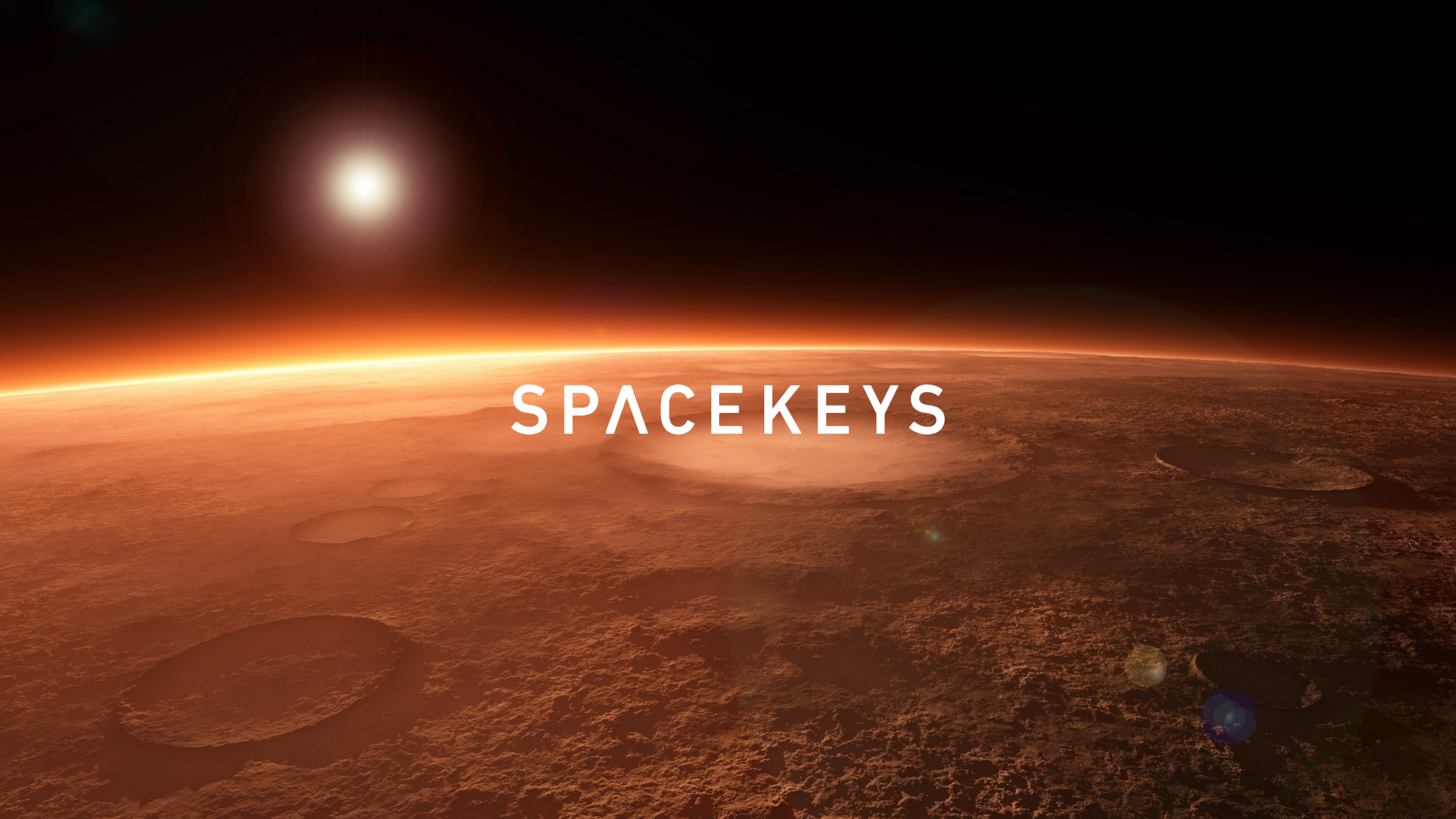
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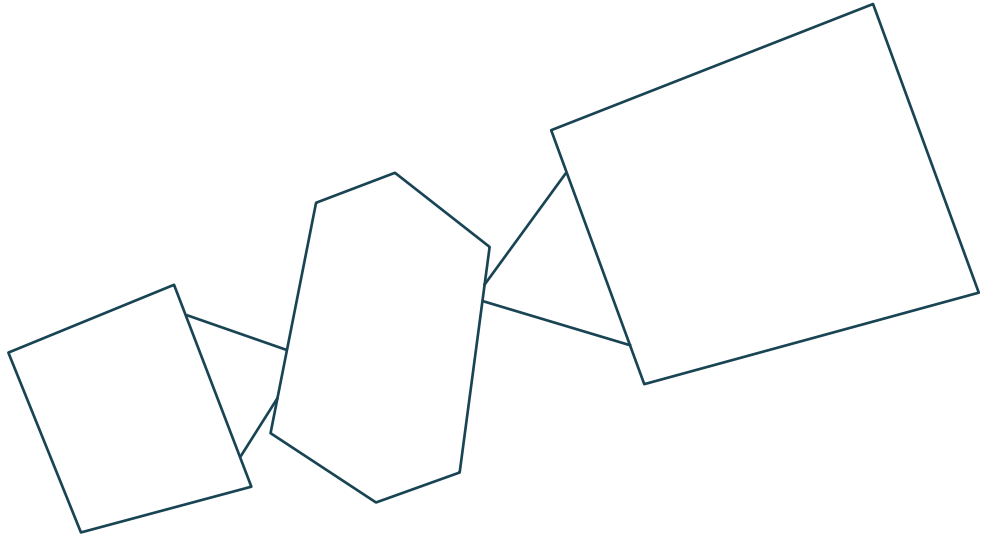
Topics

SPACEKEYS

- Executive Summary – ADS-B Mandate
- What is ADS-B
- AC90-114A
- Exemption 12555
- FAA SAPT
- SPACEKEYS



Executive Summary

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By January 1, 2020, all aircraft must be equipped with **ADS-B Out** to fly in most controlled airspace in the US.

Federal Regulations 14 CFR 91.225 and 14 CFR 91.227 contain the details.

What is ADS-B

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ADS-B stands for Automatic Dependent Surveillance – Broadcast:

- **Automatic** - it periodically transmits information with no pilot or operator involvement required.
- **Dependent** - the position and velocity vectors are derived from the Global Positioning System (GPS) or other suitable Navigation Systems (i.e., FMS).
- **Surveillance** - it provides a method of determining 3 dimensional position and identification of aircraft, vehicles, or other assets.
- **Broadcast** - it transmits the information available to anyone with the appropriate receiving equipment.

ADS-B replaces radar technology with satellites, bringing potential major advantages. Radar relies on radio signals and antennas to determine an aircraft's location. ADS-B uses satellite signals to track aircraft movements.

What is ADS-B Out

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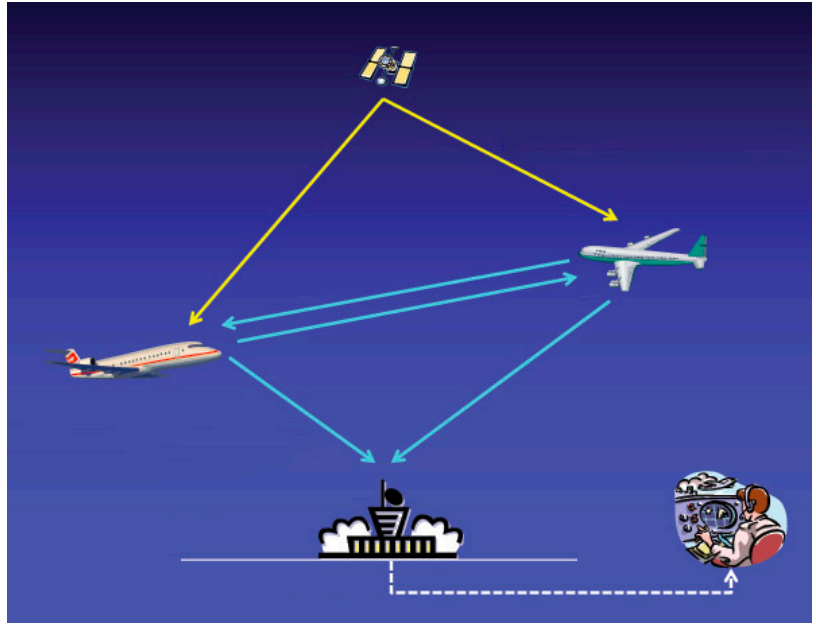
Broadcasting information about an aircraft's GPS location, altitude, ground speed and other data to ground stations and other aircraft, once per second.

- Air traffic controllers and aircraft equipped with ADS-B In can immediately receive this information.
- This offers more precise tracking of aircraft compared to radar technology, which sweeps for position information every 5 to 12 seconds.
- ADS-B ground stations are smaller and more adaptable than radar towers and can be placed in locations not possible with radar.
- With ground stations in place throughout the country, even in hard to reach areas, ADS-B provides better visibility regardless of the terrain or other obstacles.



SPACEKEYS

U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: Automatic Dependent Surveillance-Broadcast Operations

Date: 3/7/16 **AC No:** 90-114A

Initiated by: AFS-400 **Change:** 1

1. PURPOSE. The intent of this advisory circular (AC) is to facilitate operations using Automatic Dependent Surveillance-Broadcast (ADS-B) technology in compliance with Title 14 of the Code of Federal Regulations (14 CFR) part 91, §§ 91.225 and 91.227, which are required after January 1, 2020. The appendices provide guidance for the authorization of additional ADS-B Out and ADS-B In operations and their associated aircraft qualification and maintenance requirements.

2. PRINCIPAL CHANGES. This change incorporates new ADS-B guidance related to a technical amendment to § 91.225; equipping type certificated (TC) aircraft, light-sport aircraft (LSA), and experimental aircraft; and preflight requirements in U.S.-designated airspace. This change also modifies guidance for Cockpit Display of Traffic Information (CDTI) Assisted Visual Separation (CAVS).

A Problem!

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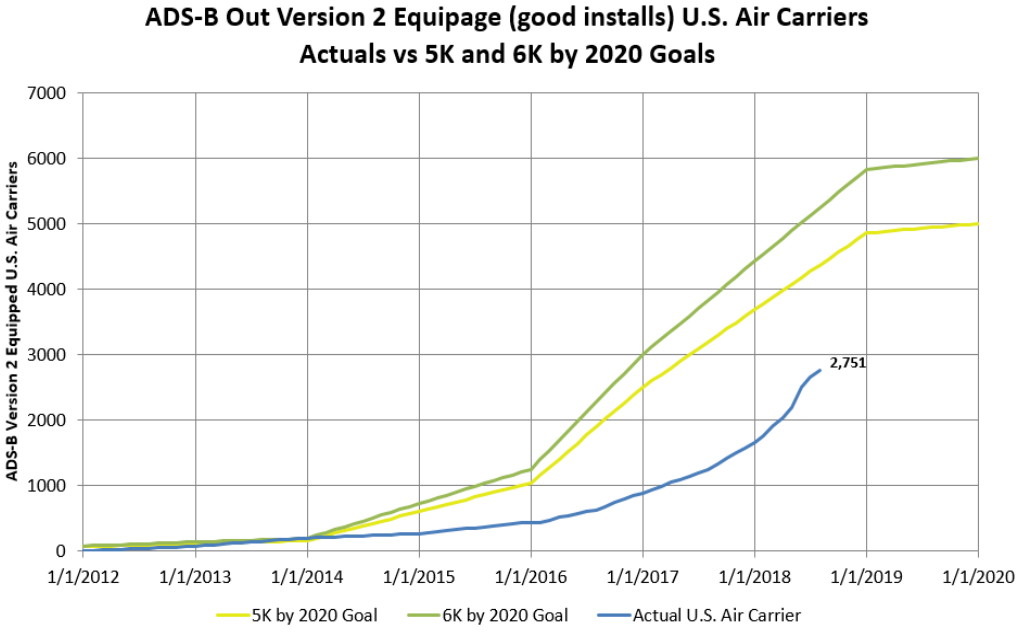
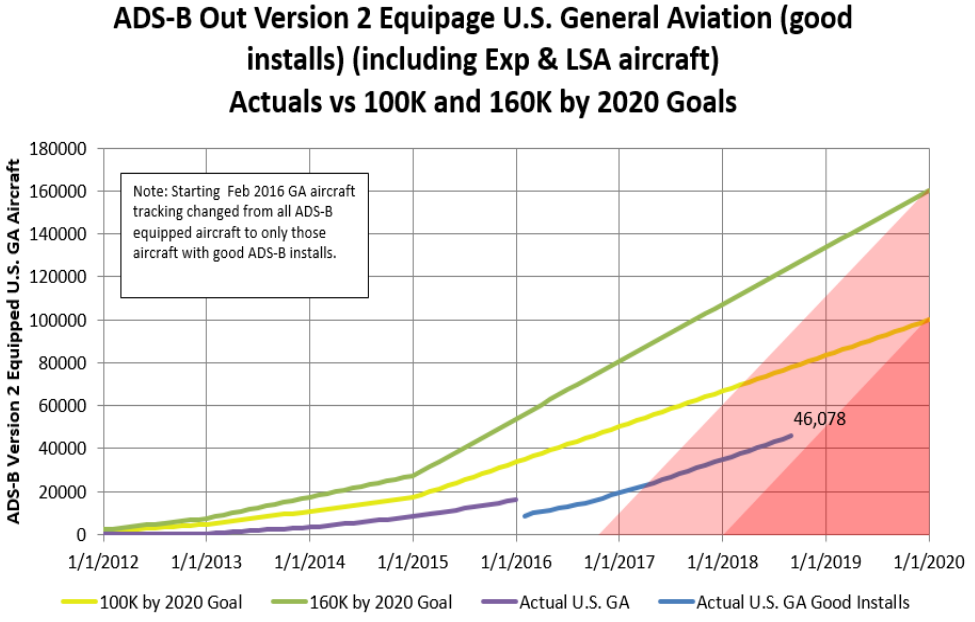
Category	As of 1-August 2018 (ATAT)	As of 1-September 2018 (ATAT)	Monthly Increase		% of estimated fleet equipped^, as of 1-September-18
All Link Version 2	54,535	56,491	1,956	3.59%	
1090ES	47,095	48,935	1,840	3.91%	
UAT	6,522	6,621	99	1.52%	
Dual	918	935	17	1.85%	
US General Aviation (includes EXP & LSA)	44,604	46,078	1,474	3.30%	28.8% - 46.1%
US Air Carrier**	2,651	2,751	100	3.77%	45.9% - 55.0%
Intl General Aviation*	3,286	3,378	92	2.80%	
Intl Air Carrier	1,076	1,101	25	2.32%	
U.S. Military & U.S. Special Use***	450	525	75	16.67%	

A Problem!

SPACEKEYS





Time is running out!

A Second Problem!

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Operation procedures to capture all the ‘what ifs’ common to airline operations.

- Not yet defined and may not be until well into 2019.
- Major airlines take 6 months minimum to change/approve operational documentation.
- Major airlines need to train dispatch staff.

Exemption 12555 – Until 2025

SPACEKEYS

The FAA has granted Exemption 12555 with a strict, limited timeframe in which operators must equip with new navigation receivers.

- Does not exempt the requirement for ADS-B Out equipment to be installed and operational on aircraft.
- Does allow for the extended use of an older type of GPS navigation receiver already installed in some aircraft.
- GPS receivers suitable for transport category aircraft that meet the ADS-B Out requirements will not be available for purchase or installation in sufficient quantities until closer to 2020.
- Imposes certain conditions, limitations and additional pre-flight responsibilities on the operators. **PRE FLIGHT PREDICTION**

1 August 2018 deadline!

A Third Problem!

SPACEKEYS

1 August deadline for exemption application.

- Operator must supply Letter of Intent (LoI) **AND** a plan to equip.
- Many known non compliant operators have missed deadline.
- Some operators have submitted LoI but not the plan to equip

So.....?

FAA SAPT

SPACEKEYS

Automatic Dependent Surveillance-Broadcast (ADS-B) Service Availability Prediction Tool (SAPT).

- RAIM and ADS-B predictions
- US Only
- Deliberately conservative
- Not always in line with front line large modern airline operations methods

Requirements (Surveillance)

SPACEKEYS

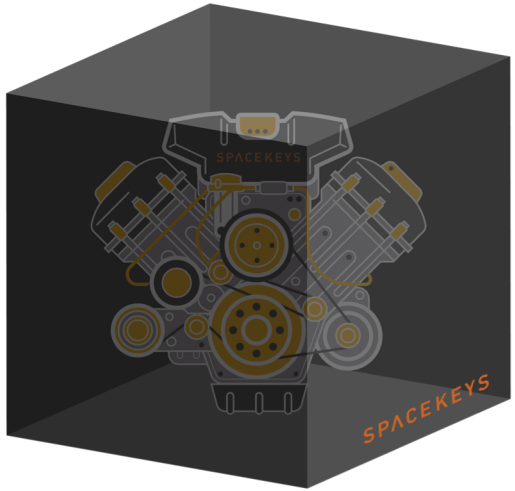
AC90-114A Change 1 – Prediction methods:

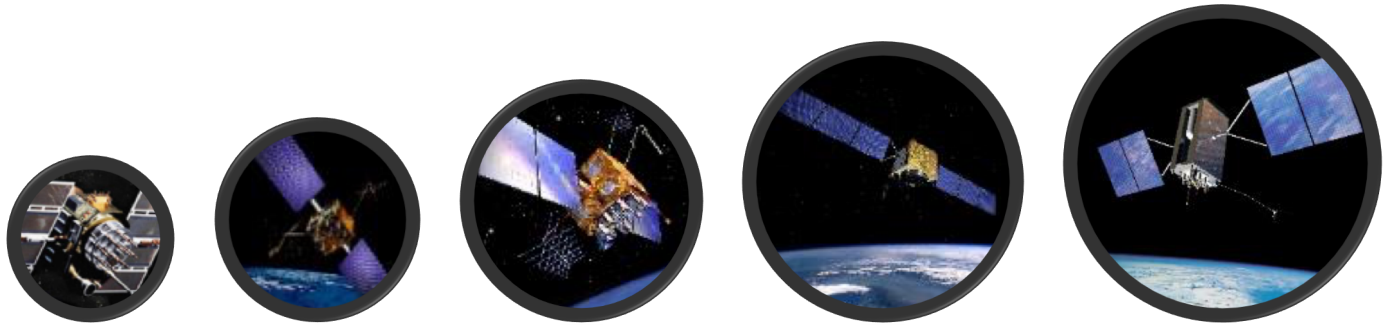
"Operators of large fleets of aircraft or users of flight planning programs may wish to use their own preflight availability verification tool. The operator is responsible for selecting a tool that accurately predicts the performance for their aircraft. The tool needs to account for the GPS satellites that are in service at the time of the prediction, and may take into account unique characteristics of the GNSS receiver, aircraft integration or installation; including performance better than required in FAA standards or use of inertial information integrated into the ADS-B Out position source. The FAA does not evaluate or approve a particular tool, but may evaluate the basis of the operator's determination that the tool is appropriate to their aircraft, particularly if its use results in noncompliant flights in airspace where ADS-B Out is required."

Overview

SPACEKEYS

As the GPS satellites themselves have evolved over the years, so have the systems that allow operators to take the benefit of satellite navigation. SPACEKEYS presents the ultimate evolution of GNSS RAIM prediction solution. It provides for worldwide RAIM predictions for all aircraft types and for all navigation and surveillance specifications. SPACEKEYS is a project funded by European Space Agency (ESA) under the NAVISP programme (NAVISP EL2-007).





Requirements (Navigation)

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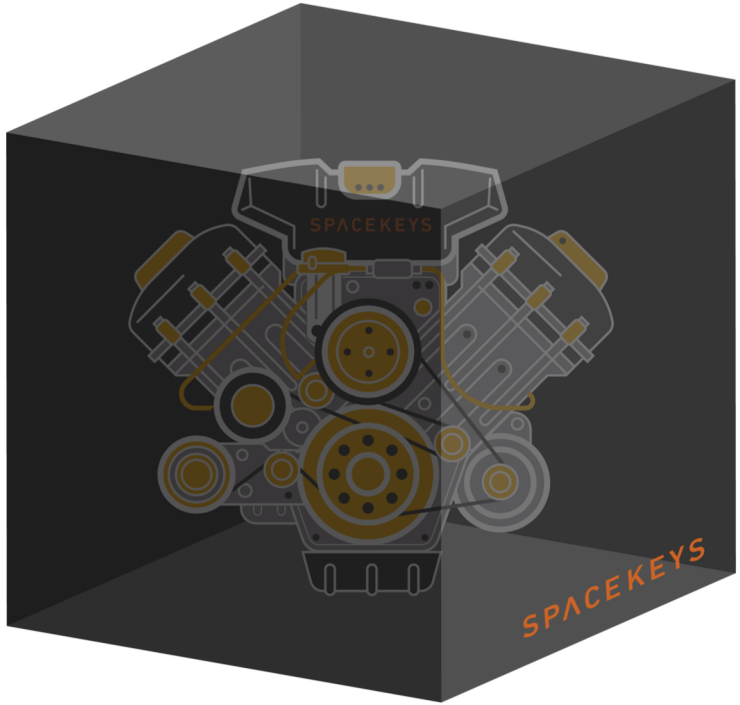
The RAIM solution performs predictions in compliance with the following navigation specifications. Terrain screening is performed as required for RNP AR predictions. ADS-B included!

	RNAV 10 RNP 10	RNAV 5 Basic-RNAV	RNAV 2 US RNAV Type A	RNAV 1 Precision-RNAV US RNAV Type B	RNP 4	RNP1	RNP Approach	RNP AR Approach	MNPS
FAA (U.S.A.)	AC 90-105A (replaces Order 8400.12C)	AC 90-96A	AC90-100A	AC90-100A	AC 90-105A (repl. order 8400.33)	AC 90-105A	AC 90-105A (LNAV, LNAV/VNAV) AC90-107 (LP, LPV)	AC 90-101A AC20-138D	N8110.60
EASA (EU, EFTA and other countries)	AMC 20-12	AMC 20-4 JAA TGL 2	AMC 20-16 JAA TGL 10	AMC 20-16 JAA TGL 10		AMC 20-16 JAA TGL 10	AMC 20-27 (LNAV, LNAV/VNAV) AMC 20-28 (LP, LPV)	AMC 20-26	
CASA (Australia)	AC 91U-2(0)	CAAP B-RNAV-1	AC 91U-II-3-B	AC 91U-II-3-B	AC 91U-3(0)	AC 91U-II-C-3(0)	AC 91U-II-C-5 (LNAV) AC 91U-II- Attachment (LNAV/VNAV)	AC 91U-II-C-5 (RNP AR) AC 91-U-II-C-6	
SVRSOP (Latin America)	AC 91-001	AC 91-002	AC 91-003	AC 91-003	AC 91-004	AC 91-006	AC 91-008 (LNAV) AC 91-010 (LNAV/VNAV)	AC 91-009	
Transport Canada		AC 700-015							

Black Box Design Solution

SPACEKEYS

One solution for ALL users.



- Airlines
- CAA/ANSPs
- Flight Planning
- Flight Following
- Weather
- Business Jets
- General Aviation

SPACEKEYS Access Highlights

SPACEKEYS

- Modern System To System APIs
- Sophisticated And Responsive Web User Interface
- Daily Reports – Users Customizable
- File2RAIM – file the ICAO flightplan to us and get a RAIM report
- Dynamic “Just In Time” Terrain Screening for RNP-AR
- RAIM Outage Avoidance During Flight Planning
- Pro-Active Alerting

Requirements (GNSS Receivers)

SPACEKEYS

The RAIM solution performs predictions for all currently known receiver types in commercial aviation. This includes receivers compliant with TSO-C129, TSO-C196 and TSO-C145/146. The system is Future Ready For Multi-Constellation Receivers and Advanced Horizontal RAIM.

The following GNSS receiver parameters are supported:

Parameter	Options	Details
Algorithm	FD or FDE	
Barometric Aiding	ON, OFF or ON only on Failure	The option „On only on Failure“ provides the user the possibility to apply BA only in case the RAIM prediction resulted in an outage excluding BA. This is only available in the Spacekeys RAIM prediction solution.
Selective Availability	ON or OFF	
Mask Angle	-25° to 30°	
HAL Multiplier	Any certified value	Some aircraft are certified to apply a horizonal alert limit bias during RAIM predictions.

System Integration / API

SPACEKEYS

Spacekeys RAIM supports real time integration with third party systems such as flight planning and flight following systems. Both SOAP and REST APIs will be provided for system developers to develop integrated solutions. The APIs are load and stress tested and deliver outstanding performance.

The following integration options are possible:

- API to request a location RAIM prediction for any airport with specific RNP levels (departure, destination, destination alternates,...)
- API to request a trajectory RAIM prediction for any trajectory of a flight (main, alternates,...)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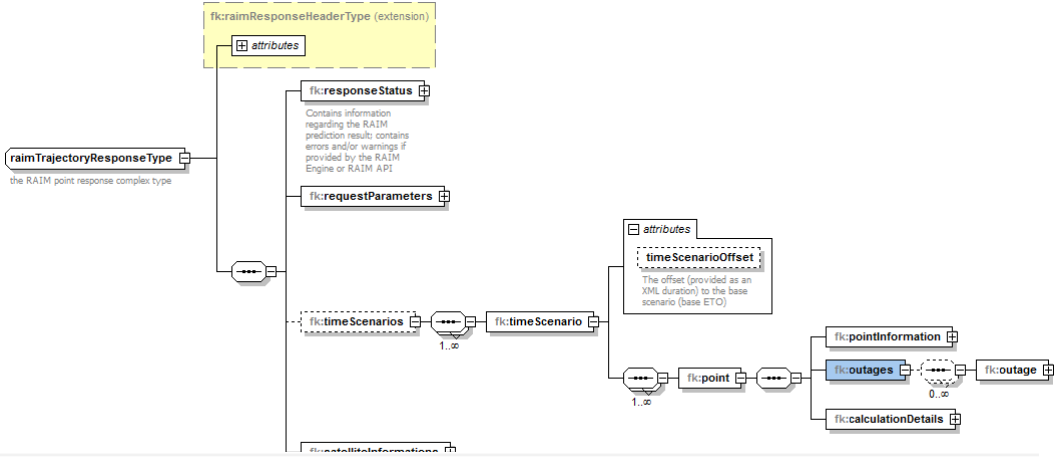
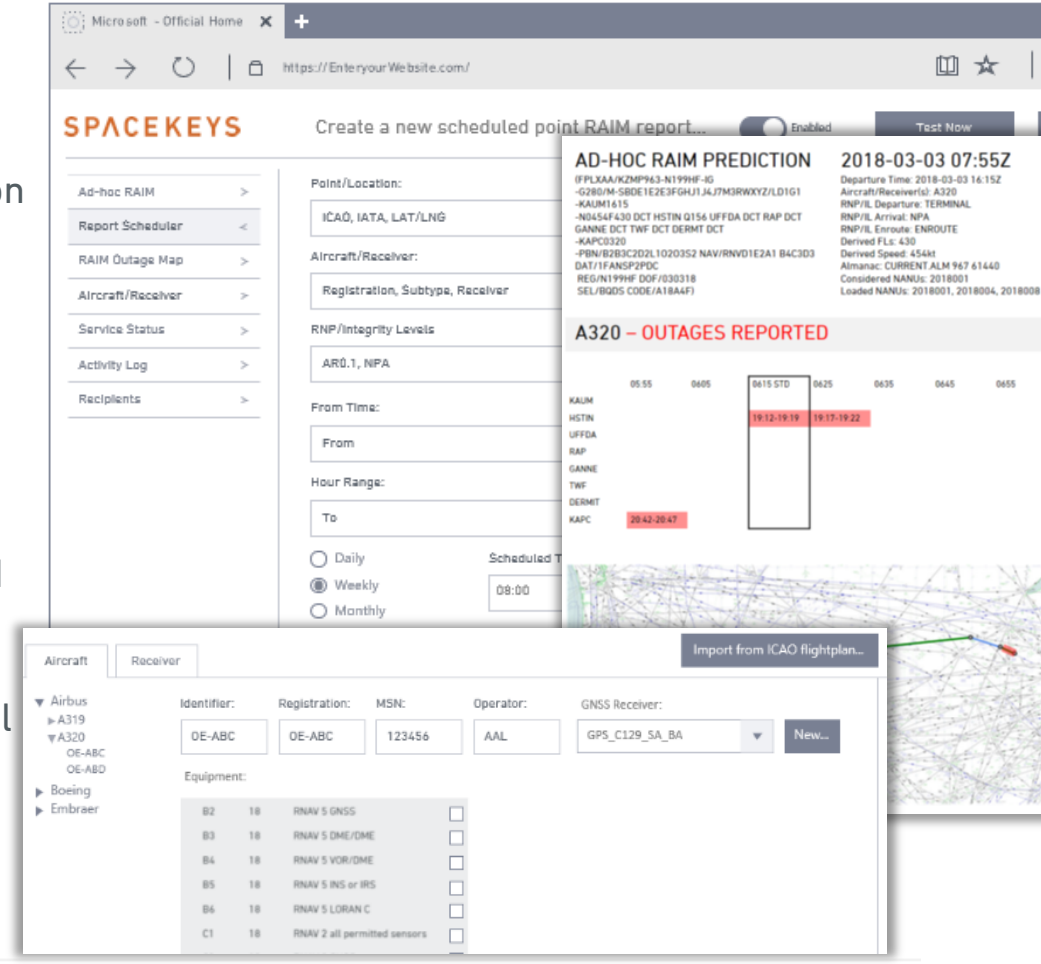


Web-Based User Interface

SPACEKEYS

A full suite of web tools to allow the user to perform RAIM predictions:

- Manual ad-hoc operations including ad-hoc location predictions or route predictions
  - ICAO flightplan copy/paste
  - Supported by an interactive map
- Storing of ad-hoc predictions for future re-usage
- Configure automated reports
  - Providing the capability to set specific schedule parameters
- Configure aircraft types, aircraft registrations[2] and receivers
- XML Flight Plan Import (e.g.: ARINC 633)
- Full Worldwide area map display (with navigational data overlay)
- Activity Log / RAIM Prediction History
- Service Status Monitor

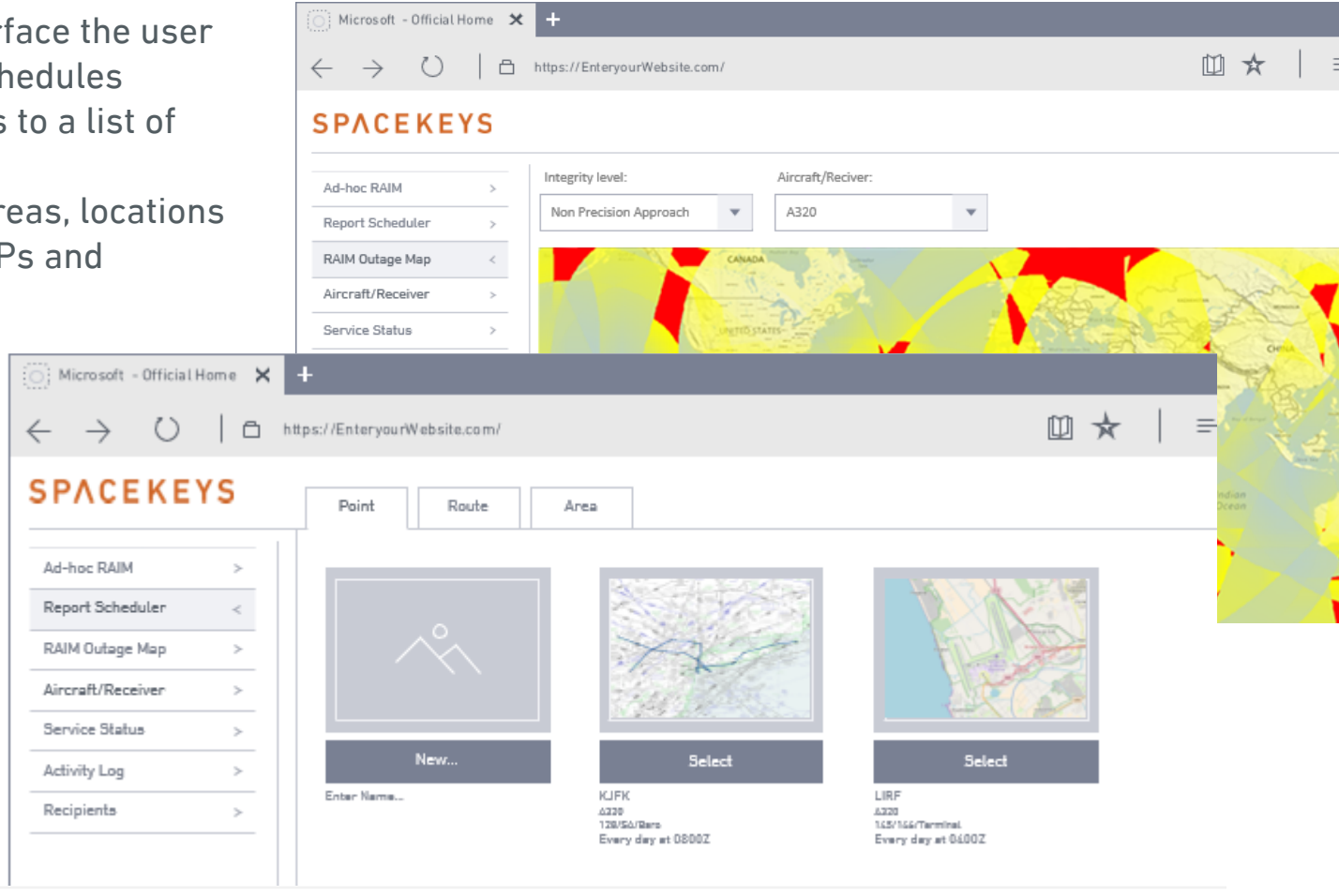


[2] Utilizing the unique FLIGHTKEYS 5D dynamic aircraft parameter inheritance system

Automated Reports

SPACEKEYS

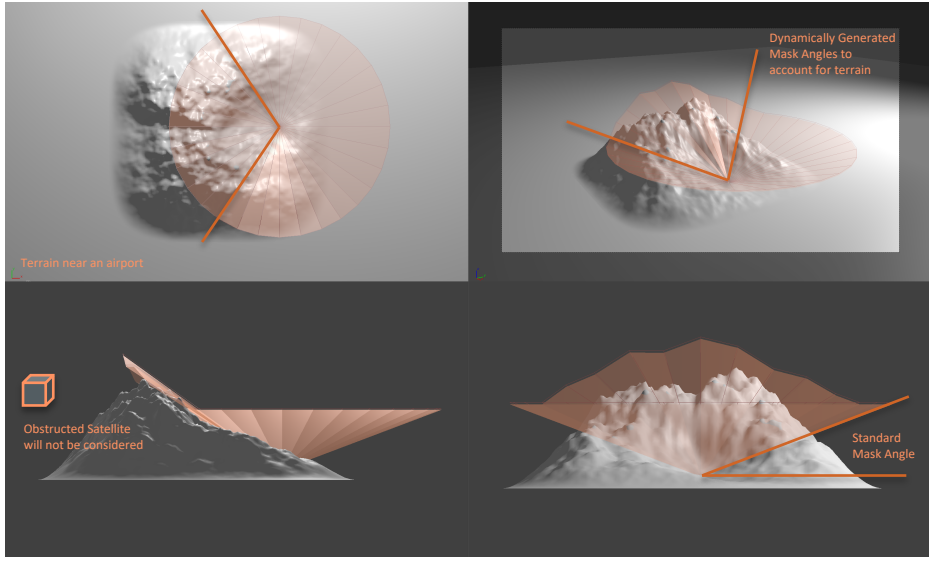
Using the Web-based User Interface the user can create automated report schedules which are sent on specific times to a list of configured recipient.
Reports can be scheduled for areas, locations and routings using different RNPs and receiver types.



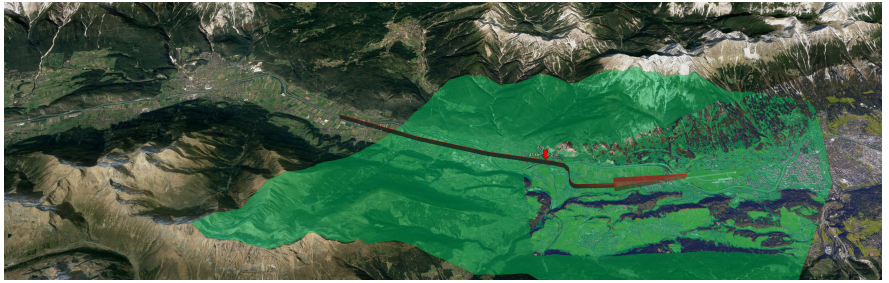
Terrain Sceening for RNP-AR

SPACEKEYS

For RNP-AR approach procedures not only the satellite constellation needs to be considered to predict the achievable GNSS accuracy, but also the potential obstruction of satellites by the surrounding terrain. Spacekeys dynamic terrain screening engine analyzes the surrounding terrain for every RNP-AR request to ensure compliance with this requirement. The main advantage is that any new RNP-AR approach at any airport globally can be RAIM checked right away.



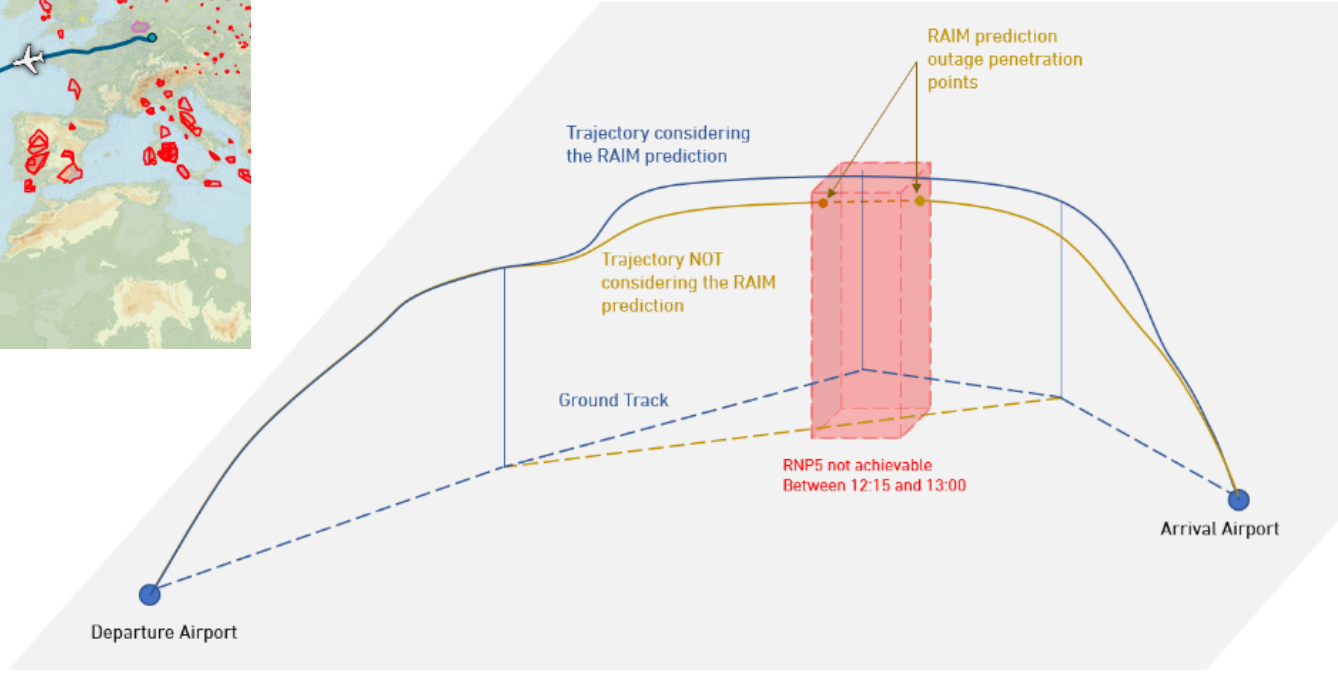
During an approach, the terrain is different on every point along the trajectory and is dynamically derived if required.



Advanced Flight Planning Integration

SPACEKEYS

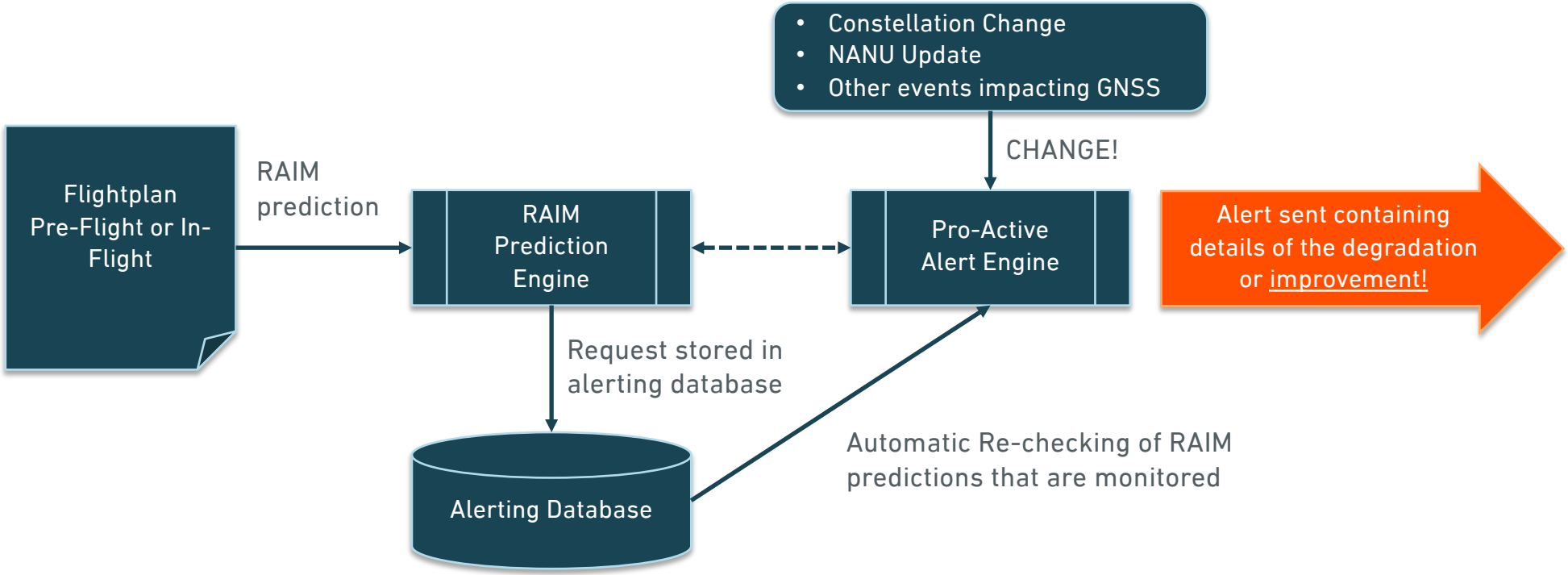
Spacekeys RAIM predictions produce RAIM outage forecast data which can be used during the flight planning process to avoid areas of predicted RAIM outages. The data is available through SOAP or REST webservices in a machine readable format (e.g.: GeoJson).



Pro-Active Alerting

SPACEKEYS

A unique feature, that will only be available in Spacekeys RAIM prediction, is the pro-active RAIM prediction monitoring. This will enable flight planners to react to degradations and improvements even if they no not re-check RAIM for a given flight. Flights may be monitored and alerts generated for flights that are pre-flight, but also during the execution phase.



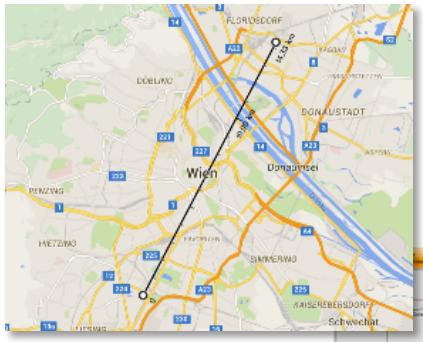
Architecture and SLA

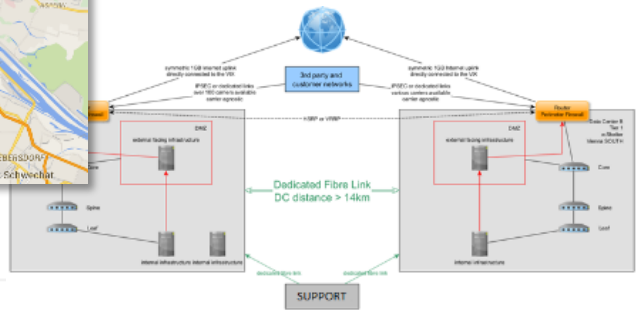
SPACEKEYS

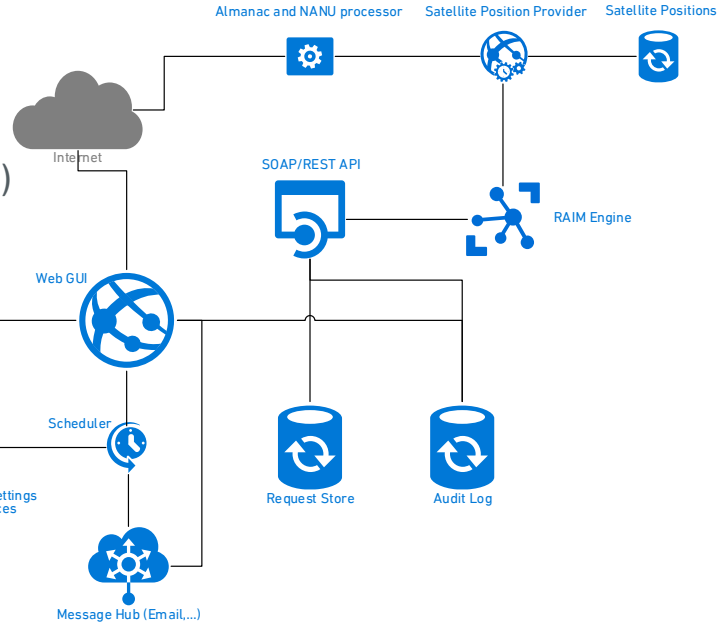
The system architecture has been created using latest technologies with the main focus on stability, scalability and performance. Each component is resilient and deployed over multiple physical locations. Deployment in a commercial cloud provider's infrastructure (AWS, Azure,...) is supported out of the box.

Spacekeys guarantees the following Standard Service Levels:

- 99.95% system uptime.
- New Almanac Processing within 2 minutes.
- New NANU processing within 60 minutes.
- Average 500 requests per aircraft registration and day (fair use)
- 24/7 support







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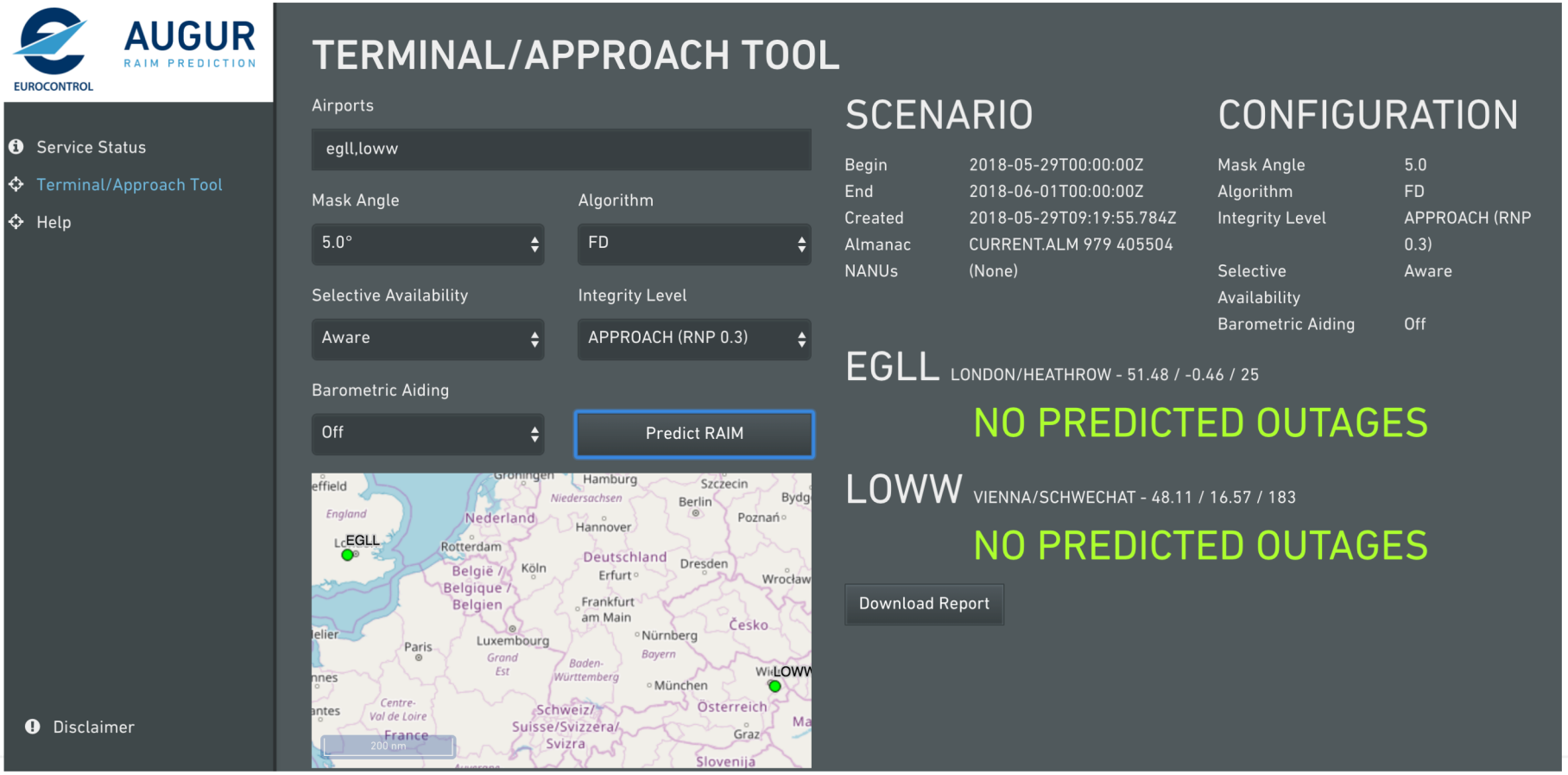


THANK YOU!
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