The Future of the Flight Inspection World
A Crystal Ball Look into changes ahead, based on current trends and developments

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ABSTRACT

The Flight Inspection community is faced with a variety of changes that will have a significant impact on the way we will execute our profession in the near- as well as in the long-term future. The following paper tries to address some of these changes and their potential impact on our industry. The most apparent change will come from the implementation of PRNAV/RNP. Apart from shifting the focus from calibrating signals in space to a more procedure design verification and database integrity process, one of the interesting questions for flight calibration organisations will be to see which system(s) will be introduced as a back-up to the primarily GNSS-based PRNAV / RNP concept. Different options are currently under discussion (DME/DME, INS, LORAN), which all will have a marked impact on the technical and operational aspects of a flight inspection unit.

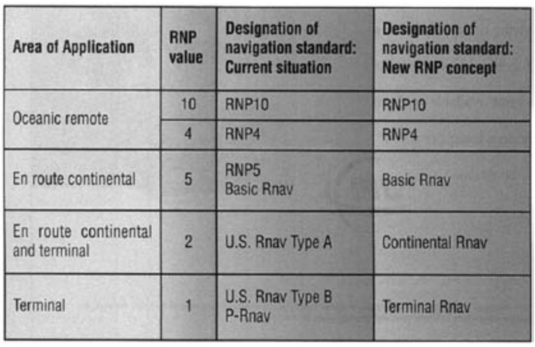
The paper continues with an outlook to future developments in navigational systems. Here, so called Enhanced Vision Systems (EVS) and Synthetic Vision Systems (SVS) systems showed great progress in the last two years. The author investigates how this might translate into future navigational and procedure concepts and their associated calibration requirements.

The paper then switches to future trends in Flight Inspections Systems. Under ever increasing cost and efficiency pressure, further miniaturization will become even more important. The resulting aspects in crew number and airframe size are discussed.

Finally, in this context, the author addresses the issue of so the called Unmanned Aerial Vehicles (UAVs), which made significant progress over the last years, and investigates their potential for the flight inspection role.

IMPACT OF PRNAV / RNP

The aviation industry is currently at the doorstep of introducing a major change of its navigational infrastructure with the introduction of the Precision Area Navigation / Required Navigation Performance (PRNAV / RNP) concept. A quick word on terminology: PRNAV and RNP are not yet internationally harmonized terms. Different authorities and entities, FAA; ICAO and EUROCONTROL, still use slightly different definitions and acronyms, which are not always 100% compatible. Table 1 below gives a first impression as just how opaque the current terminology picture still is:



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

Table 1: Current terminology and acronyms in use.
Source: Fitzsimons / AIN

To cover all these different aspects of terms and definitions would go far beyond the scope of this paper. For details the interested reader might turn to the appropriate literature listed under the reference at the end of this paper.[1]

For ease of communication, this author uses the term PRNAV / RNP in the context of a navigational concept, which main characteristic is a shift in the required navigational performance provided from discrete navigational aids on the ground to onboard navigation solutions, based on, primarily spaced-based, navigational systems, like GPS.

Before this paper addresses the impact of this paradigm shift on the Flight Inspection Community and its Flight Inspection Service Providers (FISPs), we should have a short look at the background of the PRNAVV / RNP concept and its underlying implications and open issues.

BACKGROUND OF PRNAV / RNP / OPEN ISSUES

The main rationale behind the introduction of PRNAV / RNP was twofold:

1. Increase airspace capacity by safely reducing separation minima, based on improved navigational performance of the air traffic
2. cost savings by eliminating / reducing ground based navigational aids

Space-based navigational systems, and here primarily GPS, have always been regarded, more or less, as the main components of this new concept. And GPS has indeed been a major break-through: it provides a low-cost, world-wide navigational service with unprecedented precision. It quickly conquered the aviation community, and today is a major, indispensable part of that industry.

With the potential of space-based navigational systems clearly identified, other nations or group of nations started to develop their own systems: Russia stated its GLONASS system more or less at the same time as the USA introduced GPS. After years of neglect, the Russian government just recently vowed to restart investment into the system, with the aim to have GLONASS in full operational mode around 2012.

The Europeans created their own system, GALILEO, and after the usual hiatus of multi-national projects over cost, control, work-share and related issues, a pre-production satellite (GIOVE A) has successfully been launched at the end of 2005. A second test vehicle is to follow soon, with the aim of having all space vehicles in place, and reaching full operational capability, by 2011.

So, in the near to mid future, aviation will be able to rely on 3 different spaced-based navigational systems, a fact that initiated a change in nomenclature as well as today we talk about GNSS (Global Navigation Satellite System) rather than GPS.

In the wake of the euphoria surrounding the introduction of GPS in the operational world in the 1980s, Air Navigation Providers and authorities worldwide were quick in drawing up plans to retire their ground based navigational system, and switch to GNSS completely, envisioning significant cost savings in the process. Both the FAA as well as the German DFS, for instance, in their Radio Navigation Master Plans of 1996, stipulated the complete withdrawal of all conventional navigational aids, including ILS Cat III, by 2010.

Now, only 4 years away from that deadline, it is fairly evident that this will not happen, and the appropriate Master Plans have been revised accordingly. What caused that change?

With all the benefits like precision, cost-efficiency, or coverage, GNSS is offering, there have always been 2 issues that could not be resolved 100%: Integrity and vulnerability.

The integrity issue has been tackled by introducing fairly sophisticated, complex statistical / mathematical procedures within the receiver on board the aircraft (RAIM, Receiver Autonomous Integrity Monitoring). Integrity has further been enhanced by introducing augmentation systems, both space- as well as ground-based (Space-Based Augmentation Systems SBAS, Ground Based Augmentation Systems GBAS, with DGPS being an example for GBAS).

Integrity of GNSS will further be enhanced with the availability of additional spaced based systems like GALILEO, providing the capability to crosscheck one system against the other (suitably capable multi mode receivers provided). Nevertheless, certain effects (e.g. Multi Path) may never be eliminated reliably enough to warrant a Cat III-like operation.

The main issue with GNSS that has not been resolved to this day is that of vulnerability. In August 2001, The John A. Volpe National Transportation Systems Center issued its final report on the "Vulnerability Assessment of the Transportation Infrastructure Relying on the Global Positioning System".[2]

This in-depth study clearly identified the risks of interference to GPS due to both intentional or unintentional spoofing or jamming of its signal. Unfortunately, this susceptibility to interference is a system-inherent weakness due to the very weak signal strength the system is operating with: with just 10-16 watt, equivalent to –160dBw, on the Earth's surface, the signal operates at, or around, noise level.

The study identified a number of technical and operational measures to reduce the effects of interference, however, it states very clearly that it is not possible to eliminate these effects completely.

Using a second space-based navigation system like GALILEO, was one of the options the Volpe Study identified as a means of mitigating the interference risk, however, it was again very clearly stated that this approach will not eliminate all risk, as GALILEO is operating in the same frequency band, with a comparable power level, as GPS, thus being exposed to the same source and level of interference.

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.

Table 2: GPS Jammer - Source: AIN

Unfortunately, due to the weak signal strength of GNSS, only little power is required to interfere with the system effec¬tively.[3] As the Volpe Study pointed out, easy to produce, and easy to conceal jammers with as little power as 1 Watt might be sufficient to deny the usage of the system over an area of roughly 20 Km2. Any increase in power, elevation in transmitter location plus emitting a more sophisticated spoofing and / or jamming signal might disrupt a GNSS signal over several hundred of square kilometres.

Evidently, the Volpe Study spelt the end of GNSS as a sole means of navigation. GNSS is now, in most countries, accepted as primary means of navigation, but for the reasons stated above, for the foreseeable future, it will not be sole means. of navigation

It is interesting to note that the threat assessment as explained in that study proved to be no unrealistic worst-case scenario, as the events in New York in September, 2001, just 2 weeks after publication, showed. The world did not really got safer since then, and one unfortunately has to admit that a potential for intentional interference does exist.

It might be further of interest to note that this author, over the course of the last 18 months, experienced 4 significant GPS outages, lasting longer than 2 hrs, up to several days. 2 of these outages were observed in Europe (Spain and Italy), 2 in the Middle East. The outage in Italy (Villafranca) could possibly be traced to a joint military exercise going on near the airport at that time, one outage in the Middle East (Bahrain Int'l Airport) coincided with the presence of specific military aircraft on the apron and in the vicinity.

The second outage in the Middle East was observed in Kabul, Afghanistan, were the reason behind it was more obvious. For the second outage in Europe (Pamplona, Spain), a plausible cause could never be established.

All outages had in common that they were not announced, not published in any way, and that all RAIM prediction tools available at that time did not indicate any RAIM impairments, let alone complete GPS outages, for these specific dates, time and locations. Further, it was very evident that the respective Authorities, informed about these outages, had tremendous problems to handle the situation, to approach the correct counterparts, and solve the issue.

One of the findings of the Volpe Study was a strong recommendation for an appropriate frequency protection and management program by the responsible authorities. From our experience over the last years, the aviation community is still a far way off this required closed-loop frequency management, with still a lot more work required to effectively protect the vital GNSS frequencies, as required for a safety-critical asset as there are in aviation.

The Volpe Study went on to recommend the identification, and subsequent introduction of a viable Back-up system. Potential systems under consideration were:

- DME / DME
- LORAN C
- VOR / DME
- INS
- ILS

All systems have their advantages as well as their drawbacks, which in general boil down to cost, and to the important questions as to who is going to cover them – the ANSPs or the operators.

A combination of GNSS with INS has the tremendous advantage of giving a high degree of autonomy to the individual aircraft being so equipped, as INS is immune against radio interference. Unfortunately INS comes with a big price tag, which makes it rather unsuitable for smaller operators and / or the General Aviation community. The ground based navigational aids listed above, apart from DME / DME, have a proven track record, and they are much more difficult to interfere with (particularly over greater distances), however, their operation involves a high degree of investment and cost, something the industry tried to get away with in the first place when introducing the PRNAV / RNP concept.

Today, 5 years after publication of the Volpe Study, the main issues it raised – the vulnerability of GNSS and the resulting requirement for a viable back-up system – have not been satisfactorily resolved. On an international level, there is still no agreement on a standardized back-up solution, and there is no such thing on the horizon.

Nevertheless, under constant capacity and cost pressure, the aviation community apparently decided to continue with PRNAV / RNP anyway, with implementation dates, even in terminal airspace, coming closer (the current time frame under discussion being 2008 – 2010), and with some procedures in specific locations, like Innsbruck, Austria, Juneau, Alaska or Queenstown, New Zealand, for specifically approved operators already in place.[4]

With no standardized navigation back-up solution agreed upon, it stands to fear that the ANSPs / authorities worldwide will use a mix of, if not all, potential back-up systems mentioned above. The FISP community will have to take that into account.

IMPACT OF PRNAV / RNP ON THE FLIGHT INSPECTION COMMUNITY

With regard to the integrity and vulnerability issues related to GNSS-based navigation systems, it is the conviction of this author that for the foreseeable future conventional, ground-based navigation aids will play a vital role in aviation: for these very reasons, GNSS-stand-alone-based Cat III approaches simply will not happen (at least not on a grand scale), necessitating to retain conventional Cat III ILS. To keep ILS online, even to lower categories, might further be required for back-up reasons. Therefore, ILS calibration will form a significant part of the flight inspection world for the next 20 years.

Other conventional navigational aids will have to be retained as well, for three distinct reasons:

First, they might be an integral part of an PRNAV / RNP system, which does not necessarily have to rely on GNSS as sole means of navigation, but might be based on DME / DME or VOR / DME as well.

Second, current legislation, both by ICAO as well as EUROCONTROL, for instance, stipulate that the missed approach sector of any PRNAV procedure being defined by conventional navigation aids.

Third, it will be inevitable to supplement the GNSS-based segment of an PRNAV / RNP concept by a conventional back-up system.

As said earlier, this back-up system has not been agreed upon internationally yet. This means that a flight inspection organisation, and an internationally operating one in particular, has to prepare itself for being able to calibrate all these potential back-up systems.

On the flight inspection system side, this will put a certain stress on the FISPs, with a number of cost, certification and training issues for a now rather disparate set of navigational aids and their respective calibration requirements involved.

Hardware requirements will further go up with the need to being able to receive and flight check the upcoming GNSS systems GALILEO and GLONASS, respectively, as well. Needless to say that appropriate flight inspection receivers for these systems still have to be developed; the same applies for a flight inspection receiver for LORAN C.

DME / DME flight inspection receivers are at an Initial Operational Capability stage, and should become available within the next 12 – 24 months. However, detailed flight inspection procedures of DME / DME still have to be developed. Open questions like how to identify the "critical" DME on specific segments of the procedure, and at what distance, for instance, still have to be answered.

LORAN C flight inspection procedures would have to be drawn up and further developed, together with the appropriate flight inspection hardware.

EUROCONTROL, in Autumn 2005, published an initial Guideline for Flight Checking of PRNAV Procedures. This guideline gives a first insight into future things to come, however, given the stage PRNAV / RNP currently is at, this document has to remain rather generic, with details to be filled in the future by the appropriate stake holders.

Issues still under discussion are, for instance:

1. On GNNS-based procedures, shall the measurement of the signal in space be part of the calibration process? In Germany, this is, at present, a requirement by the authority DFS, for GNSS Stand alone procedures. But with the underlying satellite constellation constantly changing, this flight check of signal in space can only be a spot measurement; it's value can be viewed as limited. Does that mean, for the future, it can be discarded? DFS thinks so, as latest draft version of their flight inspection guidelines revokes the requirement to flight check GNSS-based procedures, and thus signal in space, altogether, after initial commissioning flight checking of the procedure.
2. How often shall a PRNAV / RNP procedure be flight checked? Not at all after the initial commissioning flight check and procedure verification? Only after major modifications to the procedure? What changes warrant a major modification?
3. What kind of aircraft shall be used for flight checking purposes? An airliner type, which would be more representative of the main traffic using the procedures, but would be cost-prohibitive, plus excluding smaller / General Aviation types? Or using, on cost grounds, smaller aircraft (like in most cases today), with the disadvantage of them being not really representative of the main traffic using the procedures? This discussion is probably as old as flight checking itself; however, the shift from measuring signal in space to a more procedure evaluation type of flight inspection lends new impetus to that discussion
4. Will simulators be able to supplement, or even, replace, aircraft in the flight inspection of PRNAV / RNP procedures? Simulators have been used in this context in the past, in part extensively so, for instance in the trials to verify the new PRNAV procedures in Innsbruck. Although this approach warrants significant merits (safety, cost, reduced stress on ATC / capacity, reduced environmental impact), it has its limitation: the terrain database has to be extremely accurate to be representative of the real terrain; obstacle assessments will not be possible in a simulator, as well as signal in space evaluation (signal reception along the flight path, potential multipath effects etc.). For these very reasons, simulators, in the future, will be able to supplement flight inspection aircraft, but they will not be able to replace them.
5. As indicated in the chapter before, the Volpe Study calls for a strict frequency management and protection program. Shall FISPs be part of that program? Should they be tasked with constant airborne frequency monitoring, with the aim to identify, track and pin-point any possible interference, being it intentional or unintentional? Technically, this would be possible, but as it would involve some rather sophisticated technical equipment, plus a significant amount of airborne time, this concept might prove extremely costly. It might prove to be desirable, from an integrity and reliability point of view, but would the community be willing to pay for it?

Apart from all these open items associated with PRNAV / RNP, there is one future trend clearly identifiable: a stronger emphasis on procedure evaluation and verification, rather than a mere measurement of signal in space.

With this shift in focus of interest comes a new set of requirements: in an ideal world, a FISP, on checking a new, or a routine, procedure, would look at an integrated package, including databases, coding, charting, and distribution of the procedure within the aeronautical system, which includes the authorities, respective ANSPs, data houses as well as data packers (data packers are those avionic manufacturers that organise / manipulate aeronautical data in a way to make them compatible with their respective Flight Management Systems FMS).

It is no secret that the aviation community, at present, is still very far off this ideal world. It starts with the raw data of any PRNAV / RNP procedure, its waypoints and their underlying geographical coordinates. Here, from experience, much more effort is required in the future, to make this raw data more accurate, and most important: reliable. In the past and current world, this has not been much of an issue: a localizer coordinate being off by 100 meter, would have no effect, as the localizer would still lead an aircraft safely to the runway, as long as it is properly aligned with it.

A threshold coordinate, being off by 100 meter, would produce rather undesirable results.

In the PRNAV / RNP world, tens of thousands of coordinates have to be measured with high precision, and processed and distributed to various stakeholders every day. It will be a major challenge to bring that system to the reliable status that is now required. To indicate the scope of that challenge: in the ECAC region alone, 60% of all national authorities and / or ANSPs, responsible for these data, do not have a quality system in place, which means, they create their coordinates one way or the other, but not in a re-producible, documented way. One authority this author dealt with, was not even sure as to what geodetical system they were using.

Further issues arise with the variety of FMS in use today, and their wide variety of capabilities. Most of the FMS manufacturers manipulate the data base they receive from the data houses, to make them compatible to their individual product. This in turn produces some interesting results, as now procedures might appear quite different on the FMS then originally envisaged by the procedure designer.

Here, more standardization on the field of FMS design will be required: the code for translating procedures into FMS-compatible formats, ARINC 424, currently being an industry standard only, and as such, being subject to rather rapid changes, has to be declared an international standard (and be frozen subsequently). Further, a requirement for FMS to be capable of processing all ARINC 424 formats should be mandated. All this will involve cost, but it is the firm conviction of this author, from experience, that otherwise PRNAV / RNP will not be a safe, and thus, viable option.

Any FISP dealing with flight checking of PRNAV / RNP procedures in the future, will have to be aware of these issues, and cater for them accordingly. Being in the middle of the net, FISP might play an important role in counselling the various stakeholders on all these issues in the future.

ENHANCED VISION SYSTEMS / SYNTHETIC VISION

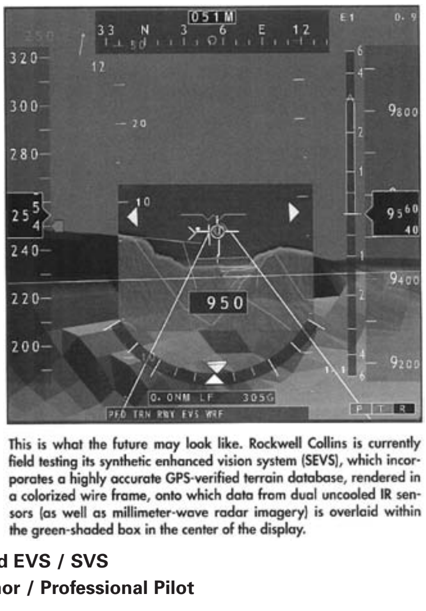
Enhanced Vision Systems (EVS) are sophisticated avionic systems that help penetrate darkness, clouds and fog.

Synthetic Vision Systems (SVS) are systems that generate an image of the outside world of the aircraft, based on accurate digital terrain models as well as on maps[5]. Both EVS as well as SVS, particularly when combined, show great promise for the future, as they will resolve some lingering integrity issues with current or foreseeable navigation concepts, as EVS / SVS brings back human vision as a valuable tool to verify the position of an aircraft. As this might have a significant impact on future airspace and procedure design, as well as on future navigational concepts, this paper addresses some issues behind this new avionic concept.

In general, EVS is based on one or more infrared sensors, operating at different frequencies within the IR bandwidth. These sensors are capable of penetrating darkness, clouds and fog, however, they are limited in their performance by the shape and size of precipitation (i.e. rain, dense clouds etc.). To overcome this limitation, more sophisticated (and thus, more costly) EVS additionally work with millimetre wave radars that are able to penetrate precipitation.

The capabilities of EVS are significantly en¬hanced by combining it with Synthetic Vision Systems (SVS). SVS benefits from progress being made over the last 10 years in the field of remote sensing: with the NASA / Space Shuttle Radar Mapping Mission of the Earth successfully completed, a fairly accurate digital terrain model of most of the Earth's surface is now available. Advances made in the filed of sensing technology means that today, commercially available satellite pictures with a resolution of 1,0 – 1,5 meters are no longer the domain of the military / security community.[6]

Add to that the tremendous progress being made over the last years in computation power being available even in small-sized, on-board com¬puters, and the result is a very impressive digital representation of the outside world. The main benefit of SVS, when combined with EVS, is, that it greatly enhances the field of vision; it is possible to generate a fairly big picture at any given time, whereas the field of view of an EVS, due to sen¬sor limitations, is always somewhat limited. So in a combined EVS / SVS system, SVS is respon¬sible for presenting the digital overview, whereas EVS, concentrating an a smaller window straight ahead, verifies the digital world with an outlook, along the safety-critical flight path, of the real world outside.



This is what the future may look like. Rockwell Collins is currently field testing its synthetic enhanced vision system (SEVS), which incorporates a highly accurate GPS-verified terrain database, rendered in a colorized wire frame, onto which data from dual uncooled IR sensors (as well as millimeter-wave radar imagery) is overlaid within the green-shaded box in the center of the display.

Table 3: Fused EVS / SVS
Source: Connor / Professional Pilot

EVS / SVS information is presented both on so-called Head-up Displays (HUD), or on Multifunction Displays (MFD) in the cockpit. HUD, by some sophisticated optical means, offers the advantage of presenting all necessary information at an indefinite point in front of the pilot, eliminating the need to lower the head and look down on instruments, with eye-sight being able to stay focussed on distance.

The disadvantage is, again apart from cost, that at current, HUDs are only monochrome, thus reducing the amount of information being presentable. Further, their field of view is rather limited.

MFDs on the other side, with their much bigger size, and their colour-capabilities, offer a tremendously powerful tool for keeping situational awareness.

At present, there are already a variety of EVS available on the market, ranging from low cost (single, uncooled IR sensor, no radar enhancement) to highly complex, sophisticated – and costly (multiple, cooled IR sensors, radar enhanced). Most of the system so far have been used on high-end business jets only.

EVS / SVS is an emerging technology. Nevertheless, the FAA certifies specific EVS down to Cat I minima (i.e. on Non Precision Approaches, with a nominally higher minimum). EVS carries a hefty price tag, which, most probably, will make it unsuitable for small operators and / or the General Aviation Community., at least at the time being. On the other hand, EVS / SVS offers tremendous potential to mitigate the integrity and, most important, the vulnerability issues associated with GNSS based navigational concepts. EVS / SVS relies on some form of navigation sources, like GNSS, as well, however, it would not be so much dependent on their respective performance and accuracy, as at safety-critical points of the flight, i.e. on approach, a visual verification of the assumed position would now be possible again.

To make that concept of EVS / SVS a viable option, both technically as well as commercially, still a lot of research is required. Nevertheless, the potential benefits from that technology warrant a closer look.

EVS / SVS based procedures are not yet available; the complete regulatory framework behind them is still missing. In line with that flight checking rules and regulations of these procedures are missing as well so far.

For FISPs all this would translate into the fact that flight checking of EVS / SVS procedures will most likely be focused on procedure design verification and its associated issues, like terrain and obstacle clearance, flyability etc, maybe, to a lesser degree, to verification of clear signal reception, should any such procedure being combined with other navigation sources.

Using SVS, their underlying digital terrain models and maps would require constant updating and verification, especially with regard to terrain and obstacle clearance. That would be another natural task for FISPs. At present, this can only be performed by flying these procedures and, by looking out, verify the terrain and obstacle situation. For the mid-term future, again in the light of the progress made in the field of remote sensing, this might be more and more supplemented by satellite data analysis.

FUTURE TRENDS IN FLIGHT INSPECTION SYSTEMS

After covering aspects of the future air navigation architecture, what will be in store for our industry with regard to future Flight Inspection Systems FIS ?

The continuing trend in miniaturization of electronic components will translate into more compact, and more lighter, FIS. Onboard computers will get more powerful, yet more compact at the same time. Integrating components in single elements, like Multimode Receivers, is a trend currently emerging (a good example for that being the Honeywell / Aerodata RNZ 850 Multimode Receiver), a trend that is likely to continue.

Manned ground-based reference systems (e.g. Lasertracker) will more and more be replaced by unmanned and / or FIS-integrated systems, like DGPS, Phase Solution or Camera-update Solutions.

Advances in the sector of datalinks open up the option to put the NavAid Inspector on the ground, close to the customer, with all vital data downlinked to a powerful laptop in front of him. The downsize of this concept might be that datalinks, capable of producing a viable bandwidth, with the required integrity and immunity to interference, for realtime applications are still rather expensive. Putting the NavAid

Inspector on the ground might impair possible options for trouble-shooting onboard the FIS aircraft.

The technical advances mentioned above will translate into a reduced crew complement. However, a crew of 3 will probably remain the minimum level (2 pilots and 1 NavAid Inspector), as legal requirements dictate a cockpit crew of 2 as a minimum under most operational environments.

All these factor cited should translate into more compact FIS, which in turn should translate into smaller aircraft required for the flight inspection role, with ensuing savings in operating cost.

The emerge of the Very Light Jets VLJ, in this context, might be interesting to watch. These aircraft, like the Eclipse 500, or the Cessna Mustang, to name just two, offer good performance, and an acceptable payload and cabin volume, for very competitive capital and operating cost. In how far these new designs are robust enough to stand the rigours of the flight inspection operation regime, however, remains to be seen. For operators able to live with a compact FIS, they might prove a very interesting option.

The final answer to the question of future FIS size lies indeed with the answer to the lingering integrity and vulnerability issues of GNSS. The trend to smaller FIS might be counteracted by the requirement to cater of new or additional navigation systems.

GALILEO, and maybe GLONASS, are good examples of additional capabilities a future FISP will have to feature. The requirements for back-up systems to the GNNS part of the navigation infrastructure, as laid out in the first part of this paper, will add additional hardware requirements to future FIS. DME / DME or LORAN C flight checking receivers will eat up space and weight won by miniaturization.

Should the flight inspection industry indeed become part of the GNNS frequency protection program, with the ensuing requirement to identify, track and pin-point any interference signals on a routine basis, this will most certainly translate into more complex, and bulky, hardware on board.

In the end, the flight inspection community might be faced with the similar set of weight and size parameters for their future FIS, due to the increase in required mission capability. That in turn means that future flight inspection aircraft , most probably, will be of the same size as their contemporary counterparts in the King Air / Citation class.

UNMANNED AERIAL VEHICLES UAVS A POTENTIAL OPTION FOR THE FLIGHT INSPECTION WORLD?

UAVs experienced a marked progress over the last years. For military applications, in an military environment, today they are considered a mature technology, with a wide variety of models for an even wider variety of missions now being available.

So in the literature, questions began to rise, as to why not use UAVs in aerial work, like fire fighting?[7] And, in the light of ever smaller and more compact FIS, taking this idea further, and translating it into our ever cost.-conscious flight inspection world: why not use UAVs in the flight inspection role?

Before we can address this question, maybe some background information on UAVs:

The main driver behind the development of UAVs was the idea to get human lives out of harm's way. UAVs are therefore intended for missions that are either too dangerous or too laborious for human beings. Good example for these missions are high altitude, long range and long endurance missions.

The original intention of saving cost as well was quickly proved to be a myth, as developers rather rapidly faced a dilemma: either build UAVs cheap, thus simple, but then they will not meet their mission requirements (which turned out to require rather complex and sophisticated technical solutions), or design UAVs according to the challenging mission requirements, which in turn necessitated complex, and thus costly, technology.

Nevertheless, today a wide array of UAVs are available on the military / paramilitary market, for roles like reconnainsence, electronic intelligent gathering (ELINT), relay duties, border and maritime patrol, and even combat.

With all this technology already in place: are UAVs an option for the future flight inspection world?

UAVs are a mature technology in the military environment, but not in civil airspace yet. Operations in civil airspace, at current, are limited, cumbersome, and require a high effort in coordination with the appropriate authorities and ANSPs.

Of course, the goal of the UAV community is to get unrestricted access to civil airspace in the future. However, there are still a number of open technical issues to be solved prior this becoming reality.

Open issues still under development are, for instance, the requirement to see and avoid other traffic autonomously.

Further, reliability and integrity issues still remain to be solved. One has to bear in mind that the appropriate certification requirements (e.g. EUROCONTROL's ESARR 4 &5) stipulate a maximum error rate of 10^{-9}. It is yet unclear, how , if ever, an UAV will clear that hurdle.

What is clear, though, is the fact that all these technical requirements inevitably will drive cost up. One of the prominent members of the UAV community, the NorthropGrumman Global Hawk, cost already US$ 75,- million per copy, with roughly US$ 15,- million attributed to the airframe and flight control components. And Global Hawk is not yet certified for civil airspace!

The cost benefit of UAVs vs. manned aircraft in general is not as high as one might expect, as unmanned does not mean uncontrolled. In fact, an UAV, at least when operating in civil airspace, will always require minimum 1 "pilot" on the ground to watch over it, and serve as counterpart for ATC instructions.

UAVs are not completely autonomous, they are not "Fire and Forget". To program, and coordinate a string of flight inspection missions over a certain period of time (e.g. a week), with all its vagaries with regard to weather, technical availability of navaids, ATC constraints, etc., will mount to a very challenging, or better: impossible, coordination effort.

And finally, as stated above, UAVs certified for civil airspace will come with a very hefty price tag. In our flight Inspection community, where most operators find it difficult to justify new FIS and aircraft at all in front of their respective stakeholders, it seems extremely unlikely that any stakeholder would sign any such costly undertaking, with prospects of only marginal savings, if all.

So, to sum it up, the answer is: no, UAVs are not an viable option for the flight inspection industry, at least not for the foreseeable future.

CONCLUSIONS

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
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 will do away with manned ground-based reference systems
10. Datalink technology might put Navaid Inspector on the ground
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.

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