Common Standards in Flight Inspection Operations – The Way Ahead to Improve Safety?

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ABSTRACT

The following paper continues from the paper and presentation given on the last IFIS 2012 in Braunschweig by the same author, which covered flight safety on flight inspection missions, and ways to mitigate risks associated with flying these particular types of missions. The new paper represents the status of discussions the Operational Working Group within ICASC reached on this topic to this day.

After briefly re-visiting the specific risks involved in flying flight inspection missions, the paper continues with giving a detailed insight into a proposed structure of a flight operation dealing with flight inspection / flight validation. Aspects like the operational environment or set-up of the flight department, safety and risk mitigation strategies, equipment and training will be covered.

Although some topics are dealt with rather in detail – like Operation Manuals, Standard Operating Procedures (SOPs), Check Lists and Crew Coordination Concepts – the author is trying to strike a fine balance between over-regulating and laissez-faire, knowing very well from experience that a one-size-fits-all-approach simply does not work in the flight inspection industry.

In closing, the paper continues the discussion towards a common ground in flight inspection operations, by trying to establish a minimum standard for a flight inspection / flight validation department.

INTRODUCTION

Flight Inspection and Flight Validation represents a rather demanding operational environment in aviation. Its very nature translates into a certain amount of risk elements – which are covered in a following chapter - , that have to be identified, addressed and subsequently mitigated in order to achieve a safe and reliable flight operation.

The tools to mitigate these risks are wide and varied. This paper tries to identify these tools, concentrating on the organizational set-up and environment of a flight inspection entity. In each chapter, recommendations are given how to address certain aspects. The idea is to arrive at a common set of tools that might be useful in achieving the goal of a safe flight inspection flight operation. But prior to start the discussion on this tool-set, let us have a look at the flight inspection-specific risk elements again:

FLIGHT INSPECTION-RELATED RISKS REVISITED

International accident data show that a combined 56,6% of all accidents in aviation happen either on take-off, approach or landing - the very segments of the flight envelope the flight inspection community spends between 70 to 80% of all their flight time. [5]

Further challenges we encounter in our flight inspection / flight validation work:

- We have to fly low, sometimes very low.
- We fly in densely populated airspace, seeing and avoiding other traffic is absolutely paramount.
- We fly demanding missions with at times high crew workload, necessitating to liaise with ATC, ground engineers and the NavAid Inspector on board simultaneously.
- We might find ourselves in operationally harsh environments, both with regard to climate / weather, as well as infrastructure, ATC, etc.
- On commissioning flight checks, unknown terrain and obstacle data might pose a challenge.
- Working internationally, language barriers might hamper communications, both on the ground as in the air.
- Flying demanding missions, maybe on deployment for several days or even weeks in a row, ever poses the danger of crew fatigue.
- Regardless of working either for a government or for a private service provider, we most of the time face a certain commercial pressure, as flight inspection does tend to interrupt the usual routine at any airport, which might cause delays to (and in turn: generates pressure from) the airlines.
- To keep the aircraft being used for flight inspection and their respective systems technically up to date with current requirements at times poses a challenge, again in the light of ever present commercial pressure.

All these bullet points mentioned above form the mission related factors that govern the risk of our work. To put all this a bit more into perspective, let us re-visited a more generic risk model as described in the last paper of the IFIS 2012:

According to the standards of risk research, all aviation accidents fall under the category of the so-called low probability / high consequence events (lp/hc), were "The lp/hc problem domains are inherently ill-structured, multi-layered, and characterized by consequences with low likelihoods, high severities and numerous, pervasive uncertainties. Decision making is typically complex, multitiered and non-transparent with conflicting objectives and multiple perspectives" (Clement 1996) [1]

Translated into a much more simplified formula, it might be fair to say that risk is the product of probability multiplied by severity

$$\mathbf{R_{isk} = P_{robability} * S_{everity}}$$

To further refine our formula above we might break down probability into number of (flight) events multiplied by interfering factors – and these are all the things that might go wrong, like weather, ATC, crew performance, technical issues with airframe and systems, operational environment and circumstances, etc.

$$\mathbf{R_{isk} = P_{robability} * S_{everity}}$$

with $\mathbf{P = (E_{vents} * I_{nterfering}\ F_{actors}),}$

= $\mathbf{R_{isk} = (E * IF) * S}$

We can further break down the Interfering Factors into being mission-specific – all the bullet points above, which we can only influence to a certain degree – and operational aspects: how we set-up up our flight operation in terms of training, aircraft, equipment, operating guidelines, etc.:

with $\mathbf{IF = (M_{ission\ Specific} * O_{perational})}$

= $\mathbf{R = (E * (MS * O)) * S}$

= $\mathbf{R_{isk} = P_{robability} * S_{everity}}$

$\mathbf{(E_{vents} * I_{nterfering}\ F_{actors})}$

$\mathbf{(M_{ission\ Specific} * O_{perational})}$

In the light of this formula, it is quite obvious that the flight inspection community has to focus on the operational aspects (**O**) of our working environment, as this is the part of the equation we can directly influence; the other factors like Events (= number of flights) are dictated by the required flight inspection intervals and the Mission Specific factors are governed by the very nature of our mission profile.

How to address these operational aspects is dealt with in the following chapters.

OPERATIONAL SET-UP: GENERAL

Flight Inspection / Flight Validation organizations come in wide array of forms and shapes: they can be organized as a government body or come as a private enterprise. They might be a big organization with dozens of aircraft and hundreds of employees, or being a very small operator with just one aircraft and a handful of staff.

The regulatory oversight imposed on them might be fairly strict, or might be rather relaxed: in most countries, aerial work – under which domain flight inspection will fall – is governed by appropriate government rules and regulations, dealing specifically with the requirements of this specific activity in aviation.

Other countries do not have such a dedicated regulatory framework. Interesting enough, Germany is such a country, where aerial work is not subject to specific regulation.

Most customers, on the other hand, today require their flight inspection service provider to be subject to some form of regulatory oversight and to have an appropriate Air Operator Certificate (AOC).

With flight inspection organizations coming in all forms and shapes, flying a wide variety of flight inspection missions, it is quite obvious that a one-size-fit-all-approach simply will not work. Each organization is called upon to come up with a set-up and organizational framework that bests fits its individual work environment and requirements. In the interest of safety, and on top, a common standard in the flight inspection community, it is recommended, though, that whatever the organizational framework, whatever the size of any flight inspection organization, to give some consideration to some elemental requirements for a safe operation of the entity:

- A clearly defined mission profile:

  What kind of missions are expected to be flown? Where? With what kind of equipment?

- A clearly defined organizational set-up of the entity that reflects the mission profile above and clearly defines interfaces within the entity:

  Who is responsible for doing what within the organization, requiring what training, reporting to whom?

- A clearly defined set of rules, procedures and best practices, laid down in an appropriate set of company documents (best maybe combined in a single document like an Operation Manual (OM)):

  Who is doing what and when with what

Elements of this organizational set-up will be described more in detail in the following chapters. Prior embarking on that endeavor, though, some words on an underlying principle that should be part of the organization's philosophy: Keep it simple and stupid (KISS) ! It is very tempting to try and govern and cover every little detail of the organization: The result might be arriving at 400 procedures with 1200 related documents – the sheer volume of the work to maintain and support that level of governance will put even big organizations to the limit, and even more important: it will overwhelm the front-end crews, resulting in the end in a unsatisfactory performance in terms of quality and safety. It should be remembered that the final product of flight inspection is generated by a flight crew (cockpit and cabin), flying an already demanding mission. All aspects of internal governance and it related documents must therefore reflect that fact and thus be kept concise, clear and reduced to the maximum.

Safety Philosophy / Safety Management System (SMS)

Safety, as per ICAO, is defined as

"…the state in which the risk of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and risk management"

ICAO Doc 9859, 1-1[3]

To arrive at that point, each flight inspection entity should define its own safety philosophy, identifying risks of its individual operation and strategies to mitigate them.

The ICAO Doc 9859 Safety Management Manual gives a very good oversight on the topic and provides valuable tools and procedures how to arrive at a safety philosophy, and how to implement it in one's own flight organization.

The Safety Management System (SMS) is the formalized approach of an organization on how to implement its safety philosophy, by describing risk identification methods and tools, risk communication and mitigation strategies, clearly defining lines of responsibilities and accountability.

As safety is a very complex topic, and Doc 9859 alone covers 290 pages, the reader is referred to that document for details. A number of topics shall be addressed in this paper, though, in more detail:

An essential part of any safety philosophy and its ensuing safety management system is the clear and unambiguous commitment of all stakeholders within the organization to safety. That always has to be a top-down-commitment: management of the organization has to encompass and support the safety concept of the organization with uncompromised rigor, otherwise it will ultimately fail. This commitment is easier said than done, as safety, more often than not, has cost implications – these cost implications notwithstanding, safety has to be communicated and lived up to! as the number one priority of any entity's leadership.

As part of the SMS, it is recommended to implement a **Reporting System**, allowing each member of the organization to give feedback on any issues that might be safety-related. Again, in the light of keeping the organization lucid, and depending on the size of the organization in question, a reporting system does not necessarily have to be formalized with sophisticated forms and lines of communication, some form of feedback should be established, though (i.e. in the shape of regular safety meetings, simple emails, etc.). That form of communication should, in any case, be encouraged by management.

An integral and essential part of any reporting system is the implementation of a so-called "**Just Culture**", which means that no repercussions or negative effects have to be expected by those individuals who report any issues, even when these issues have been caused by omission or error. Without this just culture, a viable form of feedback on safety issues cannot be established, and thus an important loop of communication on safety cannot be closed.

Finally, and again in line with the requirement of keeping organizational policies and documents light and lucid, it should be noted that a SMS does not necessarily have to be published as a stand-alone document; in an ideal world, the SMS is an integral part of the Operations Manual of the organization, thus keeping documents to be maintained, read and understood to a minimum. ICAO in Doc 9859 supports this approach.

Operating limits

An essential part of any safety philosophy should be the publication of Operating Limits applying to the individual organization.

Operating limits should cover all aspects of the flight operation, addressing topics like:

- Weather minima
- Minimum Equipment status and requirements
- Crew qualification, training and recurrency standards
- Flight and Rest Time Limitations (FTLs)
- Airport criteria
- Security aspects

These bullet points will be addressed to a certain extent in the chapters to follow. In general, though, operating criteria should be realistic in the light of the missions intended to be flown. Here, a balance between safety and operational requirements has to be struck: Minima with an excessively high threshold might enhance safety, but will limit the operation up to a point where providing a reliable service to the customer will be impossible.

Again, operating limits have to be accepted by all stakeholders from top down; raising minima and expecting the same productivity output, for instance, will not be a realistic prospect.

Therefore, operating limits should be set after careful study of the operational environment to be expected, equipment to be used and crew qualification considered. The limits have to be open, transparent, clearly communicated and no ambiguities must exist between the organization's ambitions and targets and its operating limits.

Again, for ease of operation and reference, the operating limits should be an integral part of the Operations Manual of the organization.

Equipment

One of the most important factors affecting safety on flight inspection / flight validation missions is the choice of the appropriate aircraft. Again, in the light of the wide variety of flight calibration missions and theatres of operation, there is no one-size-fits-all solution in picking the right aircraft. In general, the aircraft type should be able to fly the mission required without too many restrictions (i.e. fuel load, payload), in order not to pressure crews too much into accepting risks, just to get the mission done.

Under normal circumstances, the size of the equipment required to fulfill the role more or less dictates the size of the aircraft in use. With the advent of very small, low cost Flight Inspection Systems, using fairly small twin-engined piston aircraft became a viable option in the flight inspection world. A prominent example of this new breed is the Diamond DA42 Twinstar. Under defined circumstances (limited amount of flying required per year, moderate climate, moderate terrain, no high top speed required at busy airports) it is already clear that the combination of low cost FIS and low cost aircraft do work; it remains to be seen over the next years, though, how well this combination fares when pushed harder, both in terms of flying hours required and harsher external environments encountered.

With the advent of modern single-engine turboprops, like the Cessna Caravan, the Pilatus PC12 or the Socata TBM850, there are even projects envisioned to use these aircraft for flight inspection missions. It remains to be seen how the regulatory environment will react to this proposition; it would further be worthwhile to discuss within the community the use of single-engine aircraft for flight inspection work.

The flight inspection aircraft in use should be maintained and upgraded as best as possible to the current, mission-specific requirements.

Proper maintenance based on an appropriate maintenance program, by qualified staff, at the right intervals, is a must that goes without saying.

Providing a cockpit environment that offers a good support to achieve situational awareness is highly desirable. Today, this almost automatically translates into a glass cockpit with a suitable Flight Management System FMS, and moving map displays that goes with it.

Being able to depict the calibration mission (desired tracks, tracks to starting point of a run) as well in one way or the other to the cockpit crew is highly recommended as well , either by interfacing the Flight Inspection System FIS with the existing avionics (preferred option), or by providing an additional display.

It cannot be stressed enough that keeping situational awareness is absolutely paramount on flight inspection missions, any piece of equipment supporting that goal, therefor, is highly desirable.

When flying Procedure Validation missions, a FMS commensurate with the task is a must – the FMS must be capable of processing the ARINC424 formats used by the procedure designer / coder, for instance, and depicting them properly.

A Traffic Collision Avoiding System TCAS is a highly desirable piece of equipment to have on board, especially when flying in densely populated airspace. As TCAS is not really cheap (USD 250.00 – 500.000,- per aircraft), this might easily collide with the commercial pressures mentioned above. Nevertheless, as this is a very effective tool to enhance safety, it should be installed whenever possible. To benefit from it, proper training should be supplied; part of that training should be to raise awareness that TCAS might not be able to "see" all traffic, as some other targets might have switched off their transponders or do not have on to start with – like gliders, a major challenge in Germany at times, for instance. So the requirement for constant airspace surveillance remains.

There are other, low-cost TCAS-Look-alike solutions out there on the market. When installed, great care must be taken that the installation was done properly, otherwise false / nuisance indications might result, which effectively do more harm than good, as they distract the crew and undermine the confidence in the system.

Enhanced Ground Proximity Warning Systems EGPWS are another valuable safety feature. On flight inspection missions it does have its limitations, though, as it will cause false alarms when flying low approaches with gear / flaps up. As repetitive false alarms must be avoided, when EGPWS is installed on flight inspection aircraft, having a switch available to turn the system off and back on, when required, is paramount. For turning the EGPWS off and later back on after mission, an appropriate SOP has to be devised by the respective flight operation, and that SOP has to be reflected by the Normal Checklist in use.

In order to reduce stress for the crew as much as possible, all systems that provide cabin comfort should be operational and effective (heating in cold climate, air conditioning in hot climate). Notably an effective air conditioning is paramount in hot climates, as heat tends to foster the onset of fatigue considerably. Apart from issues affecting the crew, a functioning air conditioning in hot climates are paramount for the integrity of the Flight Inspection System (FIS) and its respective navigation receivers.

Crewing

Every operator will have his individual selection and hiring process. Great care should be spent on finding pilots that do have a professional attitude towards special mission flying – not too many per the classes that annually leave the flight schools, by this author's own experience, as the vast majority of the pilot community is striving for a job with the big airlines. Emphasis should be put on adjusting the candidates focus on the aircraft being merely a tool for a greater purpose; when in commercial flying the task is to fly safely from A to B, in our world the real job only starts at B.

ICAO Doc 9906 vol 6 gives a very good insight into initial qualification requirements for Flight Validation Pilots (FVPs). By and large, these criteria apply to a Flight Inspection Pilot as well. For Commanders on a flight inspection mission they read as follows:

- CPL or ATPL with IR
- Current type rating for the type to be flown on mission
- Total flight time > 1.500 hrs
- Command time > 400 hrs
- Flight Inspection Pilot for more than 2 years[2]

It is recommended to set up policies regarding initial and recurrent training, recency, and crewing in the light of mission requirements and individual qualification.

Again, it is recommended to keep this qualification matrix not overly complex, as it might hamper operations considerably otherwise.

Operational status

A number of flight inspection missions are outside the normal operating envelope of the aviation community. In many case this stipulates a requirement for official approval of these kinds of operations (i.e. flying below the Minimum Safety Altitude in some countries, night flying activities, etc.) Whenever possible, it is recommended that the affected flight inspection organization applies for this approval or "waiver" at the appropriate authorities, to minimize ambiguities and potential risk of violating rules and regulations, which in turn will reduce crew workload considerably.

Quality Management System QMS

A Quality Management System (QMS) should be an essential part of any flight inspection organization. Most regulatory frameworks address this requirement – an AOC holder is required to set up a QMS, for instance.

A QMS is highly desirable for tracking the performance of, and thus providing integrity for, the flight inspection mission itself.

Again, requirements on the side of the flight inspection regulator notwithstanding, a QMS can be an integral part of the overall OM of an organization, thus again reducing complexity in the organization's documentation.

OPERATIONS MANUAL

The Operations Manual (OM) can be viewed as the central document of an organization dealing with all aspects of the flight operation.

Its format, structure and extent, to a certain degree, will be driven by the individual requirements of the regulator being in charge of that particular entity.

Numerous layouts and templates for an OM exist with various regulators; it would be beyond the scope of this paper to name them in detail.

In general, what an OM should cover, are aspects as follows:

- Organizational set-up
- Responsibilities and accountabilities
- Aircraft related subjects (Minimum Equipment List MEL, navigation equipment, etc.)
- Limitations and Minima
- Crewing
- Operational Procedures, Normal and Abnormal
- All weather operations
- Flight and Rest Time Limitations
- Training
- Security

Again, as reiterated a number of times in this paper, the OM should be concise and limited to the absolute minimum necessary, in order to avoid over-complexity, which would only create a work atmosphere of ambiguity and double standards. An OM has to be workable under all operational circumstances the organization is operating under.

Some content of an OM shall be discussed in more detail in the following paragraphs.

Crew Resource Management (CRM) / Crew Coordination Concept (CCC)

Crew Resource Management is an essential part of any professional flight organization for many years now. It is highly recommended for any entity in flight inspection operations to take up the task of defining a workable CRM system and a Crew Coordination Concept that goes with it.

A CCC basically defines how a crew on task is to work together, laying down fairly in detail which crew member is doing what when and how. It clearly describes the communication involved in executing these tasks and should be backed-up by Standard Operating Procedures (SOPs) and Checklists (more to that below).

The CRM system, however, does not only define the cooperation between cockpit members, it also should encompass procedures and communication between cockpit and cabin, and it should define the interface between the flight crew and the rest of the company, like tasking / scheduling, management, etc. This rather holistic approach in CRM is of great importance to create a working environment that takes into account all requirements to accomplish the organization's mission profile safely and reliably.

Standard Operating Procedures (SOPs)

Standard Operating Procedures (SOPs) describe how certain aspects of the scope of work are handled by whom, at what time.

SOPs govern aspects like cockpit work, crew coordination, checklist philosophy, but also issues like how to execute certain calibration profiles, how to schedule tasks, write reports, etc.

Again, SOPs should be commensurate with the task at hand. They should be concise, transparent, and again, be an integral part of the OM.

Checklists

Checklists form an enormously important part of the operating environment. Again, the KISS approach is highly recommended: it is a well-known fact that the manufacturer's checklists, especially when the aircraft in question is certified for single pilot operations, are often useless in a normal aviation environment for reasons of over-complexity and length. These checklists reflect legal and liability issues, which might be well required to keep the manufacturer from harm in legal terms, however, focusing on these legal aspects unfortunately renders these checklists almost useless.

So every operator is called upon to design checklists that do reflect its individual needs. Depending on the regulatory environment it might be necessary to get the altered checklist approved by the respective regulator.

The checklists as well should reflect the operational environment the specific missions are flown in. Again, avoid over-complexity. The checklists have to be in line with SOPs and other procedures laid down in the OM, a very important aspect to keep in mind.

TRAINING

The importance of training in aviation in general, and in flight inspection in particular, cannot be overestimated.

Every flight inspection organization should set out and establish a training regime, covering both initial as well as recurrent training, and then stick to that training regime. This translates into a certain commitment from all stakeholders involved including management, as training inevitably has cost implications.

Again, that training regime shall be written down in a concise document, with that document being an integral part on the OM of the organization.

Whenever a suitable simulator for the type operated by the organization is in reasonable reach, it is strongly recommended to use that simulator both for initial as well as recurrent training.

As the standard type rating and recurrent training provided by the big training houses does not really reflect the particular aspects of flight inspection missions, it is further strongly recommended to introduce one's own training program / syllabus and own SOPs, checklists, etc. into the training, starting from initial training on. At least the two biggest training and simulator providers are more than happy to accommodate the individual needs of an operator, train according to their syllabus, checklists, etc, or even accept their instructors as co-instructors or even full-time instructors for that particular organization.

Special emphasis should be laid on the transition training once the initial training on the simulator has been passed, as in almost all circumstances the cockpit layout, interfaces etc. of the calibration aircraft in operation will differ significantly from the simulators standard layout.

RISK MITIGATION STRATEGY

Every flight inspection organization should embark on formulating a Risk Mitigation Strategy by identifying risks associated with specific missions, address them and come up with solutions how to mitigate these risks.

In an ideal world, this risk mitigation strategy is an integral part of the overall operating procedures of an organization and well described in its documents, preferably it's OM and as such, has been covered in this paper.

Some aspects of the risk mitigation strategy warrant a closer look, though, and shall be discussed here in more detail:

Any risk mitigation strategy shall address the **external circumstances of the operation:** where do we operate, doing what with whom? How is the terrain, how is the infrastructure (fuel / de-icing / hangar available)? How well is ATC organized, is radar coverage given? Who on a specific mission will be point of contact for the company? Who for the crew? How is the security situation on site / in country?

Giving all this a thorough consideration is even more important when doing commissioning flight checks at new airports.

Dealing with these questions effectively constitutes some sort of risk assessment prior embarking on the mission, something that is highly recommended. Whenever possible, these data should be collated prior bidding for a tender; marketing or management should try to find out as much information as possible prior committing to a task, in order to reduce pressure and stress to the crew on site later.

Avoiding crew fatigue is another major issue: Most AOC holders are regulated in terms of Flight and Rest Time Limitations (**FTLs)** by their respective regulator. However, as the trend in the regulatory regime goes more and more in the direction of operator-specific FTLs that have to be scientifically based and approved by the authority, and as standard FTL regime do not really reflect the special needs of a flight inspection organization, it is highly recommended for each flight inspection entity to come up with an individual FTL regime, reflecting and taking into account the specific operational requirements of that organization.

At what point fatigue hits will very much depend on the type of mission flown (ILS low level work, in general, being more stressful then airway work high up), the aircraft being used (Cockpit equipment being available, space available on board, susceptibility to turbulence, temperature control) and the environment operated in (poor ATC? Poor infrastructure, i.e. refueling a major undertaking? Night flying involved?). Thus, geographical and climatological conditions of theatre of operation, length of deployment, transit times and other factors, like aircraft and cockpit equipment mentioned above should be taken into account when designing a FTL scheme.

It is recommended to liaise as closely as possible with the crews affected when designing FTL schemes, as they might be able to provide valuable input as to what is both desirable and practicable as well.

It goes without saying that in the end, the proposed FTL scheme has to be approved by the authority in charge.

A very important consideration also is **accommodation** and **transportation** for crews, notably when away from base. It must be assured that a good rest and a good night sleep can be accomplished at the accommodation picked. Transits in and out of theatre of operation should be as efficient as possible, both to save on valuable duty time as well as avoiding fatigue on crews after a lengthy airline flight with various connections.

CONCLUSIONS

Managing risk in the very demanding flight inspection environment is achievable by applying a number of common standards covered in this paper

Applying these standards to all organizations dealing with flight inspection not only would provide a level playing field for all parties involved, it would undoubtedly foster and enhance safety in this sector of the aviation industry considerably.

RECOMMENDATIONS / FUTURE WORK

It is therefore recommended to continue the discussion on common standards in flight operation of our industry, with the ultimate goal of establishing a common set of standards that all parties involved could subscribe to.

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