THE PROPER USE OF CHECK-LISTS

Original idea from Fred H. Lorenz

Some years ago, there have been two very serious airplane accidents which were caused by the flight crew attempting to takeoff with the wing flaps retracted. There are, of course, many examples of improper use of checklists and I would like to share a few examples with you.

CASE NO. 1

After a ten-minute turnaround, the airplane took off from Fresno runway 29R with ambient temperature of 106° F (42°C). Just over four minutes after gear retraction a fire bell sounded. The captain announced the loss of an engine and that an air turnback would follow. The cockpit crew proceeded with an engine shut down and fire drill on the assumption that a fire had occurred on the No. I engine. The extinguisher bottles were fired and the turnback to Fresno was initiated. Two minutes after the fire bell rang, a flight attendant reported a cabin pressure leak. A deadheading crew member reported he heard a bang followed by a pressure change and cold air. As the cockpit crew continued to execute the engine fire checklist, the fire bell sounded a second time. This occurred three minutes after the first bell sounding. The crew determined that the second fire bell was a wheel well fire warning and the copilot extended the landing gear whereupon the fire warning ceased. Approximately one minute later an attendant reported smoke in the passenger cabin. An engine-out landing was performed - during the rollout the tower reported tire fires. An emergency evacuation was conducted resulting in several injuries, three requiring hospitalization. Fire on the landing gear was extinguished by the airport fire department.

A four by eight inch hole was opened in the right wheel well aft bulkhead with minor heat damage in the wheel well. All tires, wheels and brakes were destroyed or unserviceable because of heat damage. The No. 1 engine showed no damage or indication of malfunction and its fire warning system tested normal.

CASE NO. 2

The aircraft contacted the runway with all landing gear retracted. The left engine separated from the airplane near the end of the runway In addition, the left wing fuel tank was punctured and the resulting fire was extinguished by the airport fire department.
The Ground Proximity Warning System (GPWS) warning was disregarded by the crew, confident the airplane was properly configured, and the GPWS circuit breaker was pulled to stop the pull-up alert.

CASE NO. 3

The flight's departure was delayed because a moderate to heavy snow shower closed the airport. Following re-opening of the airport, the airplane was completely cleared of snow using glycol water fluids. After some difficulty in pushing the airplane back, during which time thrust reverse was briefly used, the airplane started its taxi about 30 minutes after the airplane snow removal operation. The before takeoff checklist was accomplished; however the engine anti-ice was not placed ON, and the checklist response was OFF.

While waiting to take the runway, the crew remarked that they saw one-quarter to one-half inch of snow on the wings. Twenty minutes after leaving the loading area, the crew started the takeoff. During the takeoff roll, the first officer, who was at the controls, remarked on apparent anomalous engine instrument indications. Shortly after attaining V2 speed (144 knots), the sound of the stick shaker was recorded. The aircraft reached an altitude of 350 feet, at which time the airspeed had decreased to 130 knots. The aircraft then descended and struck the 14th Street Bridge (0.75 nautical miles from the departure end of runway 36) at a 15' nose-up pitch attitude, and plunged into the Potomac River at approximately 25' nose-down pitch attitude.

Recovery and inspection of the wreckage showed that engine nose cowl and inlet guide vane anti-ice valves were in the OFF position. Analysis of takeoff performance from the flight recorder showed that lower than normal thrust was present, most likely as a result of engine Pt2 probe icing producing erroneous EPR indications.

CASE NO. 4

A Model 737-200 airplane experienced a loss of hydraulic system A on final approach as the wing flaps were extended to 25 units. The LOSS OF SYSTEM A Checklist was not accomplished and the approach and landing were continued with flaps 25 and an airspeed of Vref 40 plus 20 knots. The landing was accomplished on a 6,500-foot runway with strong, gusty crosswinds. After touchdown, it was discovered that reverse thrust could not be selected and braking appeared ineffective. The airplane departed the runway at approximately 100 knots.

In all of these cases, had the appropriate normal or non-normal checklist been properly accomplished, the end results may have been very different. Further, these accidents beg the questions:

- How could this have happened?
- How could a flight crew attempt a takeoff with the wing flaps retracted or attempt to land with the landing gear not down and locked?
- How in the world could a flight crew accomplish the wrong non-normal checklist or fail to accomplish any checklist whatsoever when faced with a serious non-normal situation?
- Well, in my opinion, the answers to these questions lie in the flight crew's attitude toward checklists and their understanding, or lack thereof, of the basic philosophy of checklist usage.

To start with, let us discuss what a checklist **is not.** It is not a meaningless ritual with the speaking of an incantation which magically makes everything right. No, that is not what it is, although I have seen it performed in this manner. What it really is, is a cockpit tool which, if used properly, can help compensate for some of our human failings. The key to how well it does this is in how well the pilot understands how it should be used.

NORMAL CHECKLISTS

Normal checklists are used to verify that certain critical procedural steps have been accomplished. Only procedural steps which have a direct and adverse impact on normal operations should be included. Inclusion of unnecessary operations should be avoided because they create unnecessary crew workload and detract from the effectiveness of the checklist. It should be short, sweet and to the point with the critical nature of each item self-evident. Normal checklists are the flight *crews'safety net.*

If they forget to do something or mis-position a control which is critical to the safety of flight, the execution of the checklist should reveal that condition. However, this safety net effect can only work properly if the checklist is, in fact, accomplished properly.

The Boeing procedure is to accomplish a panel scan flow in each individual crew member's area of responsibility. During this scan, airplane systems are configured appropriately for the intended phase of flight. When a system control is positioned, the crew member also verifies that the proper response has occurred. At the appropriate time, the checklist is called for, read and responded to by the responsible crew member, the position of the control or indication is *visually verified* and stated in the response. In so doing a true double check of the item is accomplished.

When a disagreement between the observed condition and the checklist answer occurs, it is mandatory that the checklist reading be discontinued until the checklist item is properly resolved. Flight crew members need to understand that the normal checklist cannot provide that *safety net* that I mentioned earlier unless it is performed exactly in the manner that I have just described each and every time it is used. Respect for what the checklist represents and strict adherence to the philosophy of its use are essential to ensure continued safe operation of the airplane.

It should be noted here that, for some situations, there is still another level of protection against flight crew errors beyond the normal checklists. That is the Master Caution and Warning System, the Takeoff and Landing Configuration warnings, and the Ground Proximity Warning System. In several of the example accidents which I have presented, it is believed that the flight crew either disregarded or disabled one or more of these systems. This action along with the improper use of the normal checklist set the stage for the events which followed.

NON-NORMAL CHECKLISTS

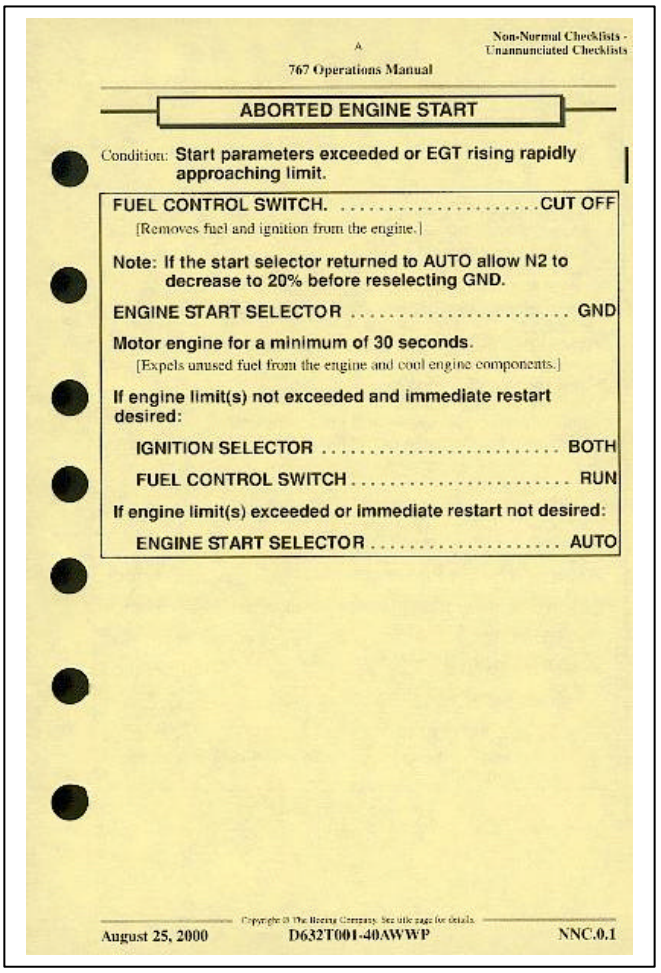
Non-normal checklists are used by the flight crew to cope with or contain certain non-normal situations. It is not possible to cover all combinations of non-normal occurrences and so the non-normal checklist, with some exceptions, is usually written to address single events. In certain unrelated multiple failure situations, crews may have to combine elements of more than one procedure and/or exercise good judgement to determine the safest course of action.

Non-normal checklists can either recall (memory), reference, or be a combination of both. Recall items are only included for those items which could require prompt or immediate action. As a rule, there are very few items which fall into this category, but those that do need to be firmly and unquestionably fixed in the minds of the flight crew. The reference items are intended to be accomplished in a read and do manner, and as such need not be committed to memory. However, the flight crew should be sufficiently familiar with the various reference non-normal checklists to be able to detect the fact that the wrong checklist is being performed should such an error be made. In all cases, flight crews should have a thorough and complete understanding of what in fact is being accomplished by a particular procedural step and what effect it may have on the operation of that system or the continuation of the flight.

We will now turn our attention to the way that a non-normal checklist should be performed.

To simplify matters we will assume that the captain is the pilot flying and the first officer is the pilot not flying. When a non-normal situation occurs, it should be positively identified before any action is taken. The crew member observing a non-normal indication should call out the condition. For example, "Engine Fire."

Execution of a non-normal checklist action commences when the airplane flight path and configuration are properly established. Under no circumstances should control of the airplane be compromised. Only a few situations require an immediate response (e.g. stall warning, GPWS pull-up warning and rejected takeoffs).



Usually time is available to assess the situation before corrective action is initiated. All actions should then be coordinated under the captain's supervision and performed in a deliberate and systematic manner. The captain will call for the appropriate non-normal checklist by its proper title.

For example: *"BUSS OFF Checklist"* or *"LOSS OF SYSTEM A Checklist."* Just saying: *"Checklist"* is not an acceptable command. At the captain's command, each crew member will systematically and without delay accomplish the recall action items (if any) in their areas of responsibility. Any item that is irreversible or difficult to reverse (such as CSD disconnect or engine shut down) should have the agreement of both pilots that the correct controls are being activated. Adherence to this procedure should minimize the chance of shutting down the wrong engine or disconnecting the wrong CSD.
(Or as one of my example accidents, shutting down an engine when in fact they had a wheel well fire warning.)

For those checklists which contain only reference items or a combination of recall and reference items, the captain calls for the checklist when the flight path is under control, the aircraft is not in a critical stage of flight (e.g. takeoff, landing) and recall items (if any) are complete.

The first officer will then read aloud in sequence each checklist item, including the response. Recall BOXED items will be rechecked by the first officer to ensure that the challenged action, i.e. switch position, instrument configuration, etc. has been accomplished. The captain will then respond appropriately to the challenge, confirming the action or describing the configuration.

The checklist reference items are read aloud, with appropriate action being taken by the first officer. After accomplishing the checklist item, the first officer states the checklist response.

The captain may also direct reference procedures to be accomplished by recall if no hazard is created by such action or if the situation or time does not permit reference to the checklist. The captain then calls for the appropriate checklist.

Checklist informational items or notes are read aloud. The captain does not repeat such items, but responds in some manner to indicate that he has heard and understood the information.

Checklists provide lists of inoperative equipment only when knowledge of the condition of such equipment is essential for planning the remainder of the flight.

The captain should be made aware when landing preparation items exist. Accomplishment of such items can be delayed until preparation for approach.

SUMMARY

In summary, the proper use of normal and non-normal checklists can aid in preventing airplane accidents. The important points to remember are:

- Recognize the normal checklist for what it really is: *Your Safety Net.* Treat it with the respect that it deserves. Do not read it like an incantation, but in the manner of a true double check.

- Know your non-normal recall items thoroughly and completely and have a good working knowledge of all non-normal reference checklists.

- Know and apply the proper checklist action philosophy when you execute a normal or non-normal checklist.