Be prepared – Check Flights and Aircraft upsets

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Introduction

Recent events have brought into sharp focus the subjects of post maintenance check flights. This paper deals with the important subject of how to prepare and conduct such flights. Included in the broader definition of preparation is a section on selection of the right kind of people for such work. The likely causes of upsets during check flights and the recovery methods from such upsets is discussed but the coverage is deliberately limited to the check flight situation and it is not intended to be a paper on the whole subject of upset training and recovery.

The paper deals with four sections.

1. **Selection and training of the right people to do the task**
2. **Planning and preparation for the task**
3. **Execution**
4. **What to do when it goes wrong** (in a manoeuvering sense)

As in most aviation tasks, the key words in the title are "be prepared". First then lets look at selection of the right people

1. Selection and training of the right people to do the task

There are certain characteristics of individuals that are more important in check flight work than in other tasks. In the airlines, most young pilots are selected against criteria with a different objective in mind. However, check flights are a fact of life for all airlines and often the task falls to the Chief Pilot or other senior personnel like the fleet captain, or the fleet technical pilot who see it as a chance to get some flying in. Not all these categories of people, important as they are, may necessarily be best suited for the task nor do they necessarily have the available time to prepare in the way they should and probably would wish to. So what should we look for in a pilot or engineer who will be recruited into the checking community?

There are 4 pillars on which a check crew member builds a successful career. These are Knowledge, Skill, Aptitude and Experience. "Not much difference there from my world" one may rightly say but let us look at some of these characteristics more closely in a "checking" sense.

Knowledge

A deep knowledge is clearly required of the aircraft, the theory behind the task and the role. A determined inquisitive mind is essential if one is to survive in the check flight world, and one would expect all check aircrew to be asking questions and then more questions until they receive an answer that is both "right" and makes sense. Questions coming from newcomers are especially welcome, as they keep the organisation true and sharp. Disinformation and "bullshit" is generally easy to recognise and has no time is the checking world so the answers had better be good. Equally, an answer that was right 5 years ago may not be right today. Circumstances change and those changes sometimes demand a re-think. Equally, it is important to be

self reliant in this regard. Don't wait for the information to come to you, go looking for it and develop good contacts and sources of quality information

Skills

Valued skills include Observation, Interpretation, Analysis and by no means least, Communication. So called "motor function" flying skills for the pilots need to be pretty good too but it may be surprising to some that pure flying coordination and technique is not necessarily the top priority as long as this aspect is to an acceptable level for the task. However, flying ability does have an impact on the capacity of the pilot to handle high workload situations and therefore it will be referred to later in the section about Upsets. Some of these skills do not come naturally to some. It is necessary to think through each check point or task and decide which parameters are important. Know also when and how often to read them and then when to record them. For the third crew member in this situation this recording task is always secondary to acting as the safety "observer", someone with an immediate oversight of the way the check point is being conducted and someone who can therefore issue timely warnings. The process of recording data should not be the only activity. Interpretation and analysis of the data captured is where the real value is added, so the third crew member has to be able to write and record at the same time as thinking about what it all means to the safety of the flight. Not easy!

Aptitude

Aptitude is a bit more complex. In this context, I am referring here to whether someone "thinks in the right way" and demonstrates the right judgement.

Firstly, check flight personnel need to be able to handle several apparent paradoxes, Let us take an example or two. Take the issue of when a check crew member has to stand their ground on a given topic versus when they can afford to be flexible. If we take a situation where an aircraft may need some re-work before or after a check flight but is due on the programme later in the day, you can immediately see the pressure that has to be handled in this fairly common situation and knowing when it is ok to be flexible or when a tougher stance has to be taken is part of the job. Taking another example, in a typical group discussion about, for example, a specific systems check, some people will inevitably have more knowledge than others, so the issue of when to speak from within your own knowledge and when to listen becomes a skill and a challenge. With the right level of sensitivity and awareness of each other, the team dynamic has to lead to the right answer. Perhaps the most well known is the issue of confidence. A check crew member has to have sufficient self confidence to make decisions when necessary and to intervene in developing situations but not so much confidence that may lead to check points being flown in conditions outside the safe limits. There are many such paradoxical situations to be faced and correctly resolved in the world of check flights. Good team members get more of these situations right than wrong.

The right type of pilot or engineer should therefore be naturally skilled at Crew Resource Management and be especially good at listening but check flight CRM is very different from the normal airline route situation. A ground engineer who is acting as a Functional Flight Check Engineer, may well be the person with the best knowledge of a particular system. The second pilot likewise may be a specialist on a given area so the classic cockpit leadership balance may change during a check flight and should only tip with certainty towards the Captain when and if a final safety decision has to be made. In my many years as a test pilot, almost all decisions have been taken naturally as a result of mutual discussion by the testing team and have not require heavy handed "captaincy". If a given situation demands immediate response then whoever is flying at the time commences the action supported by the rest of the team and if he so desires, the Captain may take control later. Often such a decision is probably more a case of ensuring that if something subsequently goes wrong, he is rightly able to take responsibility later. Clearly, in the normal airline situation, where the authority gradient is much more clearly defined, such an approach may lead to confusion and weaker decision making. Each airline will need to decide how to handle the authority gradient

issue in the context of their local and national culture. However, the trick is to ensure on check flights that all those with knowledge and useful information are really heard, whatever their level, number of rings on their jacket, nationality, gender or salary grade.

Check pilots in particular, also need to be able to achieve a good balance in their activities and maintain the necessary level of self confidence without an over developed ego. Look for people who are not trying to prove how good they are but rather how good (or bad) the aircraft is. Interestingly, this trait is critically important in the flight display world.

In some respects this is the key difference between the checking world and the normal operational pilot world. Younger pilots spend their developing career improving their skills as a pilot and having to demonstrate that skill under test conditions. If the flight doesn't go too well the normal reaction is "it must be me" or " I am having an off day". In other words they look inwards at their own performance. The checking world is different. It demands that they become "the standard" and that they use that standard to assess the aircraft they are flying. It is the aircraft that is under examination not the pilot. They have to look outwards. If the same type of aircraft was flown yesterday and its response through a given manoeuvre was "normal" but today it is not or it feels different, then what has changed? Has something altered? Is the weight and C of G the same", or is it potentially something more serious like a degraded flight control system with some trim control damage.

Finally, and highest on the list of desirable characteristics, is personal integrity which is valued above everything else. The check flight specialists need to be people mentally strong enough to take responsibility for their decisions (good and bad) and then be able to live with their mistakes, learn from them and communicate them to others. Hours can be wasted chasing a non snag or flight characteristic when in fact the culprit was the pilot who had selected the wrong configuration or moved the wrong switch at the wrong time. In the development test world there is no hiding place as everything done is filmed, instrumented, telemetered and examined by teams of specialists but this is not true of the airline check flight situation where good old fashioned integrity is vital. There is no more important characteristic in this activity.

Experience

Experience (of the right kind) is extremely valuable in terms of improving judgement, prioritisation of task and risk evaluation but experience can also be a great deceiver. There are many 35000 hr airline guys, in some parts of the world, who are totally unsuited to check flight tasks. Such people have much experience of doing repetitive tasks rather than a range of different experiences against which to make good informed check flight judgements. So look beyond the hours and find out what relevant checking experience lies within the log book and how many non routine operations have been successfully carried out by an individual.

Conclusion

This has been a quick sprint through the main characteristics that should be looked for at interview, when selecting checking crew members. An attempt has been made to paint a picture in your mind of the "right" kind of person for this kind of work. If you get the people wrong, no matter how good the process, it will still be at risk. Conversely, take time selecting the right people and it will buy you many dividends in the check flight scenario.

2. Planning and Preparation for the task

So let us now move to the planning and preparation. Many questions need to be asked and answered before the check flight takes off. We start with the need to understand the task. What exactly is the objective of the flight? Can it be done on the ground? What state is the aircraft in? Who will be doing it? When has it got to be done ? Where is it to be done? And finally, with all that information, What are the risks and What will we do if it goes wrong? Some things seem to be common to most tasks and I shall try to capture those which come up most often.

The first rule is that we need to be able to justify why a flight check is being done in the first place. Many checks can be performed successfully on the test bench. Despite our love of flying, ONLY those checks that cannot be performed on the ground should be performed in the air. We can use GPWS as a good case in point. The "box" has all the logic fixed and it can be bench tested. The software will have been correctly tested and certificated. What is then needed of a possible check flight? In reality, we only need to verify the "aircraft connections" in terms of flap signal, gear signal and radio altimeter. Such a check does not require all the modes to be flown.

Aircraft

Lets deal with the aircraft first. We will need to know exactly what servicing has been carried out and which systems have been disturbed. We will also need to know if repairs, modifications and upgrades have been applied and if so, what impact they may have on the intended flight. Some notice of the flight is therefore required because a visit to the hangar is essential to get to the bottom of most of these aircraft questions. Talk to the servicing manager and look at the log books in depth. Take care with the "can you just come down this afternoon and carry out a quick check flight" type of request. More has often been disturbed or worked on than at first appears. In the longer term develop a trustful working relationship with the mechanics in the hangar. It is amazing what they will tell you once that trust is established. Humour tends to help a lot here. If the situation does not allow that due to the use of an outstation or remote facility, try to gauge the quality of the hangar guys (and their management) and the level of pressure they have all been working under.

If the aircraft has been cleaned or painted, pay careful attention as these activities can give rise to numerous "knock on" technical issues such as pitot or AOA sensor damage. Always do a detailed walk around before such a check flight and take time over it. There have been many examples of jacking pads left on aircraft, masking tape covering elevator hinges and over spring tabs, not to mention paint on static plates and vents being blocked by FOD following deep servicing or painting.

Remember also all those systems that have been required to be put into the Ground Test position to allow certain ground checks to be completed prior to flight clearance. Know what they are and make sure that they are all correctly re-positioned to the flight position prior to flight. Apply the principle that if it can happen, it will happen, and our job as checkers is to ensure that there is no adverse effect on the flight.

You will also need to think carefully about weight and C of G for the check flight. Loading ballast in an airline is not always the easy thing it is in the manufacturers test world and unusual C of G's are not so common for the loads specialists. Even so, ask anyone who has been around a while in the test world and they will all have accrued a few mis-loading incidents in their life time. My advice would be to try to put the aircraft into a weight and loading situation with which you feel comfortable and use it as a standard for all subsequent similar flights. Set up a mid C of G if possible, avoid being on the limits and do consider the effect of the weight and C of G on the expected "feel" of the controls. Expect that the aircraft will inevitably be much lighter than the aircraft on the line. No big problem there, but think about it and consider the speeds to be used in relation to stall speed and Vmca. It may be that whilst you would normally be stall speed

limited, you may now be on or near the Vmca limits. It may also be that to fully test the fuel system a specific fuel load is needed and this may drive the C of G.

Perhaps the main messages here are is to know the aircraft, take control of the way the aircraft is presented for check flight and always check the C of G calculation and loading.

Crewing

Often check flights are seen by airline management as a “chance to get some flying in”. Understandable and tempting as this may be, they may well be the least able in terms of their ability to spend time researching and understanding the issues, keeping their flying skills at the right level and at being able to focus completely on the task and make the right technical judgments whilst handling the “pressure” to get the aircraft back on the line. Clearly, there are some management pilots who are “right” for the task but before selecting themselves a totally honest review of their workload, experience and technical type knowledge needs to be carried out. The primary role of management, with regards to check flight personnel, is to select the right people, then to let them do the job and finally be supportive in a safety sense, of their sometimes difficult decisions. Checkers need to know that they will be supported by their boss in this regard and yes they will sometimes make mistakes too.

Having a small team of hand selected crew members who are properly prepared for the task is a better approach than trying to “be fair” and rotating the checking flights amongst all to give everyone the experience. A group needs to be defined consisting of sufficient support or check engineers and pilots to manage the checking workload of the airline. They should have a nominated head who, through regular meetings with the team, reviews the schedules to be used, and ensures learning from the experience gained from each flight. He can also recommend to senior management how aircraft to be checked should be presented. Such a person can also act as the liaison with the aircraft manufacturers to pick their brains and ensure that the airline receives the best advice possible from the manufacturers test specialists. We recommend a crew of three wherever possible, so perhaps the major challenge for many airlines is to be able to integrate a ground operations engineer, a licenced quality engineer or specialist check engineer into the "test" crew environment in such a way that his voice is "heard" and his opinion weighed and valued alongside the pilot's. No easy task in some cultures.

The checks to be undertaken will determine the number of check personnel in the full checking crew. With the increasingly complex cabins and cabin systems, several Cabin Engineers are used by the manufacturers in a test capacity. The basic flight deck checking group should consist of the pilots and the senior Functional Check Engineer who may also be cabin qualified. If needed, specialist Cabin Engineers can also be included. Take care during depressurisation checks, when using a small team as there is a risk of one crew member being isolated in the cabin. The size of the cabin and the complexity of the systems checks in it will generally dictate the overall size of the team in the back of the aircraft.

These crews will need to be trained. It is quite possible to do this inside an airline when the expertise exists and is supported fully by management to get their people “up to speed” in a check flight sense. Some of the airlines with very large fleets have a dedicated professional department whose role is to carry out the checks on all their fleet aircraft. Equally, a new manufacturers’ Functional Check Flight course has recently been developed by Airbus with very positive results. It is not designed to generate full test qualified crews but rather to give an initial immersion into the right type of thinking and to help airline check personnel get some way up the learning ladder to prevent some basic errors. The course uses one of the Airbus aircraft types as a vehicle on which to hang the “generic” teaching on the subject and Airbus uses this type to demonstrate the level of knowledge and skills that are needed to safely carry out functional check flights. Other aeronautical training agencies also do the same sort of thing but in a much more general way. The choice is with the airline.

One final point, check flights should not be used to carry any form of passengers or people "along for the ride" or just for "the experience". Whilst appearing to be tempting for various reasons, passengers in the checking situation often lead to adding complexity, health issues and pressure to an already complex exercise. If there is a requirement to move people from A to B then carry out the check flight first and then pick up the passengers for the simple transit.

Airfield

The airfield to be used is rarely a choice matter but it is wise to consider any implications stemming from the airfield itself. The runway capability, the height above sea level and its effect on performance, high ground and obstacles, the available navigation aids, and the active NOTAMs, all need to be considered as well as the general operational situation. For example before doing a rejected take-off or braking check, ask the question "is the operational runway the only runway in use" and consider at what time of day the RTO will be carried out in respect to scheduled traffic. Burst a tyre at a busy time and you will not be too popular. At the bigger and busier central hubs, a short flight to another quieter airfield will probably be the answer.

Air Traffic and Airspace

ATC can be our best friend or our worst enemy in a check flight sense. The check crew have got to ensure that they are a friend. Pre-flight ATC briefings, directly between the pilots and the controller who will look after them, are very valuable and tend to act as a positive "bond" between pilot and controller so that the controller will tend to move other traffic rather than the check aircraft. Prior to the call fax a copy of the intended flight check schedule to the ATC controller involved. A simple line profile will do with each check recorded at the right height and configuration. If trim stability or performance is needed on a set heading put it on the one sheet profile diagram.

No briefing and the opposite happens. The controller may become irritated by the continual and seemingly illogical demands for turns and odd levels and can then add to the workload of the check crew by making things a lot more difficult.

Wherever possible a quiet ATC environment is helpful and if the ATC agency has such a quiet frequency channel it should be used. In the pure manufacturers test environment we have dedicated controllers to ensure efficient flight separation and conflict avoidance but normally an airline does not have this privilege. However, a careful look pre- flight at the airspace and the prevailing weather can often lead to selecting a good quiet, out of the way, corner of airspace like an inactive danger area which will serve the check aircraft flight profile well. If in doubt, ask the controller for his advice and through this advice he again tacitly binds himself to the success of the mission.

Weather

During certification development flight testing, the weather criteria often drive the ability to carry out a given test. However, in the check flight world it is rare to have the privilege of waiting for perfect weather. That said, it is certainly wise to know what the bottom line is for the checks to be undertaken. It may not be wise to carry out a check of the brakes in a 30 kt crosswind for example.

In Airbus the minimum weather for a first flight of a new build aircraft is defined. If full authority flight control checks or envelope protection checks are to be done then some clear vertical airspace between clouds is needed. Autoland systems are checked out in Cat 1 conditions before they are used for real and a lot of attention is paid to avoid icing layers in the descent for the low speeds handling. Even small amounts of icing can significantly change the onset of buffet speeds and the schedule speeds at which warnings operate.

So as part of the flight preparation and in the cool of the office it is best to define the rules of the game that will be applied from a meteorological point of view. Apply as few rules as possible as this will allow the greatest flexibility for the check crews. Apply only as many rules as may be needed to ensure safety. But then they must be respected - always.

Checklists

Bearing in mind the more normal airline “standards driven” operational situation, the check crew will need to be able to think and work "outside" the standard checklist (whilst still understanding and recognising its importance) and be comfortable doing so. Checklists should still be used but they should be used for guidance and not treated as if they are the holy grail. No checklist can cover all check situations.

Test schedules

Different approaches to check schedules are used. A different check schedule can be developed for each type of check flight to be carried out or a master reference check schedule can be created where certain checks are crossed through if they are not applicable. The document should not only have the item to be checked but also any associated safety warnings written before the check together with the success criteria and the maximum tolerances allowed. Where a check demands the approach towards a hard limit like a Vfe limit, then the NOT BEYOND figures need to be clearly written as this will form part of the mini item briefing later in the execution phase. Avoid writing a check over two pages if possible and certainly avoid having the safety warning detached from the check to be done. Better to have gaps on the pages. Also as check flights rarely work out as planned, format the schedule to make it easy to handle and use in a different order but take care with this. Certain checks should be carried out before others i.e. low speed handling before approaches.

Airbus, currently offers its Customers an In Service Aircraft Test Manual (ISATM) which can be used as a reference by Customer airlines to create their own check schedules. Along with the data provided, the other factors mentioned above should all be taken into account in the final airline version. The process, of generating one’s own check schedules, forces the discipline of thinking about all the factors mentioned and ensures a better pre-flight preparation.

3. Execution

Ok, so now the right people have been selected and as much preparation as possible has been done. It is time to fly, but in this paper there is no intention of going through a test schedule check by check. This is well covered in our Technical Flight Familiarisation Course. The emphasis has deliberately been on preparation. However, some of the good things to do and some good general practices that should be followed will be mentioned.

Let us start with the briefing. No matter what the level of advance preparation certain things will change just before the flight and they need to be covered at a pre flight briefing.

Briefing

Some guidelines on the briefing are useful here.

1. All involved parties need to be present and listening. Let us remember that this is a pre flight briefing not a long maintenance diatribe on what has been done item by item to the aircraft. Such data should already have been reviewed and frankly most of us can only remember a certain amount of detailed information at a time.. The briefing is run by the Captain or the Check Engineer and needs to stay relevant to the flight. By all means have background technical people there to answer any questions that may arise.
2. Everyone must understand the task, their role in that task, the planned check sequence and the way in which the flight will be conducted. Any limits and key words should be agreed.
3. The weather needs to be specifically briefed with regards any impact on 2. above
4. Likewise the airfield and ATC and airspace situation must be reviewed
5. A brief flight risk assessment should be made. This deals with the practical "what will we do if this or that happens" question. It is not a deep engineering risk assessment but rather a review of the sequence assuming that things may not always go exactly as planned. It should include the things most likely to cause a problem and the fall back plan should they happen.

Those sections of the flight that are primarily a pure flying activity (like flight control checks or low speed handling) will be identified as will those which are essentially systems related (like a de-pressurization check) and it will be decided who is flying and who is monitoring. Always have one person flying. I have seen many situations where the whole crew gets "involved" in the detail of the check sequence. There is absolutely nothing wrong in having one crew member quietly listening but focused on the basic flying.

This pre-flight briefing will be later supported by mini "in flight briefings" that will be made before certain phases of the check sortie to "remind" everyone what is coming next, what the limits are and what action needs to be taken by whom "in the event of" certain situations arising.

Getting airborne

The pre-flight preparation should consider any need for FMS programming regarding fuel transfer and also back up flight plans in case the manoeuvres flown early in the plan erase waypoints. Also electrical checks can sometimes cause some interesting computer responses on modern aircraft.

As stated, it is expected that most airlines would use the standard checklists in the run up to getting airborne in their normal way. The difference is that a third crew member will probably be present in the jump seat. His or her role is to record data and to monitor the work of the pilots in a non intrusive way but with a right of intervention should something occur that he doesn't understand or that he thinks may be incorrect.

Over the years and irrespective of the good use of checklists, I have developed a personal habit (along with most of the test fraternity) of always carrying out a quiet final configuration check just before take-off and also just before landing.

Take –off

In the manufacturers test world, some specialist Flight Test Engineers are included in the take –off brief so as to allow them the right to call STOP, as a key word command. The circumstances under which they would exercise this right are discussed and carefully considered and if in doubt they say nothing. In the airline world such a protocol probably would not be appropriate (subject to the experience and training) and I would recommend staying as close to the local standard practice as possible. In general, the flight deck should be quiet and free of unnecessary "chat" and certainly so below FL100. Careless words can be mis-interpreted and sometimes create a dangerous response.

Switching

Switching and system selection needs to be thought about. Who switches and how? In general a two man principle on all switching actions should be used, with one person pointing at the switch and then after verification that it is indeed the right switch, the selection is made. Some may consider this as overkill but there have been cases where due to poor switching discipline, engines have been "accidentally" shut down and also hydraulics and electrics systems lost when APU's have been inadvertently switched off on acceptance flights. Under stress bad things can happen and its best to develop good practices right from the start.

Actually, in the manufacturer's world, the principle is carried a bit deeper than this and it is normal to have two members of the three man check team always "in the loop". Normally the flying pilot is allowed to concentrate on that task whilst the non flying pilot and the "engineer" focus on system switching safety. It is also easy for one person to get "buried", for example whilst carrying out radio checks (normally the non flying pilot) but under those situations it is essential that the non flying third member is in the loop with the person on the controls and aware of what is happening in a general flying sense. The switching situation can be avoided by only carrying out one check at a time.

Communication

Really good crew communication throughout is required. Key words are sometimes useful. These can include commands such as STOP or GO AROUND but there are also some unwritten but absolutely clear rules for events such as one crew member not being comfortable with the test progression. If any test / check crew member says "I am not happy" the active pilot recovers immediately and the crew reviews the situation. Likewise if someone declares themselves as being "out of it" through workload or whatever, again, a recovery is carried out and then a re-brief to ensure all crew members are mentally on the same test point with the same level of understanding of the plan. Even silences need to be "listened to" as they can tell you that another less experienced crew member may be concerned about something. After a while it is possible to develop a "nose" for when its not going according to plan and that is the time to slow it down and think about what is happening and whether the plan still makes sense. The pacing has to be led by the slowest crew member but of course there are situations where ATC has no choice but to dictate the check pace such as when you are in the pattern or on the approach. Often the aircraft may be carrying a snag or two by this stage and the impact has to be continually re-assessed against the "remain to do" checks. This is where good check crews work together to continually formulate a new and safe plan of action.

As regards external communication, if there are radio problems then the safe continuation of a check flight quickly becomes very challenging and it may well be wiser to concentrate on getting on the ground safely to get the radios fixed before continuing with other checks.

Workload

Workload also has to be continually assessed on an individual and group basis. One person may become overloaded for a short while but if two out of the three reach this state then the situation can become very critical very quickly. The whole crew must never be allowed to reach this state, so if the test crew is only a two person crew the increased threat is obvious. A third check qualified crew member for this type of work is to be strongly recommended.

One of the problems with workload is that it can rise very quickly and in such a way that the individual concerned, although aware that he or she is working too hard, is unable to take the decisions that will reduce that potentially dangerous situation. The person involved may even be unable to "see" the problem, never mind the solution.

So as the workload increases the crew has to prioritise the tasks. Firstly, and always the safety of the aircraft is secured. Easy to say but often this requires some tough decisions to be made and sometimes ones that

local management may not be too happy with. If the crew has a problem that they do not understand they should put the aircraft back on the ground while they think about it. There is no room for “pressing on” when a situation is not understood and may be potentially dangerous or worse, catastrophic.

Secondly, the objective is to secure good quality check or test data. There is no point in being there to gather poor data that the engineers cannot use. And finally the whole process should be carried out as expeditiously as possible. It is not a pleasure flight although when done well its extremely enjoyable. The objective is to re-clear the aircraft so that it can back into the air quickly and earning revenue with passengers on board.

Snag resolution

The whole purpose of a check flight is be able to give an aircraft a clean bill of health, so it is not surprising that if a snag is found there is a desire to find out as much as possible about that snag as possible to help the mechanics. Laudable as this may sound it can lead quickly to some very unhealthy situations. Great care needs to be taken when “snag chasing”. The implications of one failure needs to be understood across all the systems affected as do the implications of selecting certain associated systems into a degraded mode so as to “isolate” a snag. Remember too that there may be another dormant but un-reported snag in the system already, which when coupled with the original snag and the crew switching may put the aircraft into a serious risk area. We tend to think, with modern aircraft, that everything is captured by the BITE system or is presented to us through the Flight Warning Computers but this is not so. We return to the issue of integrity and if the crew do not know ALL the ramifications of complex and multiple switching actions then they should not do it. Put the aircraft on the ground, examine the situation very carefully, call the manufacturer if in doubt and only then proceed after having tried to fix the problem.

I have never known an anomalous indication on an aircraft to appear for no reason. Some are small, some have little operational significance, some are intermittent (the worst kind) but there is always a reason. It is no good just hoping a snag has somehow just “gone away”. It may indeed not be easy to reproduce the symptoms or it may be limited to certain very precise flight or meteorological conditions but it will still be there and if left, these types of snag have a habit of returning at the worst possible moment. In my experience, sometimes the smallest of apparent issues can lead to failure scenarios with some very serious consequences. Watch out particularly for snags associated with “enabling” functions like weight on wheels switches. Their impact can be seen over several systems. Pressure controllers are another area where a snag can turn from fairly benign to serious pretty quickly.

Tricky test points

Some checks are certainly more difficult to fly that others or some may have a more immediate impact if they go wrong. The failure of a generator to come back on line does not have the same immediately damaging effect as allowing the speed to exceed Vmo by too much. So it is sensible to treat the “tricky test points” with the care they demand and not to rush them. Think about them on the ground carefully and decide how they should be flown and what the “break off” point is. These tricky tests can include speed limit checks, envelope boundary checks, depressurizations, initial handling checks, low speed checks and of course some engine checks.

It is also important that no one becomes tempted to “take- a look at” some of the certification test points. There are many “interesting” experiences in this category where hardened development test crews can earn lots of beer telling stories over the bar. Taking one example like Vmca definition, fuel starvation on some types of aircraft has occurred in the past on this test (which is done at very low altitude) causing the remaining engine to stop. The lowest I have heard of was 400ft agl. Not pleasant. No, the job of the checker is not to try to re-define the basic certification criteria of the aircraft. Those criteria have been flown and examined by experts under strict weather conditions and rigorously controlled conditions. The checkers job is to check “this” line aircraft against a pre-defined and approved Airworthiness standard or to clear a reported squawk or snag.

Different flight plans

With a modern aircraft check flight there are several “plans” being conducted at the same time. You have the desired planned check schedule. You have the approved Air Traffic Flight Plan which may involve some “on airways” flying and will often start with some sort of procedural departure. The FMS may have to be set up to a slightly different plan to ensure some functions work as they should like fuel burn logics. There is also the Flight Warning computer flight phase plan which may throw ‘stored” snags at you at pre-determined times and you also have an Air Traffic Control handover plan which drives the communication world and to some extent the workload. Finally, God controls the most important “plan” and it’s called “the weather”.

The crews’ job is to safely carry out the check points whilst also conducting this orchestra of differing plans not all of which are in sequence and not all want to align conveniently. Its not unusual to have a check point set up and ready only to be asked to change frequency, squawk and then head straight towards a Cb.!! Or you may require an altitude or a block of altitudes only to run out of the ideal bit of airspace in which to do the next point. Patience is required and it is this aspect that benefits most from pre-planning, a good weather examination and pre consultation with the ATC guys. It may be that on some days it simply becomes impossible and the sensible conclusion is to keep it safe and call it a day. Such judgments are not easy as they often have a considerable cost implication.

The day /night question

Each organization will need to make a decision on the question of whether to carry out check flights by day only or by day and night. In my mind, there is no major issue with carrying routine checks at night provided the meteorological conditions are VFR. However, there are nights when you can see for miles and there are other nights when it is inky black out there with no moon to assist. The combination of night and IFR should start to ring a warning bell or two and certainly will increase the workload on the crew a lot. So it is recommended that a daylight flight is better, particularly for smaller airlines where these types of flight are flown less often and the crew currency may be lower. Also, after a significant deep service, the flight should commence in daylight if at all possible. In Airbus production testing, the last possible take off time for a first flight is related to the time of useful daylight so that at least the first slow speed handling checks can be carried out in daylight and VFR. If there are any serious weather concerns, a day only flight is the logical decision.

Cabin systems

Increasingly this area of testing, as said before, is becoming more and more important. Complex seat systems and entertainment systems prevail and it is worth getting to know basically how they work. With the new larger aircraft, there is much closer integration between cabin systems and the flight deck, so no longer are cabins “something back there”. They are check areas that have to be thought about quite hard.

This whole paper could have dealt with pressurization issues that have occurred during testing but in order to be brief it is worth thinking about emergency oxygen if a depressurization is planned. Plan which oxygen sets the crew will use. The typical therapeutic oxygen bottles may be “a bridge too far” for someone working in the back of the aircraft to get to. Try getting one out of its stowage and in use in 20 secs and remember that if you are in the cabin checking something you may have to walk some distance to get to the bottle. A better idea is to select and allow a few well placed oxygen masks to drop in the event of a full de-pressurisation, so that the cabin checker can immediately take a seat and then breath oxygen with the nearest passenger system. Think also about communication with the guys in the back and ensure the ability to inform them of what is going on and when to be strapped in. Likewise, there are many tasks they can help with like wing inspections and they will need to be able to communicate with the flight deck.

4. What to do when it goes wrong (in a maneuvering sense)

In a routine check flight, the highest risk of a crew losing control falls into three phases: Firstly, whenever the workload reaches a critical level due to the combination of multiple system snags, changes in the check plan, poor weather, communication and / or difficult ATC conditions coupled to a final "triggering" issue. Secondly, during the control handling check, especially in marginal weather and thirdly during the low speed handling verification phase if sensible check flight "guidelines" are not followed. Whilst these represent the most likely causes of check flight problems, maintenance issues also represent a serious threat. The likelihood of a servicing error being duplicated for example on both engines is much higher under these post maintenance and heavy check scenarios.

In the first case above, the crew must be aware of the overall crew workload and as previously stated the whole crew must not reach a critical workload condition. Someone, normally the Captain, has to make it clear that until the technical systems issues are resolved or their implications fully understood, no more check points will be carried out. Enter a hold or ask for a vector away from the airfield, to give thinking time, are other workload reducing techniques.

Regarding the control checks, two cases exist, aircraft with an envelope protection system and those without. For those with a serviceable and working envelope protection, an upset during the flight control handling checks should not occur as the aircraft should not reach attitudes that are difficult to recover from, provided that the protection system is fully serviceable. Of course that may be the reason for the check flight in the first place, so it is always best to assume that the protections may not work. In fact all good check pilots assume that the system will not work as advertised until it proves it does, rather than the other way around.

Perhaps one word of warning is necessary with regards to the selection of nose down pitch angles in the flight control check or high speed warning checks. If a pilot is too aggressive in terms of his control inputs he can exceed Vmo or Mmo fairly quickly, even with envelope protection in force. The protection is designed to protect from an accidental exceedance and not from a determined 10 to 15 degree nose down pitch attitude with power applied and a high rate of speed increase. In general, as with all aircraft in this class, care should always be taken with high speed trends and nose down pitch angles. We see many cases during deliveries, of pilots allowing the nose to drop well below the horizon with power applied during flight control checks.

Without envelope protection, the pilot must maintain VFR conditions and pre-decide and brief to which bank angle and pitch limits he will fly the aircraft. He must then stick to that brief and demand that the non flying pilot warns him as he approaches the limits he has set. Although its fun to do, there is little value with the large passenger class of aircraft in exceeding 45 degrees of bank by much or of exceeding 20 degrees nose up or 10 degrees nose down. The "feel" and characteristics of the controls can certainly be checked inside these limits.

During the low speed handling checks it is always prudent to ensure sufficient height for recovery from a stalled condition even if there is no intention of stalling (there should be no need to stall protected aircraft). The primary objective of these checks is to ensure that the handling of the aircraft on the approach and during the later landing will be as expected.

Three factors deserve special mention in the case of the low speed handling checks, the rate of speed reduction, the effect of trim and the pitching effect of powerful low mounted engines. An excessive rate of speed reduction can give rise to many problems. The whole thing happens too fast for some pilots who are not trained to observe and check all the various warnings, so it is best to take it slowly and make the speed reduction progressive. There is also an additional risk of entering a stall dynamically and going more deeply

into an out of control situation. This must be avoided. Aim for the classic 1 kt per sec rate of speed reduction as evidenced by a 10 kt speed trend line.(if you have it available).

The historical classic recovery from an approach to the stall involved the use of power to increase speed towards a normal flight condition whilst minimizing the height loss. The recovery from a stalled condition requires that the angle of attack be reduced first to ensure a satisfactory stall recovery and then the application of a progressive increase in power. In recent times it has become clear that the precise point of stall is less easy to recognize, in terms of pilot recognition, with more modern transport aircraft, therefore all approach to the stall and stall conditions should be treated in the same way. In simple terms, treat all such situations as a full stall. Remember that low mounted engines will tend to increase the angle of attack and if power is applied too aggressively and before reducing the angle of attack, there is a significant risk of re-stalling or remaining in a stalled condition. Similarly, increasing speed will cause a secondary pitching effect which will also need to be controlled through the recovery man oeuvre.

Never forget that during a full aircraft check flight the crew is there to ensure that the primary control system and the warnings are working correctly. Provided that the alpha values at Green Dot and VLS are ok there should be no need to reduce further but if it is airline policy to also check the alpha protection and alpha floor functions then that should certainly be sufficient to prove the system software integrity. Recovery should then be initiated immediately. There should be no need to go as far as V min and certainly not to the stall itself.

The reason that alpha protection systems stops the tail plane from trimming beyond a certain alpha angle is because a control of that size and aerodynamic power will override the elevator easily and thereby may prevent recovery using elevators alone from speeds close to the stall and at high alpha angles. Typically, trimable tail planes have roughly twice the aerodynamic power of the elevators. Therefore, in conventional aircraft, trim no slower than 1.3 VS for the check configuration, in the speed reduction phase.

Throughout these checks it is important for the handling pilot to maintain one hand on the throttles and to be operating them manually. We recommend having the Flight Directors switched off and the Flight Velocity Vector in sight. As said above, with low mounted engines, applying full power aggressively at very high alphas will lead to a significant pitching effect and if the tail plane has been incorrectly manually trimmed, on unprotected aircraft, or there has been a system failure leading to a high alpha condition in a protected aircraft, a possible loss of control and upset condition can be the result. In a recent accident, according to the report from the investigation, the tail plane continued trimming due to a fault in the AOA system, well below the alpha protection point, so that when full power was eventually applied, the aircraft suffered a strong pitch up and entered an upset and then finally an out of control condition. The act of reducing power under these circumstances as a recovery agent cannot be over emphasized but it may not be entirely instinctive with a high nose attitude. In fact all power applications need to be carried out with care at these low speed test points. Power is as strong a recovery agent as it can be a disturbing one on low wing mounted engine systems.

In order to prepare for low speed checks properly, the rules need to be set and followed. Firstly, have enough height available in which to recover should things go wrong. Secondly, stay VFR, thirdly select manual thrust levers. Fourthly, know what alpha values you would associate with and expect to see for each warning level. Finally, have someone in the check crew monitor the alpha values carefully throughout the speed reduction. The pilots can also monitor alpha in a rough sense by noting the delta between the Flight Path Velocity Vector and the Pitch Attitude. If it doesn't look right, stop the deceleration and investigate. A crew member may have read the wrong weight tables or there may be a system failure of some sort but stop and check – don't press on.

So the real trick as always is to avoid these upset and out of control situations by good planning, preparation and discipline. Should one occur, the biggest difficulty is in diagnosing the problem, whilst at the same time being in a severe, potentially overloaded workload situation. After all, you would not be in this situation if you completely understood what had caused it to go wrong.

There is no one convenient answer but my advice is to simplify the problem. When a crew “loses the place” completely in a handling sense, they probably have a little more time than they think to sort it out and regain control before they will enter a potentially disastrous upset. But it won’t feel like that. They should not over react with power or control inputs. The last action taken has probably triggered the current condition so if the height and speed situation allows it, consider reversing that action. If it was a power increase, take control of the thrust levers manually and reduce power to a mid range. Seek to select either a straight and level attitude or a climb if close to the ground, then hold the attitude. Check engines and energy. Ask the other crew members how they see the situation, make the effort to listen and if need be relinquish control to the other pilot who may “see” the way out of the upset before you. Systematically check the basics – Attitude? - Configuration? - Instruments? to see if you can sort out the confusion. Have you missed a key warning, or an annunciator message.

One final bit of advice - take great care with the use of rudder. Modern rudders are not intended to be used other than for engine failure control and for reducing the drift at landing. They are not an upset control device and the certification requirements on passenger aircraft do not demand that the rudder design should allow repetitive opposite full deflections of this control.

I have tried to take you through the upset and “out of control” situations that are most likely in the check flight scenario but lets remember that its better not to allow the aircraft to get into an upset condition in the first place. Avoidance is always better than recovery.

Conclusion

The key is to prepare thoroughly on the ground and to ensure the best information and knowledge is available to the well selected and correctly trained crew. Once airborne, the most common weakness in the overall checking “system”, of aircraft and crew, will probably be the active pilot as he is the most likely to become over loaded in a workload sense. Therefore, well communicated and timely, support from the rest of the check crew is critical in ensuring the success of the check mission. It is the role of the Captain to encourage such communication. It is the duty of all crew members to be active in a communication sense. The challenge for the crew is to avoid critical crew workload levels by excellent preparation, by mini briefings and by being ready for the unexpected as they conduct each test. Superior flying skills help as they allow a greater concentration on the communication aspects of the whole operation.

So the final messages are: Select the crews well, train them properly, brief carefully including the ATC and Airspace agencies and then fly “defensively” with escape routes planned and being failure minded. Finally, communicate well and no matter what pressures exist, always default to the safer decision.

I wish you good check flights and remember always that good and thorough preparation is the key.