GPS RAIM Prediction Service

FAA’s Operational Tool GPS Navigation Predictions in the Flight Planning Process

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GNSS Service Availability Prediction

Operational Mission Planning Tools
--Anticipate Service Outages
--Mitigate Continuity Breaks
--Enable Graceful Degradation
--Improve User Acceptance

Satellite Service Level Prediction Model (SSLPM)

Constellation: Build/Update Daily or on GNSS Status Change
48 Hours * 60 Min/ Hour Timesteps
Predictive Model Based on TSO for Each Waypoint & Timestep
HPL → NIC/NAC

No Outages
Predicted Outages

Predict When/Where Protection > Alert (HPL > HAL?)

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US FAA GPS RAIM Prediction Service Overview

- **Early Motivation:**
  
  AC90-100A establishes rule for pre-flight check of GPS navigation

- **Modeling and Prediction Function**
  
  - Provide location-based information on expected availability of GPS navigation services
  
  - Account for active state of GPS constellation
  
  - Evaluate availability of require navigation performance (RNP) service against certification models (initially, FAA TSO-C129)

- **Web based Service:** [http://www.raimprediction.net](http://www.raimprediction.net)
  
  - Two primary interfaces:
    
    -- Interactive, graphical display via web browser
    
    -- Procedural, XML protocol on tcp/ip stack
  
  - “Live” monitoring of the SVN constellation via GPS Almanac, SV NOTAM, and US DoD NANU
GPS RAIM Prediction Service Network

- Presentation & Display
- Service Volume Model (Calculates HPL)
- Relational Database
- Network Protocols
Interactive GPS RAIM Service Interface

- Nominally 24/7 Web Access via Browser
- Reads Out Three Levels of RNP Service (all horizontal)
  - En Route (HAL < 2 nmi)
  - Terminal Area (HAL < 1 nmi)
  - Non-precision Approach (HAL < 556m)
- Graphical Display
  - Interactive URL http://www.raimprediction.net
  - Service volume (US NAS)—1x1 degree (0.5 x 0.5 for NPA) grid
  - Time resolution is 1 min sampling of the GPS constellation with 6 min outage threshold
- System Auto-Refreshes on Any Constellation Change
  - New almanac issued
  - SV NOTAM issued or cancelled
  - NANU issued or cancelled
Interactive Interface (Web Browser Display)
Interactive Interface (Playback Modes)

Playback mode

Playback Controls

Playback mode
Interactive Interface (Zoom/Pan/Select)
Procedural GPS RAIM Service Interface

RAIMWebServiceSOAP Interface Control Document (ICD)

- Schema Advertised via Web Service Definition Language (WSDL)

- Inputs:
  - Trajectory of 4D points
  - Desired RNP level
  - Avionics configuration

- Outputs:
  - Echo of input data
  - Diagnostic information
  - Point-by-point indication of any predicted outages (HPL > HAL)
Procedural GPS RAIM Service Interface

GIS Server

Route-of-Flight Data (XML)

Dispatching Systems (Carriers/Dispatchers)

Other Consumers (GA/GNSS Service Providers)

Bulk Grid Data (HTTPS future path)
GPS RAIM Prediction Service

Operational Statistics Since Deployment (1 Jul 2009)

- 8 million+ Transactions Served
- Response Time Performance (< 5 Second Transactions)
- User Adoption
  - Carriers/Operators: Horizon, NetJets, Continental, JetBlue, Delta
  - Vendors/Dispatchers: DUATS, WSI, Sabre
- Primary Demand Is Trajectory Based Operations (Procedural Interface)
Conclusions

- **Service Availability Predictions Important Factor in Adoption of GNSS Services**
  - Gives users confidence and additional convenience
  - Assists service providers with automated forward looks at service volume performance
  - Improves conditions for safety of operations via planning

- **Customized Prediction Services**
  - Presentation and interface options
  - Selection of models (nominally TSO specifications)
  - Access control, secure connection, transaction history, etc.

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