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The Future of the Flight Inspection World

A Crystal Ball Look into changes ahead, based on current trends and developments

Capt Thomas WEDE

AFI Flight Inspection GmbH, Braunschweig, Germany

Introduction
1

- **Aviation industry at doorstep of major change in navigational infrastucture by:**

  Introduction of the Precision Area Navigation / Required Navigation Performance concept

  (PRNAV / RNP)

- **What is PRNAV / RNP?**

Introduction
2

- **PRNAV & RNP not yet internationally harmonized terms**
- **Different stakeholders (FAA, ICAO, EUROCONTROL, et al, use different definitions and accronyms:**

Area of Application	RNP value	Designation of navigation standard: Current situation	Designation of navigation standard: New RNP concept
Oceanic remote	10	RNP10	RNP10
	4	RNP4	RNP4
En route continental	5	RNP5 Basic Rnav	Basic Rnav
En route continental and terminal	2	U.S. Rnav Type A	Continental Rnav
Terminal	1	U.S. Rnav Type B P-Rnav	Terminal Rnav

Source: Fitzsimons / AIN

Definition:

PRNAV / RNP is a navigational concept which main characteristic is a shift in the required navigational performance from discrete navigational aids on the ground to on-board navigation solutions, at present primarily based on space-based systems.

Background of PRNAV / RNP 1

- **Main rationale behind introduction of PRNAV / RNP:**

1. **Increase airspace capacity by safely reducing separation minima, and by introducing more optimized routings, based on improved navigational performance of the individual air traffic**
2. **Cost savings by reducing / eliminating ground based navigational aids**

- **Space-based systems (primarily GPS) regarded as main components of this concept, ground-based system possible (DME / DME, VOR / DME)**

Background of PRNAV / RNP 2

- GPS breakthrough indeed: low cost, high precision, world-wide coverage.
- Additional space-based systems:
  - * GLONASS (fully operational in 2012)
  - * GALILEO (fully operational in 2011)
- Terminology: from GPS to GNSS (Global Navigation Satellite Systems)
- In the wake of GPS introduction, Radio Master Plans by various Air Navigation Service Providers and authorities (FAA; DFS et al) to withdraw conventional navigational aids completely.
- That did not happen – why?

Background of PRNAV / RNP 3

- 2 issues with GNSS :

1. Integrity
2. Vulnerability

- Integrity issue mitigated by means like RAIM, GBAS (e.g.DGPS), SBAS (e.g. EGNOS), in future: crosscheck with other GNSS systems

- Vulnerability still is – and will be! – an issue.

Says who?

Background of PRNAV / RNP 4

- August 2001: The John A. Volpe National Transportation System Center issued its final report on the

  „Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System“

- Study identified the risks of interference to GPS due to both intentional and un-intentional spoofing or jamming.

- System-inherent weakness due to very weak signal strength of just 10^{-18} Watt (= -160 dbW = noise level)

Background of PRNAV / RNP 5

- due to signal strength, GNSS easy to interfere with:

- Jammers easy to conceal

- 1 Watt denies usage of system over 20 Km^2

- Not an unrealistic worst-case scenario (see 9 Sep 2001)

GPS jammers can be small, inexpensive, easy to build and easy to conceal. Simple versions can fit in a soft drink can, while more complicated versions can be as small as a pack of cigarettes.

Source: AIN

Background of PRNAV / RNP 6

- AFI experienced, over the past 18 months, 4 severe GPS outages:
  - 2 in Europe (Spain, Italy)
  - 2 in the Middle East (Bahrain, Afghanistan)
- Volpe Study recommends Frequency Protection and Management Program by appropriate Authorities

In our context:

- None of the outages predicted on RAIM tools, none were known to the authorities
- Authorities had tremendous problems to approach the appropriate counterparts and handle the situation

= still a far way to go!

Background of PRNAV / RNP 7

- Since Volpe Study GNSS might be *primary means*, but not *sole means* of navigation
- Volpe Study recommends identification, and subsequent introduction of, back-up system(s). Potential systems under consideration:
  - * DME / DME
  - * LORAN C
  - * VOR / DME
  - * INS
  - * ILS

Background of PRNAV / RNP 8

- Back-up system not yet identified and agreed upon
- under constant capacity and cost pressure, PRNAV / RNP will come anyway
- at some specific locations already introduced (Innsbruck, Austria, Juneau, Alaska, Queenstown, New Zealand)
- With no back-up system internationally agreed upon, Flight Inspection Service Providers (FISPs) will have to prepare for all potential ones!

Impact of PRNAV / RNP on the Flight Inspection Community 1

- With regard to integrity and vulnerability issues of GNSS, GNSS Stand-alone based Cat III approaches will not come
  = ILS will stay
- Other conventional navigational aids will have to stay on for 3 reasons:

1. they might be integral part of an PRNAV procedure, which might be based on DME / DME or VOR / DME as well
2. current legislation stipulates that the missed Approach Sector of any PRNAV procedure has to be defined by conventional nav aids
3. GNSS segment of a PRNAV / RNP procedure has to be supplemented by a conventional back-up system

Impact of PRNAV / RNP on the Flight Inspection Community 2

- as no international standard for a back-up system exists yet, FISPs will have to prepare for all potential systems.
- this will translate into cost, certification and training issues, as they now have to prepare for a rather disparate set of navigational aids and their respective calibration requirements
- hardware requirements will further go up by introduction of GLONASS and GALILEO
- Flight Inspection Receivers for certain potential applications (e.g. LORAN C) still have to be developed; flight inspection procedures to be developed accordingly

Impact of PRNAV / RNP on the Flight Inspection Community 3

- Detailed Guidelines for flight checking PRNAV / RNP procedures still have to be developed.
- In March 2005, EUROCONTROL issued „Guidance Material for the Flight Inspection of RNAV Procedures“
- With current state of affairs, this guidance material had to be rather generic

Impact of PRNAV / RNP on the Flight Inspection Community: Open Issues 1

Issues still under discussions in the PRNAV / RNP context are:

1) On GNSS-based procedures, shall the measurement of the signal in space be part of the calibration process?
2) How often shall an PRNAV / RNP procedure be flight checked? Initial flight check only? Only after major modifications? What changes warrant a major modification?
3) What aircraft to be used for the flight check?
   Old questions, but new impetus, as flight check will be more orientated towards procedure evaluation rather than measuring signal in space

Impact of PRNAV / RNP on the Flight Inspection Community: Open Issues 2

4) Will simulators supplement or even replace, flight inspection aircraft?

   Due to terrain database issues, obstacle assessment and signal in space evaluation (signal reception along the flight path, potential multi path effects etc.), simulators will be able to supplement, but not replace flight inspection aircraft.

5) Volpe Study called for strict Frequeny Protection and Management Program – shall FISPs be part of it?
   To what extent?

   Constant airborne frequency monitoring?

   Capability to identify and pin-point any source of interference?
   Who will be willing to pay?

Impact of PRNAV / RNP on the Flight Inspection Community: Open Issues 3

6) PRNAV / RNP still impaired by open issues like:

* Procedure design, coding and distribution issues
* Database issues
* Flight Management System FMS / ARINC 424 issues
* Aircraft / Autopilot issues
* Open questions of Procedure Ownership

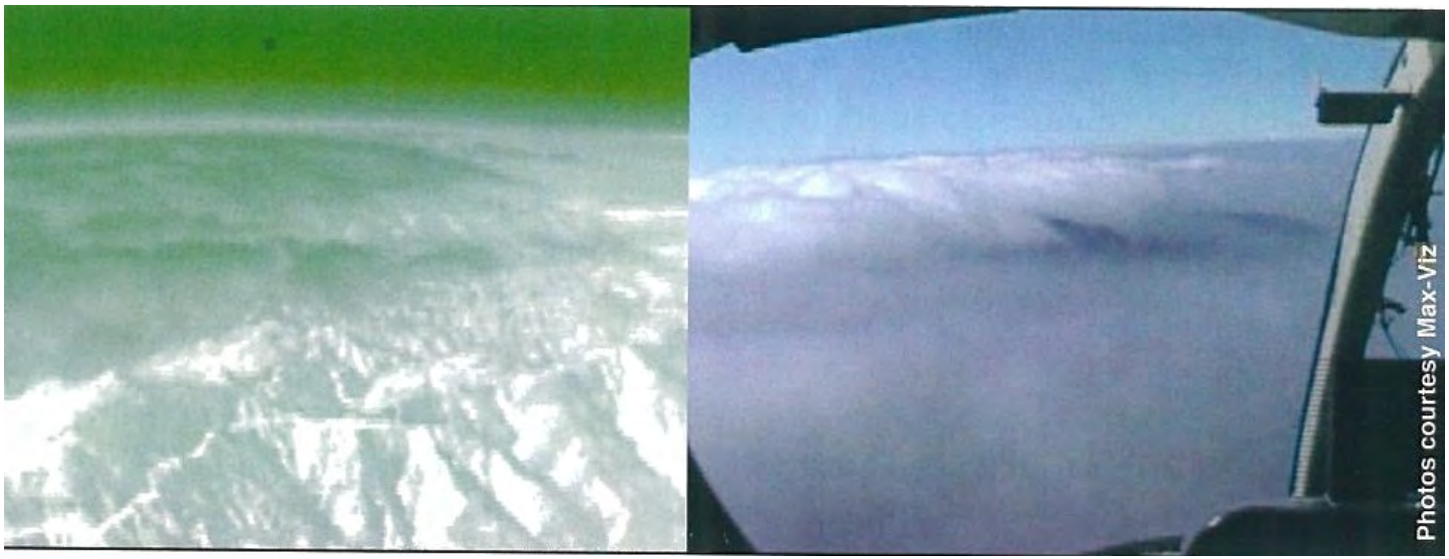
Impact of PRNAV / RNP on the Flight Inspection Community: First Conclusions

1. Shift from classical measurement of signal in space towards procedure evaluation and verification, resulting in:
2. a look at an integrated package, including checking of:
   * procedure design and coding
   * charting
   * procedure distribution within the aeronautical system
   * database generation by data houses
   * database packing by avionics (FMS) manufacturers
3. Brief / consult / assist the various stakeholders in the aviation community on these issues

Enhanced / Synthetic Vision Systems 1

Enhanced Vision Systems EVS:

- Based on Infrared Sensors to penetrate darkness, fog and - to a certain extent- clouds
- more complex (and costly!) systems include millimetre wave radar systems to penetrate precipitation

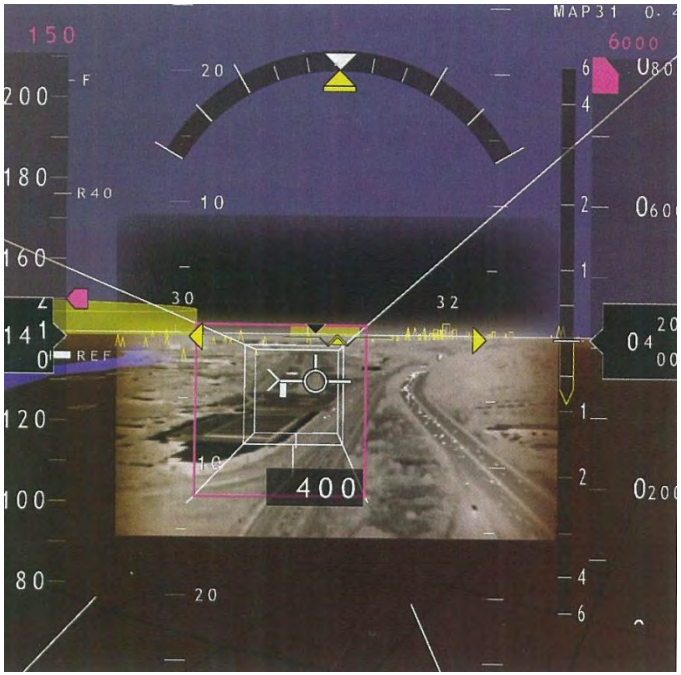


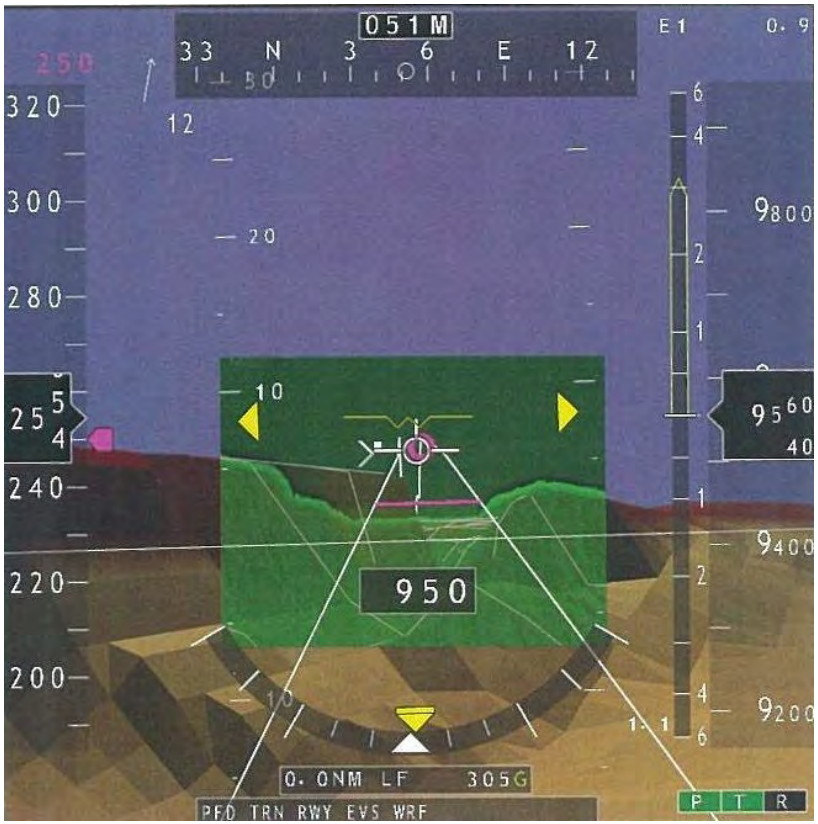
Source: Max-VIZ via Professional Pilot

Enhanced / Synthetic Vision Systems 2

Synthetic Vision Systems SVS:

- Based on Digital terrain Models as well as on Digital Maps
- may be combined with EVS





Source: Connor / Professional Pilot

Enhanced / Synthetic Vision Systems 3

- EVS / SVS emerging technology; no stand-alone procedures exist so far

- FAA certifies specific EVS for specific aircraft and operator down to Cat 1 minima at Non-Precision Approaches

- Main benefit of EVS / SVS: might bridge the „Integrity / Vulnerability Gap“ of GNSS due to restored visibility at critical point of approach (e.g. Final Approach Waypoint)

- EVS / SVS has potential for the future; FISPs should monitor progress and be prepared

Future Trends in Flight Inspection Systems 1

- Smaller, more compact FIS due to further miniturization of electronic components (computers), Multimode Receivers
- Manned, ground-based reference systems to be replaced by unmanned / FIS-integrated systems (e.g. DGPS, Phase Solution, Camera update)
- Advances in datalink technology might put NavAid Inspector on the ground
- Crew complement might be reduced, with 3 probably being the minimum, due to legal constraints (Minimum cockpit crew of 2)
- Emerging Very Light Jets VLJ might prove to be a viable, modern and cost-effective flight inspection platform

Future Trends in Flight Inspection Systems 2

- However, new capability requirements for the GNSS sector (GALILEO, GLONASS), as well as for back-up systems for GNSS (LORAN C, DME / DME etc.) might counteract trend towards more compact FIS

- In case FISPs become part of GNSS Frequency Protection Program, ensuing requirements will translate into more complex, and thus, bulky, hardware on board.

- In the end, increased mission capability requiremends might translate into similar FIS size and weight parameters as today; resulting in

- a required minimum size of the future flight inspection aircraft similar to the size of their contemporary counterparts in the KingAir / Citation class.

Unmanned Aerial Vehicles
UAV
1

- Intention was to relieve human beings from dangerous and laborious missions
- Further intention was to save cost

So why not use UAVs for Flight Inspection?

- still severe integrity issues

Here's what a bad solder joint in a voltage regulator can do. In October 1999, this Aurora Flight Sciences Perseus drone suffered progressive control failure and malfunction of its flight termination parachute during a NASA-sponsored high-altitude flight. It landed on one side of Interstate 40 near Barstow, Calif., and skidded across the median strip onto the other side (*AW&ST* Jan. 17, 2000, p. 399).

Source: Dornheim / Aviation Week & Space Technology

Unmanned Aerial Vehicles
UAV
2

- still issues with integrating UAVs in civil airspace

This 2004 close call between an airliner and a Luna UAV over Kabul highlighted a growing risk

Source: German Army via Flight International

- still flexibility issues

- to overcome all these issues, heavy cost involved, which render UAVs uneconomically in the flight inspection role

Conclusions
1

1) PRNAV / RNP, and here most noticeably the GNSS element of it, will not replace conventional navigation aids, on integrity and vulnerability grounds

2) PRNAV / RNP will require conventional back up

3) Some of these back-up elements still require development (DME / DME, LORAN C), but FISPs should already cater for them

4) FISPs should take new elements of GNSS sector into account (GALILEO, GLONASS)

5) Trend for FISPs from measuring signal in space towards procedure design and flyability verification, including database checks, will continue

Conclusions 2

6) FISPs might play important role in monitoring and protecting vital frequency bands
7) EVS / SVS have high potential to at least supplement PRNAV / RNP, might develop into autonomous navigation technology, FISPs should cater for that development accordingly
8) Trend in miniaturization will continue, with resulting FIS being smaller and lighter
9) Future FIS might do away with manned ground-based reference systems
10) Datalink technology might put Navaid Inspector on the ground

Conclusions
3

11) Trend in miniaturization of FIS will be counteracted by increase in system requirements for new navigation systems

12) VLJs look as a promising option as flight inspection aircraft, however, with new emerging system requirements, they might prove to be too small for an allround, multi-mission FIS

13) UAVs will not be a viable option in the flight inspection world, on integrity, certification and ensuing cost issues

Thank You for Your attention!

Any comments?