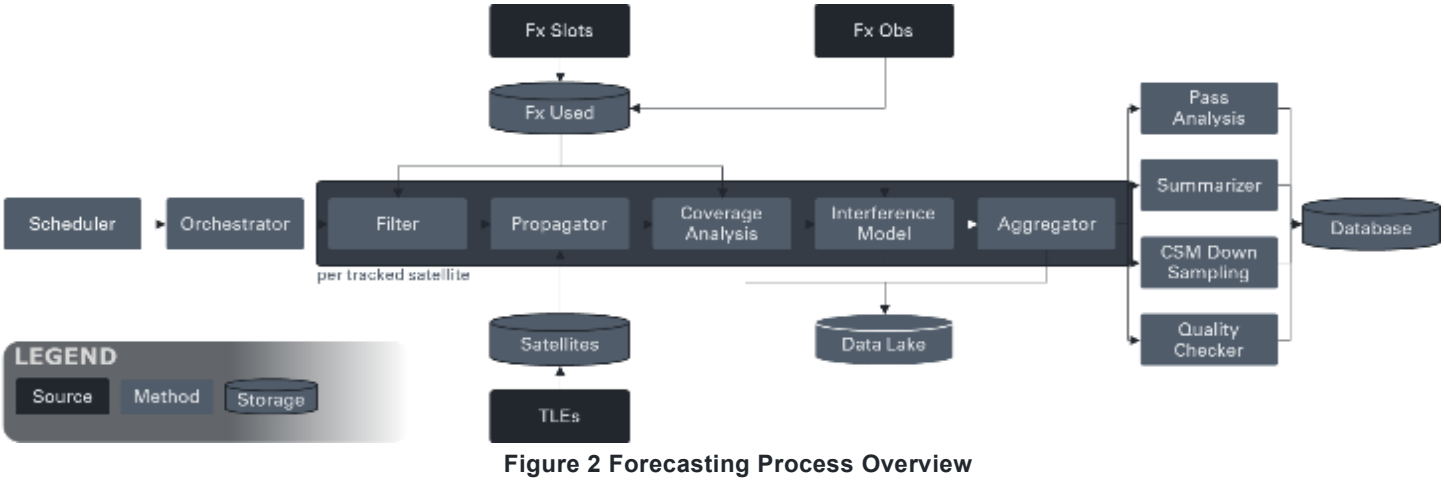


Figure 2 Forecasting Process Overview

Step 4: Interference Event Detection

Interference occurs when two satellites with overlapping frequencies have overlapping view cones. For each timestep, we:

1. Calculate your satellite's coverage footprint
2. Calculate each potential interferer's footprint at the same moment
3. Find the areas of intersection for both satellites simultaneously

Step 5: Filtered Aggregation

The millions of interference matrices (epoch × interfering satellite) are combined per operating band (e.g., S-band, Ka-band). This aggregation sums the intensities of each cell with an aggregated value stored for each cell and epoch as seen in Figure 4. The aggregated Compressed Sparse Matrix (CSM) files are stored in a data lake and accessible via the web app or API until replaced by the next day's forecast.

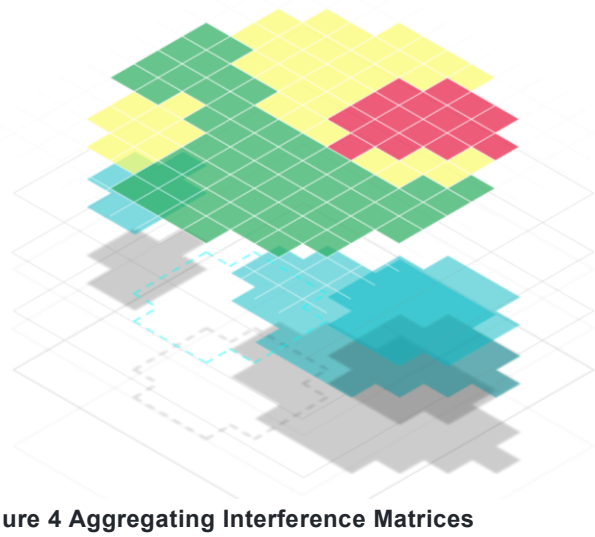


Figure 4 Aggregating Interference Matrices

Other Features

Continuous Model Refinement

Telemetry data and ground readings feed into a machine learning layer that continuously improves the forecasting models. Observed behavioral patterns for interfering satellites are grouped—e.g., satellite type, operator, regime—enabling more refined outputs and confidence scoring.

The model also continuously ingests raw ground samples to further inform the patterns exhibited by all satellites in the field of view at the time of the reading as seen in Figure 5.

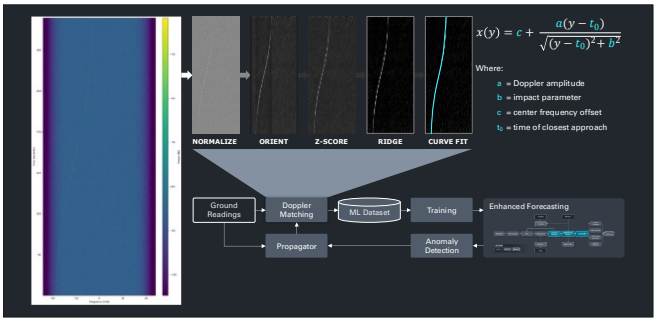


Figure 5 Parsing Raw Ground Samples

Visualization and Alerts

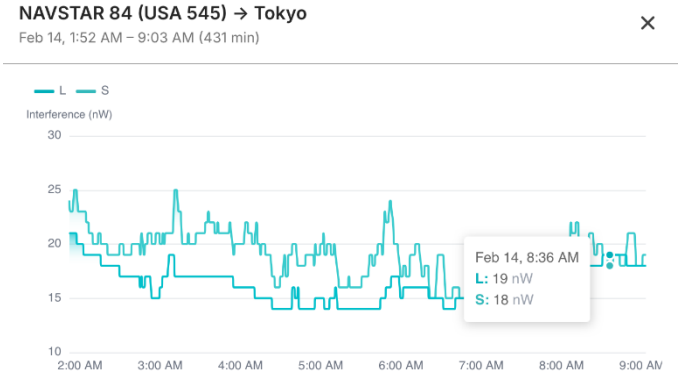


Figure 6 Typical Satellite Pass Chart

Raw interference data isn't useful without context. Vega transforms computational results into actionable intelligence:

- **Web App Heatmaps** — See interference intensity across Earth's surface in real-time, see Figure 1.
- **Time-Series Charts** — Track interference levels over multi-day windows or specific ground station passes, see Figure 6 depicting a GPS satellite pass over Tokyo.
- **Alert Thresholds** — Get notified when interference exceeds predefined acceptable levels.

Validation and Accuracy

We do not just compute predictions—we validate them against reality:

- **TLE Freshness** — Orbital data is refreshed daily; predictions degrade beyond 7 days
- **Confidence Scoring** — Frequency mappings are tagged with confidence levels based on data source quality
- **Known Limitations** — We're transparent about what we can't predict (solar storms, satellite maneuvers, intentional jamming)

Access & Integration

Web App

1. Create a free team account tied to your organization with your work email

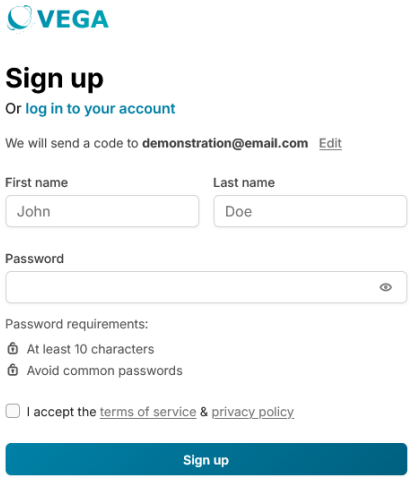


Figure 7 Basic Sign Up Modal

2. Add your ground stations either manually or from our existing set

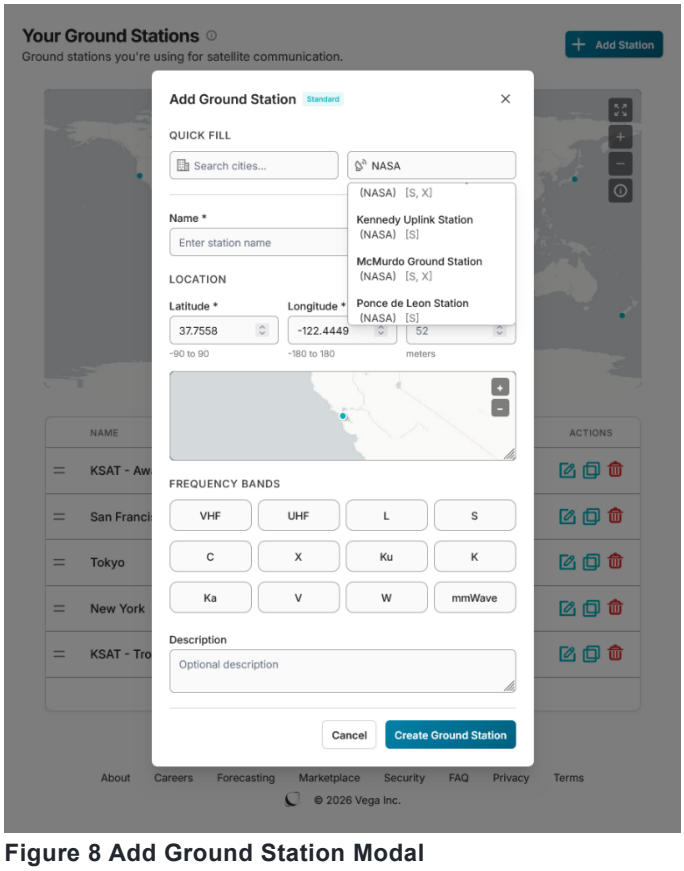


Figure 8 Add Ground Station Modal

3. Once verified, select your organization's satellites that you wish to track

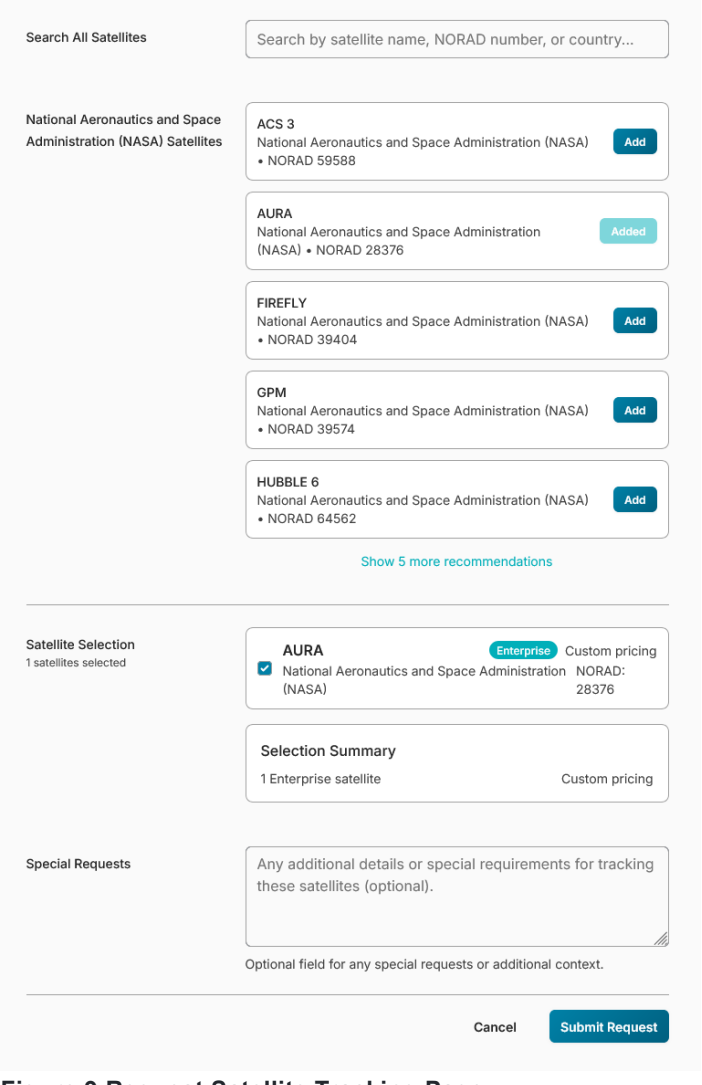


Figure 9 Request Satellite Tracking Page

4. Every morning a new forecast runs automatically — passes are also evaluated and color-coded based on predefined thresholds

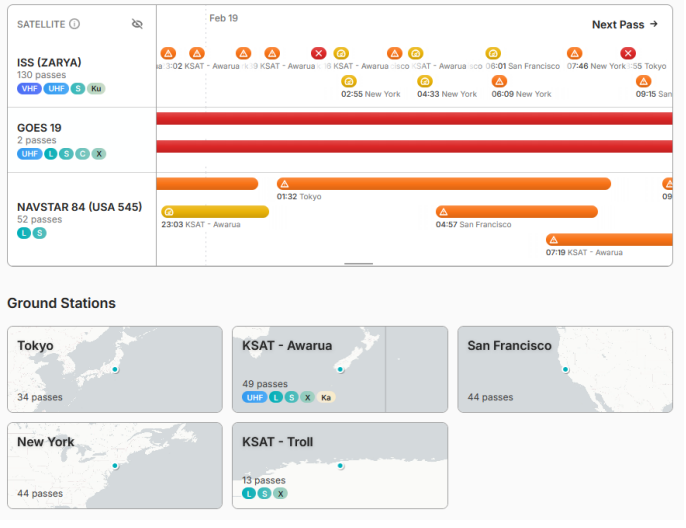


Figure 10 Passes Dashboard

RESTful API

Authentication

Pass your API token as Authorization: Bearer <token>. Enterprise satellite subscription required for all interference endpoints (returns 403 otherwise).

Core Endpoints

All endpoints are under `/api/v1/interference/`. Every request requires `tracked_satellite_id`.

Interference count at a single coordinate and time

Endpoint: `GET /at_point`

Key Params: `lat, lon, timestamp, frequency_band`

Interference over time at a location

Endpoint: `GET /timeseries`

Key Params: `lat, lon, start_time, end_time`

Interference during passes over a ground station

Endpoint: `GET /ground_station_timeseries`

Key Params: `ground_station_id`

Response Format

```json
{
"data": {
"intensity": 5,
"timestamp": "2025-12-06T08:05:00Z",
"nside": 64,
"cell_resolution_deg": 0.92,
"frequency_band": "Ka"
},
"meta": { "request_id": "...", "timestamp": "..." }
}
```

`intensity` is the count of interfering satellites visible at that location and time. Resolution is approximately 100 km (HEALPix nside=64, NESTED ordering). Timeseries endpoints return an array of `{intensity, timestamp}` pairs.

Example Request

```bash
curl -H "Authorization: Bearer YOUR_TOKEN" \
"https://vega.space/api/v1/interference/at_point?tracked_satellite_id=ts_abc123&lat=40.7&lon=-74.0&timestamp=2025-12-06T08:00:00Z&amp;quot;
```

Rate Limits

100 requests/minute per account. Timeseries maximum window: 7 days (10,080 minutes).

Security

Vega employs enterprise-grade security controls designed to protect sensitive satellite operational data. The platform enforces SOC 2 Type II controls, ensuring independently auditable standards for data handling and organizational processes. All data is encrypted in transit and at rest, and customer environments are fully isolated through logical tenant separation, preventing any cross-customer data exposure. Access is governed by role-based access control (RBAC) and secured with TOTP-based multi-factor authentication. Comprehensive audit logging provides a complete trail of system activity for compliance and incident review. At the API layer, authentication is handled via API keys over a RESTful interface. As a matter of policy, customer data is used solely to improve forecasting predictions and is never shared between operators, reinforcing Vega's position as a trusted neutral party in spectrum coordination.

Contact & Support

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