

CAT III B OPERATIONS – FAIL OPERATIONAL vs HYBRID SYSTEMS

(by Cpt Giovanni Riparbelli)

The development of Head Up Displays (HUD) made available to commercial aviation a new solution to CAT III B operations (approaches with RVR lower than 200 m.), in addition to the conventional fail operational autoland systems: the hybrid systems.

The former are based on the multiple autoland concept (two double channel or three single channel autopilots), which perform the cross monitoring function during the approach and landing and that, in the event of a failure occurring to one of them in the final part of the approach, maintain the autoland capability, ensured by the remaining part of the system.

The latter are based on the concept of a single "fail passive" autoland system, plus a HUD which enables the pilot to carry out both functions: that of monitoring the approach throughout the automatic landing, and that of taking over the control of the aircraft and perform a manual landing (or go around) in case of failure to the autopilot.

In this study we will analyze how the two systems were developed, and will try to identify advantages and disadvantages of both solutions.

Europeans have been the first to address the problem of very low visibility landings, prompted by the central European weather conditions, which, with regard of fog, definitely hold the World record.

Manual flying systems, even the most advanced flight directors, had proven inadequate for the flare, touch down and roll-out phases, since they could not provide the pilot information adequate to grant the precision required for such operations.

In fact recent experiments carried out, among others by myself too, in Europe at the Dutch Laboratories NLR with an advanced research Flight Simulator, have proven that not even a synthetic vision of the runway, shown Head Down on screens even larger than those present on the most advanced aircraft, is sufficient to carry out a manual landing.

The technology existing at that time did not yet allow the development of Head Up Displays, which required spatial reference information and flight data which would have been available only later with the Inertial Navigation Systems.

The only solution was through the improvement of autopilots, able to manage the "milliamperes" of deviations, and translate them into appropriate inputs to flight controls.

The French developed in the early sixties a "fail-passive" autoland system for the Caravelle, which allowed Air Inter landings with 150 m. RVR associated with a 50 ft. Decision Height.

The same system was also fitted to the Alitalia Caravelles, but operationally used only to Cat II minima, although the required training for Cat III operations had been completed by the pilots.

Soon after, the British developed a "fail-operational" autoland for the Trident, with three single channel autopilots, which allowed landings with RVR of the order of 100 m., associated with 12 ft. Decision Height.

The pilot was left with the sole task of verifying, at DH, that the runway was under the aircraft, to grant a safe landing.

With the passing of years even this last bulwark has begun falling down: after it was proven that pilots risked, interfering with the autopilots on the basis of the poor visual cues available in CAT III B conditions, to only cause troubles, the DH concept has disappeared from the regulation, and has been abandoned by most operators, many of them even performing those operations with both pilots head down.

In the meantime the Americans, with their DC 9, B 727, B 737, did not go beyond Flight Directors and CAT II operations.

That was somehow explainable, given the lower sensitivity to the fog problem in America, where prevailing weather conditions were well different from the European.

At the same time Inertial Navigation Systems were becoming available, and the experimental phase of HUD was started.

In Europe the French Thomson developed a system which was fitted to the Mercure, first commercial aircraft to be equipped with a HUD (unfortunately that aircraft was not a commercial success, and only few of them were built).

In America Flight Dynamics built a system which was fitted to the B 727 of Alaskan.

The two systems, which had in common the heart, being the presentation of the flight path of the aircraft superimposed to the external world in a 1:1 scale, that is in real dimensions (therefore manageable by the pilot), nonetheless differed in a non secondary aspect.

The French one, intended to be coupled to an aircraft equipped with an autoland, was of the "Situational" type, meaning that it provided the pilot with indications of the aircraft path and of the runway, but with no command cue that would help him flying the aircraft, so that manual flying to continue an approach for landing was only possible after having achieved the vision of the runway at DH.

The American one, intended for aircraft not equipped with autoland, was of the "Command" type, meaning that in addition of showing the situation (runway and flight path), it also provided a command cue to enable to manually fly the entire approach and landing.

Unfortunately commercial application of this technology did not have the success which was deserved, mainly due to the fact that American aircraft manufacturers quickly opted for the autoland solution, at least for medium and large capacity commercial aircraft.

IFALPA (International Federation of Airline Pilots Associations), convinced of the fact that during a CAT III B landing a pilot has no means to verify the autoland operation, other than checking the status of the system, and then relying on an act of faith, has repeatedly pushed toward the implementation of HUD, being able to obtain that international regulation step by step were updated in order to recognize them as suitable solution to CAT III operations.

The task of convincing the aircraft manufacturers has taken much longer, and is in the process of happening now, under the push of events that we are going to examine.

The Americans too, if they were willing to continue to sell their products in Europe, had had to fit them with autolands, but had confined the "fail operational" systems (the most expensive), to the long range aircraft.

The two work-horse of the short range, the B 737s and the MD 80s, were only equipped with CAT III A "Fail Passive" systems.

Moreover all "executives" and "regional" jets were left without any autoland system.

In the nineties, when an already significant number of airports was equipped with CAT III landing facilities, and many aircraft were operating in CAT III B, the need of updating the capabilities of the less equipped aircraft became apparent.

The addition of a HUD has enabled aircraft not equipped with autolands to perform CAT III A operations at a much lower cost than that that would have been required by a modification of autopilots and flight control systems; virtually all jets in production without an autoland offer the HUD as an option.

In the meantime, as Airbus Industries launched on the market the A 319,320,321 family, equipped with CAT III B "fail operational" autolands, Boeing and Douglas insisted with their B 737s and MD 80s equipped with only "fail passive" autolands for the CAT III A.

Again Europe was ahead of America, adding a HUD and certifying a CAT III B "Hybrid" system

For the B 737s of Aeropostal and MD 80s of Alitalia.

(Certification of the MD 80 has been carried out by RAI, Italian certifying authority, showing that also our Country can be ahead, if it wants).

America followed, with the decision taken by Boeing, which I endorse one hundred per cent (but that will be discussed later), not to modify the autopilot system on the later versions of the B 737, but to achieve the CAT III B capability through the addition of a HUD.

The CAT III B certification of that system, "command" type (FAA patriotically insists in not recognizing the validity of "situational" systems) is in the final phases.

Today a good half of the orders for new B 737s include the HUD option.

So far we have seen how HUDs have entered the market more to fill existing gaps, rather than for a recognition of their intrinsic merits.

Now we are at a crucial point: manufacturers have been convinced of the advantages of offering operators a wide flexibility of operational capabilities, as the costs associated differ widely: the same aircraft can be offered with CAT II, CAT III A or CAT III B capability.

Operators at last have the possibility to choose.

Obviously operators of fleets which do not fly in fog prone areas, have no reason to pay for systems that they will never use; let us not forget that in the USA there are

only four or five runways where CAT III B operations are allowed, and Canada does not authorize CAT III operations at all.

Let us not talk about South America, Asia, Africa, Russia etc.

This is, according to me, the right moment to bring into the discussion all the operational considerations that might enable us to reach the best possible solution, that are not dependant on the (forced) choices of the past; the moment to examine the various options available today without the prejudice we had in the past.

My analysis is limited to the problem of CAT III B operations: Fail Operational vs. Hybrid

To operate in CAT III B there must be at least two channels, one of command and one of control.

A system of autopilots can satisfy the requirement, but leaves the pilot out of the loop, confined to the role of system supervisor.

A system of two independent HUDs, where the two pilots act as the two channels, could also satisfy the requirement.

The heavy dependence on the human factor, and the recognition derived by experience that autopilots are very good in performing precision flying, do not favour, in my opinion, this solution.

The ideal seems to be a system which gives the command channel to the autopilot, and the control channel to the pilot: the hybrid system.

The pilot, not involved in the piloting task, is in an ideal condition to control what the autopilot is doing, through the presentation of the aircraft flight path and the runway; he stays in the loop with the full confidence generated by the continuous visualization of the flare, touch down and roll-out phases.

No more acts of faith are required. Man can go back and give the flight operation the added value that no automatic system can give.

In the years sixties, when HUD technology was not available, it had been necessary to adopt a full automatic solution, and pilots could do nothing else than accept it.

Today that technology is available, and it would be short-sighted not to see it's benefits.

I do not mention, on purpose, considerations on HUD merits in flight safety advancements, or operational benefits achieved by lowering take-off minima, or economic considerations connected to the much lower costs of the hybrid solution in respect of the full automatic solution.

All that would dilute my reasoning, intended to convince of the technical and moral (the latter referred to the pilots, who had to accept, due to the lack of alternatives, an operating condition that placed them out of the loop) superiority of the hybrid solution.

If operators will endorse this concept, manufacturers will be ready to fulfill it.

Airbus Industries has recently announced that it will offer HUD option on all it's models, in spite of the fact that they are all equipped with CAT III B fail operational systems.

Obviously they start recognizing that more information than those traditionally given on the Head Down panels can be presented to the pilot, even admitting that CRT represented a significant step forward compared to the electro mechanical instruments.

Boeing has requested the HUD manufacturers to design a standard system which could be fitted to all models, with the clear intent of following the same philosophy as Airbus.

Embraer offers for the new EMB 170, obviously at different prices, CAT III B capability with either a Hybrid or full automatic solution.

Now the responsibility of the choice goes to the operators.

It is them who must get to the conviction of the merits of the HUD choice.

If it will be so, in the future fail-operational autopilots (and their associated costs) will have no more reason to exist, and there will be room for better and more advanced solutions.

Technology walks ahead, and a whole new world is opening up to the future: an infra red sensor has already been certified by FAA for the Gulfstream HUD, which will enable the aircraft to operate in CAT II conditions on Cat I airports, and millimetric waves radar sensors are in an advanced phase of development.

Project AWARD (All Weather Arrival and Departures), partly financed by the European Community, to which I myself gave a contribution has proved the feasibility of on board systems, not dependant on any ground stations, that allow a landing under any weather condition through the use of radar and infrared sensors (Enhanced Vision System, EVS technology) coupled to the HUD.

I believe the right moment of rethinking the future of flight instrumentation has come.

Capt. Giovanni Riparbelli *

* Captain Riparbelli has been from 1990 to the end of 2001, when he retired due to age limit, in charge of the Alitalia Airlines team for cockpit and avionics specifications for new aircraft, and has led to the acquisition of HUD on the company's A 319/320/321 and MD 80s

...an historical record

"HEADS UP" & SEEING OUT

Flight Safety Foundation Newsletter

October 1967

With all pilots well aware of the need for keeping the scan during all flight regimes, from takeoff through landing, a recently announced system called "Heads Up Instrumentation System," holds promise of adding to safety.

Therefore, it should be of interest, whether a pilot flies a light aircraft, a business jet or an airline transport. Here's the story:

A transparent instrument mounted atop the glare shield directly in front of the pilot gives him wings level, roll, skid, heading, VOR and/or ILS, RMI of VOR, and/or ADF, and repeat of IVSI - all without his having to look anywhere except directly ahead. Not down, but OUT. This newly devised system also gives him distance from the ground, from 1,000 to 80 feet (Category II), and incorporates a warning light to tell him when his decision altitude is reached.

Components of the system are: 1) a "Heads Up" instrument, 2) attitude gyro and pickoffs, 3) slaved directional gyro with pickoffs, 4) IVSI and pickoffs, and 5) a radio altimeter.

The face of the "Heads Up" instrument itself, as mounted on the glare shield, presents heading information (on the rim edge) with RMI of VOR or ADF indication. VOR/ILS is next, with roll information and ball below that to show skid. To the right of the transparent display is the decision altitude light, and to the left, the To-From indicator for the VOR.

During an ILS approach, for example, the pilot stays head-down to the middle marker. The IVSI will stay the same as long as he maintains the correct rate of descent. At the middle marker, the pilot goes heads-up, looking for the lights. He keeps the IVSI descent rate constant, the ILS centered, the wings level, the ball centered, and he checks the radio altimeter for his decision height. All of the info he needs, except glide path, is displayed on the "Heads Up" instrument on the glare shield. The glide path info is presented by the IVSI Repeater needle.

A VOR approach or a circling VFR approach is conducted in much the same manner. In fact, using the "Heads Up" system would seem to add safety inasmuch as while the pilot is getting the necessary information he also is able to look out for other traffic.

The first "Heads Up" system is installed in an FSF-member Helio Courier and in a Super-Courier which are based at New York's LaGuardia Airport for "Heads Up" demonstration purposes. Any business aircraft pilot interested in test-flying this system and who will make a written evaluation of it, both from the standpoint of utility and the extra "see" safety it is said to offer, is invited to contact FSF's Corporate Aircraft Operations Division for details.

In this case, as in all cases, FSF acts as impartial and objective liaison ... on the side of greater safety in aircraft operations.