Drones ahead: how technology combined with pressure for efficiency will affect the Flight Inspection Service community

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0. ABSTRACT

The following paper, which is based on comprehensive strategy discussions FCS undertook over the last 2 years, discusses present and future developments in our industry of Flight Inspection and Flight Validation. Here, factors like cost pressure, capacity constraints at the major airports, ever increasing environmental concerns and last but not least technological progress, here notably in the shape of drones / UAVs, put pressure on the Flight Inspection service providers to come up with ever more cost- and effort-efficient solutions, driving, in essence, a trend to a decreasing amount of actual flying on task. This reduction in actual flying can amount to up to 80% compared to current standards.

This paper starts with a closer look into one of the major technological drivers of this change process: the use of drones in the Flight Inspection domain. It addresses the current status of capabilities, and gives a background insight into the challenges ahead and the associated business cases of introducing drones on a grand scale in the flight inspection domain.

The paper continues with an analysis of the effects the overall reduction of actual flight time will have on the Flight Inspection service provider community, which will see a profound drive towards broadening the scope of capabilities a service provider might have offer in the future, and a major drive of consolidation among the Flight Inspection service provider community. In the wake of this discussion, the paper will try to engage in a form of "Management of Expectations", as the resulting cost reduction for the reduced scope of flying, for various reasons given in this paper, will not automatically translate into a proportional overall cost reduction for maintaining and flight inspecting navigational aids.

1. INTRODUCTION: DRIVERS OF CHANGE

For a number of reasons, the Flight Inspection Service Provider community is faced with a number of challenges that will change our industry over the coming years. These challenges are driven by technical, environmental and last but not least economical factors. These factors – both stand-alone and even more so, combined – will lead to a reduction of flight time spend with aircraft of Flight Inspection missions, for the sake of cost reduction, increased airport capacity and a reduced environmental footprint.

One of the biggest game-changer in the technical arena is the advent of drones being used in various shapes and models for the purpose of Flight Inspection. We will look at this in part disruptive technology in detail in the next chapter. Another factor in the technological domain is the proven track record of digitized navigational aids – long gone are the days of tubetechnology based navaids that showed a significant drift and failure pattern. Over the years the digital components of modern navaids have proven their stability and reliability, thus opening the door for potential deviations from calibration scope and intervals as described in ICAO Doc 8071, i.e. the 180 day intervals for flight inspecting Instrument Landing Systems (ILS).

Airport capacity constraints, at least at the major airports, are another driver behind the push to reduce the scope and/or the extension of the intervals of the required flight inspection. Flight Inspection missions, by their very nature, are disruptive to the normal pattern of operation at the airport under calibration, necessitating a modified sequence of arriving and departing traffic, which in turn will result in delays and/ reduced amount of traffic an airport under calibration could accept. Reducing the time spent on calibration thus would free-up capacity, a most welcome result notably for airports with a high traffic environment.

Environmental concerns these days are another major driver behind the motivation to scale back on time spent on flight inspection missions with aircraft. This applies notably to the customers of FCS in Germany, Austria and Switzerland. Environmental considerations in this context can be broken down into a desirable reduction of the CO2-footprint and the reduction of noise, e.g. the exposure of the population around an airport towards noise generated by Flight Inspection aircraft on mission. The latter is an ever more important factor, notably for FCS' customer base that requires a considerable amount of mission to be flown at night due to capacity constraints at major airports like Frankfurt, Zurich or Vienna. For obvious reasons, any reductions in the noise footprint around these densely populated areas are highly welcome.

Finally yet importantly, in the constant drive for efficiency gains, cost considerations feature high on the list of drivers of change as well. Depending on the number of navaids to be maintained or the size of a Flight Inspection unit involved (if the unit is part of the respective Air Navigation Service Provider (ANSP)), the required budget for Flight Inspection might feature prominently on an ANSP's budget. In an environment under constant cost pressure like aviation it is quite understandable that cost for Flight Inspection is coming under scrutiny as well.

The resulting effects of the factors above lead to a trend our industry is experiencing over the last couple of years to reduce the amount of actual flying on Flight Inspection mission. There are basically 2 approaches to this envisioned reduction: a. by stretching the respective intervals of a navaid (i.e. go from a 180 days interval on an ILS as per Doc 8071 to a 360 days interval) and b. by reducing the scope of the calibration itself (i.e. on ILS no more alarm checks, coverage checks only every second year, etc.). Additionally, with a shift towards GNSS as the main source of navigational guidance, the numbers of legacy navaids are declining, adding to the trend of lower flight hours in the flight inspection domain.

It has to be said that in all cases a reduction in Flight Inspection can only be executed in close cooperation with, and approval by, the respective Regulator or Authority. An ANSP intending to reduce the scope of Flight Inspection will have to prove to its respective Regulator that the new scope of work will provide an equivalent level of integrity and safety. This prove comes in the shape of aeronautical studies, i.e. by providing comparable calibration data, which in turn have to be collected either by extensive ground or drone measurements. Depending on the requirements of the individual Regulator, the amount of data to be provided might be quite comprehensive and spanning a period of several years. So, a reduction in the scope of Flight Inspection work will not come over night, however, as outlined above, the writing is clearly on the wall, so our industry better prepares for these upcoming changes. The resulting economic impact on FI Service providers and potential mitigation strategies we will discuss under Chapter 3 of this paper.

2. DRONES

It is fair to say that drones, on a technical level, are the biggest driver for change in our industry. Being around and having matured over the last couple of years, predominantly in the military domain, and having experienced a significant development in capabilities, combined with a dramatic drop in cost, it was inevitable that drones would enter the Flight Inspection market as well.

Drones these days cover an amazing span of technical capabilities, resulting in an wide array of shape and sizes, spanning from mini drones weighing only a couple of grams to airliner-size vehicles that can stay aloft for 36 hours or even longer. With the capabilities of modern drones so present in the minds of the general public as well as in part in the minds of our industry stakeholders it is important to clearly identify what drones are capable to achieve in the FI role today and in the mid- and long-term future.

Given the current state of affairs, it is obvious that technically it would be possible to design and build a drone that could substitute Flight Inspection aircraft even today. However, to come to that point, regulatory requirements and, as a derivative of these requirements, economic considerations have to come into play as well.

To start with the first: like everything else in aviation, drones are subject to a very strict certification and approval regime. Depending on the size of the drone – more to that below – this certification effort can easily match that required to develop and certify a manned aerial vehicle, and on top, additional efforts have to be taken to develop and certify the communication gear required to stay in constant touch with the drone.

Regulatory requirements and the ensuing development and certification efforts will soar the moment one intends to use the drone beyond line of sight (BLOS), as now the drone will have to have some level of autonomy to be able to interact with the other traffic in the same airspace to be able to take evasive action, if required (sense & avoid capabilities). This effort will again rise significantly in case the intended area of operation is close to airports in so-called Terminal Airspace – that is the airspace Flight Inspection – by its very nature - has to take place in. It is a sobering fact that as of today, even the most sophisticated military drones are not certified to operate autonomously in Terminal Airspace.

Even for operations within line-of-sight, restrictions do apply, depending on the individual regulatory framework of the respective country. These restrictions mainly pertain to avoiding the overflight of densely populated areas or highways, for example.

Over time, with a proven track-record of integrity of drones, the regulatory restrictions might be lifted to a certain degree, like in the case above, allowing the overflight of densely populated areas or highways. However, flying autonomously in Terminal Airspace, for the foreseeable future, will prove to be elusive, as neither the FAA nor EASA have a consolidated framework of technical and regulatory requirements in the making, let alone approved, that would allow this type of operation.

One aspect that tends to be overlooked in the context of drones is the fact that they might be an Unmanned Aerial Vehicle or System (UAV or UAS), however, there is still a pilot-like person required to operate it. To this end, the term Remotely Piloted Aerial System (RPAS) might be more appropriate. Taking this fact into account has a direct impact on the business case of drones; more to that under 2.4

The type of drone used in the Flight Inspection context very much depends on the required mission profile:

Do I intend to use the drone for a limited, specific set of measurements only, similar to taking the ground measurements done today? Or do I plan to use the drone as a full-scale replacement of my current Flight Inspection aircraft? Or, taking that approach even further, use a drone to fly various missions in a row more or less autonomously?

The following chapters will identify 3 classes of drones that reflect these set of requirements. Chapter 2.4 will then give some conclusions on the drone topic in the context of Flight Inspection.

2.1 Small Drones 25 Kg-class

According to current FAA and EASA regulations, certification requirements for drones staying below 25 Kg/55 lbs are somewhat less stringent then for heavier air vehicles. The rationale behind that approach is the assumption that a drone below 25 Kg represents a thread similar to Remotely-Controlled (RC) model planes or big-sized birds, against which aircraft have to show resilience in case of a mid-air strike in their respective certification process.

As of today, drones of the 25 Kg class are the most prolific in the flight inspection domain. Benefitting from a huge variety of commercially-of-the-shelf (COTS) solutions being available, numerous manufacturers, and manufacturers of Flight Inspection Systems (FIS), either have embarked on modifying COTS drones or, with the specific Flight Inspection requirements in mind, have developed their own design.

These drones are in most cases battery-driven Multicopters. Their overall size and weight limit their range and endurance (normally around 10 – 20 minutes). Their operation is at present limited to Line-of-Sight only. Size and weight further limit the amount of mission equipment that can be carried. In most cases, this is limited to a single receiver or camera, in case the drone should be used for optical inspections of PAPIs, approach lights, or similar.

Figure 1. Navaid Drone FCS Colibrex Figure 2. CNS Drone Skyguide Figure 3. Flybot Drone Aerodata

In the light of stringent data integrity requirements in the Flight Inspection domain, great care should be exercised to take propeller modulation issues, caused by the numerous propellers of a multicopter, into account, as well as the three-dimensional position of the antenna with regard to the movement of the drone in space, plus, of course, the antenna specifics themself as well.

In an ideal world, the receiver used, its hard- as well as its software architecture, is as closely as possible resembling the hard- and software architecture of the FIS used, thus helping to make data collected with drones correlate as much as possible to the legacy data collected with FIS. This will help, depending on specific Regulator requirements, to augment the approval process of a reduced Flight Inspection program, as discussed under 1.

Depending on local requirements, the drone has to be visible to Air Traffic Control (ATC), requiring some sort of transponder solution, which in turn might have an impact on integrity of the measurements. This has to be taken into account as well.

To this very day, restrictions in daily operations of this class of drones might apply (no flights over highways, densely populated areas, etc.).

With its limitations in weight, range and endurance, it is obvious that drones of this class cannot substitute a Flight Inspection aircraft on a one-to-one basis. They are an ideal tool, though, to replace – and to a certain extent: expand – the current ground measurements that have to be taken for an ILS, for instance. These are currently accomplished by hydraulic masts (for the Glideslope) and specially equipped cars driving down the runway (for Localizers).

Data collected with these drones might prove a valuable asset to start the assessment / approval process for a potential reduction of a Flight Inspection program, provided the prerequisites as per above (hard- and software architecture, propeller modulation, antenna position, etc.) are taken into proper account.

2.2 Medium-sized Drones up to 1.500 Kg-class

Drones in this class feature a payload capability of around 30 – 500 Kg and an endurance of up to 36 hours. Here two examples:

Figure 3. Milkor 380

Figure 4. Primoco 150 NSM

Due to their size, drones of this class are no longer electrically-driven, but feature combustion engines like the Primoco or Milkor UAV.

In the light of their range, endurance and payload capabilities, this class of drones is indeed a potential long-term replacement for Flight Inspection aircraft. However, arriving at this point requires solving a number of long standing issues as discussed under Chapter 2 of this paper. As an example, operations Beyond-Line-of-Sight (BLOS) are of course possible with vehicles like that, however, the regulatory framework for that is still evolving and, as discussed, still a long way away for autonomous flight in Terminal Airspace, again with BLOS certification requirements (integrity requirements, sense & avoid capabilities, etc.) being the biggest stumbling block.

For any midsize drone with a payload capacity of up to 300 Kg, a drone-specific FIS would have to be developed. Weight and size restrictions might still apply (i.e. space for antenna installations with proper spacing), which in turn would translate into focussing on specific missions (ILS/DME only, no DME/DME or VOR), meaning that a drone of that size would provide less mission versatility than a legacy Flight Innspection aircraft.

Mission versatility and flexibility would further be hampered by the fact that the drone has to be shipped to the location of the mission by one way or the other, so transportation requirements have to be taken into account as well. Transport by road may consume a considerable amount of time, transport by air would have to take Dangerous Goods (i.e. fuel for the drone) consideration into account.

As discussed under Chapter 2 above, drones still require substantial support from the ground: drone pilot, mission payload operator, transportation on the ground, the required ground station – all this translates into a considerable effort with a profound impact on mission flexibility and efficiency.

In case the drone is intended as a one-to-one replacement of a Flight Inspection aircraft, communication requirements definitely have to be taken into account as well, as now mission data will have to be streamed down to the ground control station for the operator (=Flight Inspector) to be able to analyze the results and, if applicable, give correcting inputs to engineering staff at the navaid. Communication gear with a suitable bandwith, and as inmportant: integrity, is of course available on the market even today, however, due to the sheer size of the data plus the integrity requirements to be met for sensitive aviation data, the communication aspect inevitably has a profound impact on the business case of such a drone operation.

The unsolved issue of BLOS flights in Terminal Airspace, plus the development and certification effort to overcome these restrictions, combined with the limitations as per above will inevitably drive up cost considerably, up to the point where a medium sized drones lack a sound business case in the Flight Inspection role.

Hampering any business case for these types of drones is their cost point, which rises exponentially with range and payload capabilities: the Primoco drone above with its payload of 30 Kg sells for roughly 600.00,- USD, the Milkor 380 with its payload of 300 Kg for 23 mio USD!

Worsening the business case perspective is the fact that for the foreseeable future, drones will be for Flight Inspection only, Flight Validation missions will not be possible, as they have to reflect an aircraft operation environment (workload aspects, FMS database integrity issues, etc.).

2.3 Large-sized Drones > 1.500 Kg-class

Drones of this size are typically represented by systems like the General Atomics MQ-9 Reaper or Northrop Grumman RQ-4 Global Hawk

Figure 5. General Atomics MQ-9 Reaper Northrop Grumman RQ-4 Global Hawk

The good news with this type of UAV is that it is technically feasible to install a full-fledged FIS, so no restriction on payload and/or range apply. However, certification issues plus all the other restrictions as per 2.2 still apply, which renders a drone of this size commercially unviable, a statement that is backed by the sheer acquisition cost of airframes like this, which run to the tune of 75 mio USD for the Global Hawk and 23 mio USD for the Reaper, respectively – airframe only, FIS and communication cost would come on top.

2.4 Conclusion Drones

In the light of the reasons given under the previous chapters, for the time being this author views the 25 Kg-class drone being the way forward in our industry. Unsolved regulatory issues for flights in Terminal Airspace, and the ensuing development and certification cost to overcome these restrictions, render the operation of larger drones commercially unviable in the Flight Inspection domain for the foreseeable future.

Drones in the 25 Kg class, on the other hand, if designed and operated properly (see 2.1, para 4 ff.), can augment the current Flight Inspection system, up to a point, where data derived from that sort of operation support the drive to prove that a reduction in scope and expansion in intervals of Flight Inspection missions will not impair the integrity of the navaid in question. As a rule of thumb, procedures to be flown BLOS (structure, coverage/range) would still have to be flown by aircraft, with the rest of the program to be flown by drones, This potential approach might see a reduction in flying from roughly 10 hours per year per ILS down to 2 hours per year. Small drones, thus, would play a vital role in the overall reduction of the impact of Flight Inspection on cost, capacity and environmental footprint.

3. ECONOMIC IMPACT ON FLIGHT INSPECTION SERVICE PROVIDERS

3.1 General Considerations – Management of Expectations

For reasons given under Chapter 1, and underlined under Chapter 2 ff., we will see a considerable reduction in overall flying on “classic” Flight Inspection mission, like ILS flight checks. This reduction will inevitably put pressure on the Flight Inspection Service Provider community.

To address this pressure, a clear communication with customers and stakeholders is required. The expectation on the side of the customers is clearly to benefit from the technological progress offered by more reliable navaids and drones, resulting in a significant cost reduction in the process. We have to manage these expectations by clarifying with our customers future requirements. The most important question at the start of this process is: what kind of service level is required in the future, what kind of availability? If a 24 hours /7 days a week /365 days year round availability is still required, cost per flight hour inevitably will rise, as assets in the shape of aircraft/FIS and crews still be required in minimum numbers to cater for general availability issues with regard to maintenance, technical failures etc. for the aircraft, and Flight & Resttime Limitations on the side of the crews.

In other words: a reduction in the scope of flying of 80% will not automatically translate into a 80% reduction of overall Flight Inspection cost, as fixed costs for assets will have to be spread over fewer flight hours! Consider changing your charging model: if this is based on Flight Hours, it is suggested to change that to a model that takes the fixed cost into account, and charge for the actual flying only the so-called Direct Operating Cost (DOCs) of the aircraft (fuel, landing fees, accruals for maintenance and engine overhauls).

3.2 Mitigation Strategies

A mitigation approach addressing the reduction in flying might be to relax the 24/7/365 requirements, if applicable, as this will free-up assets you can either dispose of or try to capture third market share with freed capacity.

The downside of this approach: it requires a specific fleet size to be reduced (i.e. from 7 to 4 aircraft); if you go below a minimum number of assets in relation to your requirements, you might experience non-availability issues! This has to be clearly communicated and understood among all stakeholders!

Example FCS: we serve Germany, Austria and Switzerland plus their respective militaries with 2 aircraft; reducing to 1 aircraft only inevitably will result in occasional non-availability!

Having a back-up agreement in place with another FI Provider might not solve this issue, as this service provider, for commercial reasons, will not and cannot be on 24/7/365 standby for you!

An obvious approach to deal with surplus capacity would be to increase your marketing efforts and expand into Third-Party-work. For as well obvious reasons a number of FI Providers will come to the same conclusion, which will put prices and margins under considerable pressure.

Another aspect to be considered: once you have committed your assets to a Third-Party contract, they will not be at your disposal anymore, raising availability issues as per above.

A smarter way to deal with surplus capacity might be to expand your service portfolio: try to identify new areas of work that would generate an added value for your customer. In our line of work, GNSS interference has become a major issue of concern. Being able to provide a service to monitor the respective frequency band, and identify and pinpoint a source of interference, would definitely add value to the aviation community. The challenge here is to find a source of finance for this new type of work.

Bear in mind that the reduction in actual flying we discussed in this paper mainly pertains to ILS, and to a lesser degree, VOR calibrations only; Flight Validation as well as Enroute Flight Checks beyond the range of small drones, or DME/DME coverage checks still have to be accomplished. Addressing this fact, FCS came up with a concept we call Performance based Operations (PBO): a string of individual Flight Inspection and Flight Validation tasks being combined seamlessly in a single flight: flight validate a Standard Instrument Departure (SID) after takeoff, do a VOR Enroute check while enroute to the next airport, flight validate a Standard Arrival Route (STAR) there, to be followed by flight inspecting a couple of ILS procedures, to be followed by flight validating the next SID from this airport, etc.

As part of the PBO concept, FCS is in the process, in cooperation with our customers/stakeholders, of changing our charging model to a modified cost model as per 3.1 above (Fixed Cost coverage en bloc, flying to be remunerated by Direct-Operating-Cost (DOCs) plus x per flight hour).

4. CONCLUSIONS

Technological progress will lead to a reduction in actual flying on Flight Inspection mission. Small drones will play a pivotal role in supplementing classic ILS Flight Inspection, making an ensuing reduction in flying at all possible. A replacement of Flight Inspection aircraft by medium or large-sized drones will not be happening in the foreseeable future due to unresolved regulatory issues of autonomous flight in Terminal Airspace, the resolution of which renders a business case for these size of drones commercially unviable.

A reduction of flying will not automatically result in a proportional reduction of overall cost for Flight Inspection. This is a fact that has to be clearly communicated with all stakeholders involved.

At last, the Flight Inspection Service Providers are called upon to identify ways to deal with the reduction in actual flying. Mitigation strategies to that end could be branching out in new service areas, increase Third Party work, and/ or come up with new strategies how to best combine the remaining classic ILS and VOR Flight Inspection work with the other Flight Inspection work still remaining.

It cannot be ruled out, though, that despite all best efforts, we will see a certain amount of consolidation within our industry in the mid- and long-term future. In addressing this consolidation, close cooperation between Flight Inspection Service providers with an eye on sharing assets and resources might be a potential way forward.