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SUMMARY REPORT OF TRIP TO EUROPEAN ALL WEATHER LANDING FACILITIES
OCTOBER 18-29, 1971

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16. Abstract This report represents a summary of the information gathered during the joint FAA/Mitre/TSC visit to European Category II and Category III landing facilities over the period 18 October 1971 to 29 October 1971.

Part I presents overviews of the attitudes of France and England toward all-weather-landing and brief characterizations of current and projected equipment and procedures of major airlines and airports. Additionally, it includes information gathered at Schiphol Airport in Amsterdam which currently maintains ILS systems of both English and French manufacture.

Part II of the report presents comments we are able to make on the basis of the study and some preliminary recommendations.

Part III is an appendix which contains copies of the written material collected during the visit.

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FOREWORD

Efforts to develop the total capability to land aircraft under conditions of bad visibility have been ongoing for many years and have resulted in the gradual reduction of approach and landing minima. Attending this development has been an increase in the safety of not only the lower minima operations but also of operations carried out in good weather. The joint result of increased safety and enhanced capacity to operate on schedule regardless of visibility at origin or destination has been almost universally recognized as a major contribution to the establishment of the airplane as a viable mode of transportation and government and private industry have teamed together to promote further achievement.

To aid in the assurance that facilities designed and installed in different countries would meet the needs of the international community, the International Civil Aviation Organization (ICAO), in 1963, published a series of documents which set forth basic requirements vis a vis ILS beam tolerances, runway lighting and marking, control procedures, etc., for each of three categories of operation, as follows:

Category (Cat)	Height at which decision must be made to land or go-around (DH)	Runway Visual Range (RVR)
I	200 ft.	2600 ft.
II	100 ft.	1200 ft.
III A	0 ft.	700 ft.
B	0 ft.	150 ft.
C	0 ft.	0 ft.

With relatively few changes, the ICAO requirements have served as the blueprint for develpment of all-weather-landing capabilities. In the meantime, however, considerably more flying experience has accumulated under conditions of poor visibility, new technologies have been exploited in the design of ground and airborne systems, and airline management has had opportunity to sort out the economic factors associated with continuing development and operations at limits lower than currently applied.

The entrance of the U. S. into all-weather operations is expected by the end of November 1971 with the commissioning of Dulles International in Washington, D. C. as a Category III airport. It was in the interest of maximizing the benefits to be gained from this initial facility, and those planned for the near future, that attitudes and statements of experience were sought from operators in France and the U. K. who have amassed considerable data in selected areas of poor visibility operations.

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PART I

1.0 FRANCE

1.1.1 Brief History of French Operations

Operations in low visibility have been carried on for years by the French air mail carrier, Compagnie Postale, and many (probably largely apocryphal) stories exist concerning the exploits of crews in this service. As noted below, the early experience gained in landing under marginal conditions in situations in which little airport lighting or other direct guidance was provided and in which no airborne automatic guidance systems were available, has provided data of continuing value in the development of systems and procedures to support commercial operations.

The mainstay of French all-weather landing equipment since 1967 has been the Aerospatiale Caravelle equipped with the Aerospatiale/Lear-Siegler all-weather landing system. As of November 25, 1968, Caravelles with this system have been authorized to land at suitably equipped (mainly Cat II) airports with weather minimums of 50'(DH) and 150 meters (RVR). On January 9, 1969, during a regularly scheduled passenger flight from Lyons to Paris, a Caravelle flown by Air Inter made the world's first commercially recorded automatic landing in Category III conditions (70 ft. ceiling, 650 ft. RVR).

France continues an aggressive campaign to further its accomplishments. Up to January 1, 1970, Air Inter alone had accomplished some six thousand automatic landings within their SGAC authorization and an impressive program to support both military and commercial Category III interests has been developed at Bretigny Experimental Flight Test Center. A major concern of both government and the air lines now is with the economics of promoting further capability.

1.1.2 Current Official Position on Cat III

The French representatives made it perfectly clear that they hold the current goal of zero decision height in Category IIIA to be completely unrealistic. Their reasons for this position are at least two in number:

(1) The rather considerable experience of Compagnie Postale, the internal air mail operation, and more recently that of Air Inter suggests that at altitudes less than approximately 65 meters there is a ten to one linear relationship between RVR and the altitude at which an assessment of lateral position relative to the runway centerline can be made; that is to say, with an RVR reported to be 230 meters (approximately Cat IIIA limits) the pilot can be assured of a view of the ground from a height equal to 23 meters (approximately 70 feet).

(2) They are not prepared at this stage to land without visual reference or confirmation unless that reference is replaced by an integrated and independent airborne/ground system--a so-called Independent Landing Monitor (ILM); although efforts to generate such a system are underway, no suitable scheme yet exists.

As a substitute for the ICAO Cat IIIA minima, France has authorized Air Inter to operate with a decision height of 50 ft. and an RVR of 150 meters. Such limits seem to provide a comfortable tradeoff between the total set of economic factors and the fail passive systems of the Caravelle aircraft which represents the most significant type in the Air Inter operation. In addition, operations with these minima provide a favorable competitive position vis a vis the railroads in both passenger and freight transport (see discussion in Section 1.1.3.2.).

The French, then, clearly feel they have succeeded in providing a meaningful Cat IIIA capability, albeit one with a nationally unique definition. Policy standards for the conduct of operations within this capability have been published and airports satisfying the criterion that pilots must be able to make a visual assessment at 50 ft. are being equipped with the requisite lighting, marking, etc. (see section 1.1.4). Plans for development beyond this point are somewhat unclear. They feel it premature to speculate on the question of whether or not international flights conducted within the ICAO Category IIIA zero decision height, 700 ft. RVR context will be supported at French airports if the French normally operate at 50'/150m. Yet, Thomson CSF, manufacturer of the ILS systems, stated its current intention to design and build systems which support full zero decision height operations; Air France indicated its view that the current authorization is merely an extension of Category II and is not Category III; and Aerospatiale, builder of Concorde announced it plans to design to a 0/0 (standard Category IIIC) goal.

1.1.3 Airline Views

1.1.3.1 Air France

The Air France representative made the point that the ICAO classification is unrealistic. There are, he said, only two categories: one in which landings are made with visual reference, and one in which they are made without visual reference. These two different categories require entirely different solutions, and the current Air Inter authorization of 50'/150m represents little more than an extension of the see-to-land (Category I, II) concept. In addition, he argued that the operational requirements of the airlines and of the equipment they fly differ sufficiently so that it is almost impossible to generate a framework with more than these two general categories of operation.

At this time, Air France is not in full Category II operation and expects it to be a long time until they consider Category III seriously (in a non-visual, full autoland sense with fail operational equipment). The reason for this is a current lack of Category III airports on its route structure and of economic justification. As an international carrier, the airline estimates that it would take approximately 18 years to write off an investment in Category III equipment and training, an investment which the internal carrier, Air Inter, can write off in four years. An alternative which Air France considers more reasonable is to devote energy to the improvement of the "environmental infrastructure" sic - the nominal systems and procedures used to control all traffic regardless of weather conditions. Since this infrastructure is frequently the forgotten element in the total air safety picture, and since it represents a potential benefit to all airlines regardless of their individual operational plans, effort here may produce greater overall rewards.

Along these lines, the representative reported that Air France and the other five European International carriers with similar operational requirements are pressing for standardization of equipment and procedures and he noted that the decisions concerning Category II and Category III operations will be jointly arrived at by this group. In addition, he mentioned a growing interest among the airlines in a system which allows authorities in different countries to accept the certification of an aircraft by its manufacturer and country of origin, thus avoiding the multiple national certification procedures.

1.1.3.2 Air Inter (AI)

As a result of its lively competition with the railroad and the necessity for maintaining schedules in an articulated air-ground transport system, Air Inter has evolved to the point where it represents the most advanced of the French-operated passenger/cargo airlines, Flying Caravelles, and averaging approximately 100 landings per 16 hour day, Air Inter reports that in the period from January 1, 1971, to August 31, 1971, it attempted 5,585 landings and completed 5,284 (95%) in low visisbility and that in the Winter of 1970-71 it made 195 landings with RVR's of less than 400m, thus avoiding costly diversions. AI reports that prior to the 50'/150m authorization (January 1969) it suffered a drop in load factor during the Winter months which has been totally recouped on those portions of the route structure now supported by Cat III (50'/150m) landing facilities. It is estimated that the 50'/150m operation has not been an effective solution in only one out of every 1000 flights. Moreover, AI reports that on the basis of experience so far, the total investment in the 50'/150m activity(traning, equipment, etc.)will be recovered in four years.

There is little evidence that Air Inter plans at the moment to progress beyond its current operational limit of 50'/150m. It is currently authorized to these limits on five runways at four airports and it appears that the major interest is in stimulating the conversion of more Category I airports to ones which can support the current Air Inter authorization. At the most, the airline expects to add a head-up display to its Caravelle fleet to facilitate the pilot's reference in low visibility.

1.1.3.3 Union Air Transport (UTA)

UTA is an international civil carrier operating principally in Africa. Its DC-8 fleet is currently certified for Category I operations and the airline anticipates approval for Category II operations with DC-8's and Caravelles in the near future. Category IIIA capability with a fleet of DC-10's is expected in 1973.

1.1.3.4 Compagnie Postale

Owned by Air France, Compagnie Postale has for years constituted the proving ground for many of the bad weather landing techniques later assimilated by Air France and Air Inter, as well as a source of crews for the parent company. The airline carries no passengers and operates completely under manual control. It is currently authorized to land without minimums but reports self-imposed operating constraints of 50'/200m. Approximately 50% of the 120 flights per week are flown in 14 Fokker F-27's; the remaining are flown in 6 DC-4's. The major percentage (83%) of the airlines operations are in fog between midnight and 4 PM.

Compagnie Postale presents the following record of its low visibility landings from 1967 to 1969:

COMPLETED LANDINGS			TOTAL MISSED
YEAR	RVR = 200-400m	RVR <200	APPROACHES *
1967	44	66	19
1968	87	98	43
1969	55	111	17

* Total includes missed approaches due to factors other than malfunctions of airborne systems (e.g., ice on runway)

The Compagnie Postale representative reiterated the position of the government and of Air Inter relative to the shortcomings of the ICAO classification and added that the major difficulty is that visual cues necessary to make the land or go-around decision do not all become available at the same time. As a practical solution to this problem, Compagnie Postale has evolved a "successive decision height philosophy which requires that at each of three altitudes on the approach, a minimum set of specific visual cues must be available. These are summarized in the Table below:

AT HEIGHT	PILOT MUST SEE
150 ft.	APPROACH LIGHT HALO
100 ft.	APPROACH LIGHT HALO <u>AND</u> AT LEAST ONE APPROACH LIGHT
50 ft.	BOTH OF THE ABOVE <u>AND</u> IDENTIFY THE GREEN THRESHOLD LIGHTS

In the event that the required cue (or collection of cues) is not available at the required height, an overshoot is initiated and the approach sequence is restarted.

Because the needs of Compagnie Postale are different from the needs of other operators and since safety considerations do not figure quite as prominently as for those lines carrying passengers, there is considerable room for experimentation and for adoption of "whatever works". This would seem to be reflected in the effectively open authorization under which the line has operated for over 20 years. It is unlikely, then, that Compagnie Postale would conform to a normal Cat III implementation schedule or that it would lend more than moral support to carriers pressing for Category III certification.

1.1.4 Airport Equipment and Procedures

At present, there are four airports in France which meet the full set of ICAO Annex 10 requirements for Category II operation: Orly (2 runways), Toulouse, Bordeaux and Lyon. Each of these is equipped with Thomson CSF ILS equipment (with electronic modulators) which exhibits Category III beam quality. Each meets the requirements on obstacle clearance, lighting and air traffic control for RVR's less than 400m but only the runway at Toulouse and one of the two runways at Orly have far field monitors (installed at the middle marker). None of these monitors serves in an executive capacity at the moment. By the end of 1974, the following airports are expected to have full Category III capability: Orly, Toulouse, Bordeaux, Lille, Strasbourg, Roissy. All of these will have completely solid-state Thomson CSF ILS's.

Transmissometers are installed at the threshold, middle and rollout end of the runway at Orly. Each operates on a 50 m baseline, is located 120 m from the runway centerline and is 2.5 m above it. The RVR information reported to the pilot represents the averages of 50 sec. samples taken at each of the locations, corrected for the efficiency of the eye in the standard fashion. An aircraft on approach requires a minimum of 150 m RVR on the threshold and mid-runway locations to continue. Although reported, the rollout RVR is not considered in the decision to land.

Approach lights are of the standard barrette variety, with 30 m separation and 20,000 candlepower. Runway centerline lights are distributed approximately as follows (from threshold): 1/3 yellow, 1/3 yellow and red, 1/3 red. Centerline lights are on 7.5 m centers and of 1,250 maximum candlepower, adjustable in four steps. (A strong favorable opinion was expressed concerning the desirability of this spacing.)

There are two high-speed taxiways at Orly with the required taxiway lighting and plans to equip the other airports identified for development of Category III capability (see above Although some difficulties have been encountered in taxiing with RVR's of 150 m. the French do not expect too much difficulty with ground traffic control. This seems to be due partly to their expectations that landing rates will be significantly reduced during bad weather and partly to their expectations concerning the utility of the excellent Decca ASME radar equipment on hand. This system, operating from a 700 rpm antenna and including a Thomson CSF scan conversion unit, yields an extremely high resolution picture which should aid considerably the detection and control of ground traffic.

The French require all aircraft making Category II and Category III landings to report passing through 400 feet on final approach and to report again when turning off the runway or making a missed approach. If voice contact is lost for two minutes after the report at 400 feet, crash rescue vehicles are dispatched to clear the runway. It was indicated that in the event of failure of the ASME equipment, the required level of control could be maintained with this procedure.

1.1.5 Research and Development Efforts

If the interest of the French in continuing operations within a see-to-land context for some time to come is not already apparent from the individual views of the government and the airline industry, it becomes apparent when one examines their R&D efforts. Most activities seem to be aimed at enhancing the pilot's view of the runway or, at a minimum, providing him with the capacity to control the aircraft manually when his view of the ground is temporarily obstructed.

Of major interest to both operating and R&D personnel is the head-up-display (HUD) concept. Two major advantages of this device are seen: (1) the improved ability to check on the validity of the normal visual references, and (2) the opportunity to optimize (manual) control in conditions where only very few visual cues have been obtained. Benefits to the airlines are considered to be: (1) improved approaches on airfields not otherwise equipped for low-visibility operations, (2) HUD's utility as a replacement for visual approach slope indicators (VASI's - see below), and (3) its utility as a guidance alternative in the event of loss of a fail passive airborne system.

Opportunity was afforded for some members of the American team to fly approaches with a prototype HUD at the Experimental Flight Test Center at Bretigny. This system, installed in a NORD 262, utilizes trajectory and angle of attack instead of the air speed and attitude indications used in more classic HUD's. Landings accomplished by our pilots were satisfactory under both visual and non-visual conditions and comments about the HUD were favorable. Two things deserve mention, however: (1) no crosswinds existed during the landings, so the tolerances of the HUD-pilot loop weren't really explored; (2) a major value of the system is its high sensitivity to differences between actual and required performance; one wonders what performance might be achieved with an orthodox head-down flight director with the same relative degree of sensitivity.

As noted earlier, Air Inter intends to install a HUD of this or another variety in its Caravelles and Air France has been experimenting with the concept in one of their Caravelles and a B707. Some difficulties were encountered in positioning of the HUD in the B707, but the overall performance of the system was considered very satisfactory. Air France reports that the flight path information derived from the angle of attack was very useful and stable and that airspeed was much easier to control with this display than with a standard airspeed indicator. Moreover, the approach path without ILS guidance was found to be very close to the theoretical ILS flight path. However, the major concern, again, is with economic justification of such equipment for an airline which makes, on the average, one landing per hour.

One more note on HUD: The Mercure (Marcel Dassault Cie) which is designed around a fail passive autopilot configuration, is the first French aircraft to employ an integrated head-up display as a standard feature. In this case, however, the system is not to be considered a normal piloting system. It is, rather, an emergency back-up in the event of an autopilot failure below 50 feet.

In addition to HUD activities, the French Meteorological Institute expects to conduct studies on the relationship between the brightness afforded by different centerline light spacings and transmissometer readings. In these studies the center-line lights themselves will serve as the source for the transmissometer system.

Efforts to define and develop an independent landing monitor (ILM) continue. The guiding concepts are that an ILM should operate from the time that ILS information is available (e.g., from a distance of six nautical miles in a 16mm/hour rain) and that the information conveyed should be as good as that conveyed by the ILS. Currently, the French are experimenting with a radar system with three parabolic reflectors. These are located on the left side of the approach end of the runway, the right side opposite the middle of the runway and on the projected centerline at the rollout end, respectively, yielding three angles for computation of position. A 200 MHz modulator in the focal point of each reflector enables rejection of all off-axis (noise) reflections. Experiments are now underway to determine optimal scanning rates and thought is being given to how the computed information might be turned into a visual display.

A study is being carried out to determine optimal airport layout given the known deficiencies in the ILS system. Thomson CSF is generating a computer model for examining the nature of the disturbances on the localizer of taxiing aircraft, obstructions and overflights.

Neither Air Inter nor Air France has flight simulators with Category III visual simulation capability, though both utilize classical (e.g., Redifon-type) simulators for training. In flight Air Inter uses rough plexiglass screens which can be lowered gradually to simulate a visual segment from infinity to 100m, though they acknowledge a limitation in fidelity as a function of placement of the pilot's head. Air France uses polarized plexiglass screens which, it claims, gives valid results independent of head position. These airlines do not anticipate much further development of simulation capabilites, however. Air France questions the total cost/effectiveness of such a development given its schedule for implementation of Category III capability, while Air Inter shows a preference for training under actual conditions. In addition, neither airline certifies its pilots on the basis of simulated operations and neither intends to at the moment.

The development of VASI has essentially been discontinued. Where such installations are desirable (e.g., airports serving small aircraft), the French plan to use the ICAO design for the unit. Their preference, instead, is for a head-up-display.

Efforts at experimental evaluation of a ground-based doppler radar system for monitoring of traffic on the approach end of the runway were also reported. There is some feeling that such a system may have additional potential as an independent landing monitor.

1.2 Specific Equipment and Procedural Details of Interest

1.2.1 Air Inter

1.2.1.1 Crew Qualifications: The system by which individual crew members are qualified for 50'/150 m limits has been in existence for one year and during the year, 96.7% of Air Inter Caravelle captains gained certification at those limits. The system is as follows: The pilot makes 30 approaches with a decision height of 150' and 400 m RVR; after one check ride, he then makes 30 approaches at 100' and 300 m RVR. Finally, after observing one actual landing with RVR less than 300 m and one takeoff and one landing entirely with the command bar on the flight director (considered as an emergency back-up), full qualification is granted. Qualification of the co-pilot is similar insofar as his and the captain's tasks are similar.

1.2.1.2 Airborne Equipment and Procedure

Air Inter Caravelles are equipped with a fail passive autopilot configuration without automatic disconnect below 800 feet. Airborne malfunctions are annunciated below this altitude by the flashing of a red light on the glare shield. Malfunctions on the ground are communicated via standard Air Traffic Control procedures.

All approaches are conducted coupled and there is said to be no circumstance in which the pilot would normally use the flight director to 50'. (Air Inter indicates they would continue below 50' with a HUD-equipped Caravelle but, in any case, they are not authorized to conduct uncoupled approaches below 400m RVR). The flight director is considered strictly as a standby system used to make a Category II approach if the autopilot is not available. It is not used to check the autopilot; instead, this is accomplished with the artificial horizon, radio altimeter and raw ILS deviation information. Flare is automatically initiated at 50 feet after pilot has visually checked lateral position and track relative to the runway. There is an autoflare monitor which initiates an auditory alarm which sounds if pitch attitude is not correct following flare initiation or if the flare maneuver lasts too long.

1.2.2 Airports

Far field monitors (FFM) are currently installed at the middle marker location at Orly and Toulouse; they are currently being used to gather data on ILS performance and to develop a procedure for operational use. At Orly (and perhaps also at Toulouse) the facility may be downgraded from Category

III to Category II in the presence of FFM alarm. The alarm condition is exhibited on a panel in ATC and the ground maintenance shop, where the nature of the difficulty is ascertained and the decision made to continue operation at Category III or to downgrade the facility to Category II. In the event that the decision is made to downgrade the facility from Category III to Category II, the pilot is informed via Air Traffic Control.

The ILS monitor system itself is checked by the controller before each approach. Such check occurs following the depression of a "test" button on the controller's console and lasts for a period of 2-3 seconds. During this period, the station is unmonitored, but guidance signals are not affected. The test is said to be fairly complete, including, in additon to normal function, the monitor logic.

Experience to date indicates that the FFM is much more easily upset by interference than is the signal to the aircraft on the approach. Thus the potential utility of the FFM as an executive monitor is still in doubt.

To check on the axis of the localizer, an instrumented car is driven down the runway periodically, and statistical techniques are used for examining beam structure. A Collins 51RV1A LOC/GS/VOR receiver is currently included in the set of equipment used for inspection and a theodolite is used to check the glide slope.

A procedure is currently being worked out for active monitoring of approach and center line lighting. Power is supplied commercially, and, in the event of power failure, there is a 200 millisecond delay in switchover to emergency power. When commercial power is again available, it is placed on a standby status until weather minima have lifted.

2.0 UNITED KINGDOM

NOTE

A rather considerable effort was made by the U. K. to prepare formal answers to a list of questions circulated by the U. S. prior to the visit of its representatives. Because they provide information in more detail than has been attempted in the summary and may be of value to those involved in administrative/technical aspects of Category III, the questions and written replies are presented in an addendum to Part I.

2.1.1 Brief History of U. K. Operations

On June 10, 1965, at Heathrow Airport, a British European Airways (BEA) Trident 1 made the first fully automatic landing in scheduled airline passenger service. This accomplishment represented the first commercial exploitation of the pioneering work in low visibility operations begun by the Blind Landing Experiment Unit (BLEU) in 1945, and placed BEA in a position of prominence among air carriers whose route structures frequently necessitated operations in poor weather. Since then, BEA Trident crews have amassed considerable experience in flying in low visibility and in devising systems and procedures to maintain their competitive position. All BEA Trident 1's have now been modified for autoland and Trident 2E's are delivered with triplex autoland systems. Trident 1's were certified by the Air Registration Board for Category II operations in Setpember of 1968. Trident 2's were certified thusly in February of 1969. Category III operations (with a decision height of 12 ft.) will be commenced with the Trident 3B following Air Registration Board (ARB) certification (expected) in January of 1972.

With experience accumulated over the course of some 25,000 automatic landings, BLEU has continued to aid in both the definition of operational goals and in the generation of philosophy for systems designs. Its position vis a vis the requirements for fail-survival automatic systems is well-known and resulted in the early implementation of triplex and duplicated monitored systems in the Trident and VC-10, respectively. And, the unit has contributed significantly to the overall task of apportioning risk among the total set of elements involved in the landing system by undertaking a study of the performance and reliability required in different subsystems. One of the first outputs of this effort was a proposal for new ILS specifications which was subsequently adopted by ICAO. Major effort is now devoted to the development of better airport lighting and marking systems and to the further refinement of piloting techniques.

2.1.2 Current Official Position on Cat III

Like France, the U. K. acknowledges a growing disenchantment with the ICAO scheme of fixed decision heights for all aircraft. It argues that at the current stage of ILS development, it is necessary for the pilot to be able to make a judgment of lateral position over the runway in order for a land or go-around decision to be made in Category IIIA visibility. And, given the variety of eye-height and cockpit cutoff angles, as well as the differing height-loss characteristics, represented in the current generation of aircraft (including Caravelle, Trident, VC-10, DC-10, L1011 and B747), it is impossible to establish a single value of universal suitability. Moreover, even for Cat IIIB operations it may be necessary to certify certain types of aircraft at non-zero decision heights.

It is U. K.'s attitude that a total systems concept is required in the development of a safe and reliable Cat III capability. And, it is necessary that questions of aircraft and avionic systems certification, ILS integrity, operating and maintenance procedures, runway lighting and marking techniques, critical and sensitive area security and ATC procedures for insuring appropriate separation be addressed immediately and simultaneously if the safety and reliability criteria are to be met. The classical tendency to devote major effort to solution of airborne problems and to neglect those on the ground cannot be tolerated in a Category III program. Also, considerable effort must be made to standardize the systems developed to insure compatibility between airports.

In anticipation of British European Airways' (BEA) upcoming (early 72) Cat IIIA certification, DTI, from whom final approval must come, has officially promulgated the ILS at Heathrow as a Category III facility and has written obstacle clearance requirements. In addition, DTI is currently generating ATC regulations for runway 28L and anticipates their completion by the time the certification process is begun. No development programs other than those currently undertaken for Heathrow have been started but the position is taken that once the systems, procedures, and certification processes have been generated, the physical upgrading of a good Cat II facility to Cat IIIA will not be particularly difficult.

The opinion that it will be extremely difficult to depart from a see-and-be-seen concept in ATC was expressed. It was clear, however, that the expected cost of systems to support non-visual operations, rather than the technical problems of generating required systems, was at the root of the skepticism. It was felt that only if the need for extra air terminals was lessened would such a change in concept be justified.

The U. K. seems thoroughly committed to the notion that VHF/ILS, operating in conjunction with suitable traffic control procedures, is capable of supporting routine Cat IIIA operations and that operations might even be generalized to Cat IIIB without the necessity of developing an ILM. Moreover, they are of the opinion that there will be at least one more generation of VHF equipment before a viable alternative is found. They seem not to be convinced of the value of microwave ILS as an alternative, particularly at those airports where both that equipment and VHF must be co-located.

2.1.3 Airline Views

2.1.3.1 British European Airways (BEA)

In many ways, BEA resembles the French internal airline Air Inter. Over a significant portion of its route structure, it competes directly with a viable rail system. Its crews have considerable experience in poor visibility conditions and have evolved special procedures for takeoffs, approaches and landings under these conditions. And it operates an aircraft type which handles quite favorably over a wide variety of flying conditions. It is not surprising, then, that BEA's Category III development program is approximately at the same stage as that of the French carrier and that the goals of both airlines are at least superficially similar.

The BEA Trident Two aircraft is currently certified to conduct operations in Category II, and in addition to authorization at airports within its domestic route structure, such operations are authorized at Cologne, Dusseldorf, Hanover, Munich, Paris (Le Bourget) and Geneva. It is anticipated that by early 1972 (perhaps January), Trident Three operation with an RVR of 300 meters and a decision height of 12 feet will be authorized and the airlines' entry into Category III operations will have commenced.

Preparation for the upcoming certification has been extensive and apparently much was learned which was incorporated into the Trident Three system. BEA reports that approximately 15,000 autoflares and autolands were undertaken to evolve suitable systems and procedures. Perhaps the most significant of these is the change in allocation of crew duties on the flight deck which followed the observation during simulations that there was a slight time lag between arrival at (the 12 ft.) decision height and the pilot's statement, "I have command".

Whereas earlier Trident autopilots were duplex in pitch, roll and yaw with autoflare and simplex rollout guidance, the Trident Three will enter certification trials in a triplex configuration. It will not have automatic rollout guidance but will have a barber pole type para-visual display (PVD) to assist manual steering. There are no plans to implement any sort of ILM or HUD (other than the PVD). This is consistent with BEA's philosophy, and in fact with that of everyone who discussed the topic: The automatic systems must be reliable enough to land the aircraft and eventually to roll it out without the need for visual support.

It should be noted that the 12 foot decision height to be used during early Category III operations represents a strategy of initial conservatism which will be discarded as more experience is gained with the effects of interference on ILS guidance. BEA is of the opinion that the pilot should not have to assess lateral position and is reasonably confident that it won't be necessary in most circumstances but obviously prefers to play it safe for the moment.

Since the 1972 Cat III certification will be the first in U. K.'s experience, a very high degree of joint problem solving and general cooperation appears to exist between DTI, ARB, BEA, and Hawker Siddeley the manufacturers of the Trident. One has the impression that all parties participate directly in the drafting of requirements, laying out of test procedures and study of results. ARB has required the manufacturer to demonstrate the adequacy of its systems in actual fog landings at Heathrow. In addition, it has required BEA to demonstrate the adequacy of its procedures and performance of all equipment during a battery of 500 landings under intended operating conditions. During both of these series of demonstrations, airport management and government officials as well as the operator and manufacturer have had a unique opportunity to define their particular problems and to observe those of others. What has been learned so far seems to be reflected in the confidence which the parties exhibit toward the upcoming trials.

2.1.3.2 British Overseas Airways Corp. (BOAC)

BOAC is currently authorized to conduct full autoland Cat I operations in its triplex configured B747's. It anticipates that by Spring of 1972, this authorization will be extended to Cat II. Plans beyond that are somewhat unclear, but representatives did indicate that their long term goal is a 50 ft. decision height. The date on which ARB may authorize use of the 747 triplex autoland system for Category IIIA operations depends, to some extent, on when sufficient data concerning performance and reliability of the system are available.

2.1.4 Airport Equipment and Procedures

At present, Heathrow airport maintains the only operational installation of the STAN 37/38 localizer/glideslope system commissioned for Category III service in the U. K. The antenna supporting this equipment has recently been converted from a 12 dipole to a 24 depole array similar to that now employed at Dulles. It was reported that the new array was put into regular service with relatively little need for testing and evaluation (except for some nominal characterization via flight test). No formal studies of side lobes within the critical and sensitive areas has been conducted.

In the last year, Heathrow took delivery of the new Marconi Radar Systems, Ltd., instrumented visual range (IVR-1) system. This system consists of a transmit-receive sensor unit and reflector unit, background luminance monitor, data link terminal (for transmission between field site and CPU), PDP-8 central processing unit, ASR-33 TTY I/O terminal with paper punch and digital display showing the identification of the runway in question and the calculated RVR at threshold, mid-runway and stop end positions. Additionally, a Remote Control, Indication and Recording Unit (RICR) is provided for the use of the maintenance engineers. The latter unit incorporates a three-channel pen recorder providing a continuous record of values obtained at the transmissometer sites and an alarm annunciator array which presents outputs of fourteen fault detection devices within the system. The three transmissometer units are each installed on a 10 meter baseline (20 meter path length) at a height of 5 ft. 6 in. and are offset 120 meters from runway centerline. The system is said to be highly accurate, but, like other transmissometer systems, it can only be calibrated under good weather conditions.

The airport has also recently installed a Decca ASME radar system with a bright display. The system is somewhat similar to the one observed at Orly. It has a 750 rpm antenna with 15 kHz prf and 30 ns pulse length, and signals are fed to a high resolution PPI display and then to a TV display via a vidicon camera channel. The displayed picture is approximately equal in quality to that of the Thomson unit and provides similar scale control.

The ICAO obstacle-free zone requirements are currently met at Heathrow. Representatives report some doubt about the appropriateness of current frangibility standards; they are giving thought to how these might be improved.

The main supply to airport lighting systems is commercial. An eight second lag occurs during switchover to emergency generators. Outputs of centerline and threshold lights are measured every two weeks with a lightmeter. Lights are cleaned once a week and twice a day the entire operating area of the airport is inspected. (An excellent summary of the lighting at Heathrow was prepared by BAA and is reprinted in its entirety in Section 2.2.2)

2.1.5 Research and Development Efforts

Six specific research and development efforts were highlighted by U. K. representative. They are:

(1) Further development of the Trident autoland system to endow it with Cat IIIB capability. This work is practically complete and the goal now is to obtain Air Registration Board approval.

(2) Development of a ground roll guidance system. This is likely to be some variety of cockpit coaming integrated display, but designers report the requirement for industry input concerning allowable deviations in coaming design. As indicated earlier, there is only minimal interest in HUD's. Some modelling and simulation is reported in connection with a wheel contact measuring device to display rollout distance remaining.

(3) Development of a low visibility guidance system for airport emergency vehicles. Currently at Heathrow, there is a fleet of emergency vehicles which can be directed by ATC through the use of ASME. This procedure is utilized in weather down to Cat IIIA and has a response time of three minutes. Three needs were stressed here:

(a) vehicle navigation systems which are self-contained and permit movement in Cat III A, B, C weather.

(b) vehicle-borne (radar) obstruction warning devices

(c) airborne beacon systems.

(4) Development of an environmental (radio noise) monitor. Although ILS interference is not seen to be a limiting factor for Cat IIIA operations, the U. K. has not made up its mind on the significance of this problem for Cat IIIB. The noise spectrum at Heathrow is currently monitored with an omnidirectional antenna system which continually samples the environment, regardless of overt activity level and provides a "signature" for research purposes. In addition, separate van-mounted monitors, one for LOC and one for G/P, are installed. Triggered at the middle marker during an approach, these monitors receive, filter and recode the reflections of the aircraft in order that the degree of interference on flight path can be determined.

(5) Evolution of a ground movement control (GMC) system. The U. K. considers it unlikely that a non-visual GMC system supporting Cat IIIB and Cat IIIC operations will be developed in the near future. It anticipates, rather, that it will be necessary to utilize strictly visual procedures down to 100 meters, with the pilot taking major responsibility for collision avoidance. Such a procedure with the additional aid

provided by ASME, some equivalent to the French doppler system for protecting critical and sensitive areas, and further exploitation of the ground movement and runway/taxiway lighting controllers currently in the Heathrow tower is expected to be sufficient so long as traffic density is maintained at a relatively low level.

(6) Further development of high intensity taxiway lighting. Experience to date has indicated that in low RVR conditions, the lighting provided on the taxiways at Heathrow was difficult to follow. As a sunstitute, high intensity lights of 250 candelas have been developed and are under test.

In addition to these formally identified R&D efforts, U. K. reported that it is currently doing research in training procedures for flying in turbulence and low visibility and in frequency management. Additionally, it continues to investigate methods of providing better runway centerline and edge lighting and marking. On the last point, it was noted by BLEU that there are at least two deficiencies with the current generation of lights: (1) they are optimized for long range visibility but not for short range, (2) they are difficult to clean. As far as runway markings are concerned, there remains a need for materials which are not dirtied by tire marks.

2.2 Specific Equipment and Procedural Details of Interest

2.2.1 BEA

2.2.1.1 Trident III Operations

Following the recognition of a potential problem with pilot initiatives after arrival at the decision height (see Section 2.1.3.1), BEA revised its cockpit procedures and now utilizes a system which may be relatively unique among commercial airlines. The new procedures calls for the pilot (P_1) to remain head-up below 1000 ft. and to monitor (particularly lateral) performance of the aircraft with respect to the visual scene while the co-pilot (P_2) actually handles the controls. At a height of 30 feet above the decision height, P_2 warns P_1 of the impending arrival at DH. P_1 responds with "land" or "overshoot". The third pilot (P_3) monitors the systems panel and calls out altitudes on the approach. Except for P_1's command and P_3's altitude reports, there is no talking on the flight deck under 1000 ft.[1] On landing, P_3 sets a meter (connected to the main gear) to correspond to the known length of the runway and then calls out distance to go when the speed of the aircraft is equal to one-tenth of the remaining rollout distance.

BEA reports that the removal of classical control initiatives from P_1 entailed in the new procedure has caused no difficulty. A new manual has been written describing these procedures, which provides guidance for the "land"/"overshoot" decision on the basis of the number of lights which must be seen.

An approach is not started if RVR is less than authorized minima or any portion of the system is not fully operational and the approach is aborted if, during its course, RVR falls below minimums. The following table indicates the ground rules for automatic versus manual approaches and landings:

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[1] In this connection, the British expressed a dislike for the French requirement for a 400 ft. report on final approach. Their feeling is that such a procedure might be distracting.

CONDITION	APPROACH	LAND
3 miles out and visibility less than 1000 ft.	AUTO	AUTO
RVR = 500 meters	AUTO	AUTO or MANUAL
RVR = 400 meters	AUTO	AUTO

(BEA cannot autoland at Le Bourget or Geneva due to unfavorable approach terrain at these locations)

During all approaches, throttles one and three are set at idle and throttle two is set so as to maintain 11,000 rpm, thus allowing for smooth go-around.

The U. S. representatives had an opportunity to observe simulations of the following in the Trident IIIB simulator:

"1. Take-off RVR 300m Fog patches with reversion to AZ PVD head up director
2000' AZ deviation aircraft closes centre line
Full stop Cat. 3B landing with use of auto-rudder and ground roll monitor.

"2. Take-off RVR 300m Fog patches with reversion to PVD.
Cat. 3 approach P2 overshoot at 12'.

"3. RVR 400m. Cat. 3 approach roll channel fail. Auto-land 100'

"4. Take-off. Fog patches reversion to PVD
Cat. 3 approach - RED MANLAND
100 ft. loss of visual overshoot

"5. Cat. 3 approach overshoot with engine failure at 12 feet."

2.2.2 Airport Lighting

HEATHROW AIRPORT - LONDON (Text provided by U. K.)

RUNWAY 28L - APPROACH LIGHTING AND RUNWAY LIGHTING

1. Approach Lighting

1.1 The approach lighting consists basically of a centreline and 5 cross-bar system of High Intensity lighting space at 100 feet intervals to a total distance of approximately 3000 feet from the runway threshold. The inner 900 feet (300m) of the system is supplemented by red side-row barettes and white centreline barrettes at 100 ft intervals from the threshold.

1.2 LA/11 light fittings are used with 200 W lamps, brilliance of which can be controlled in 5 stages, namely 100%, 30%, 10%, 5% and 1%. (Provision in the circuits has been made for future use of 300W lamps, if required).

1.3 The fittings over the first 1200 ft from the threshold are ground-mounted; from 1400 ft to 1600 ft the fittings are mounted on light-weight frangible tripod masts. The 2000 ft cross-bar is mounted on a steel gantry and the remainder of the fittings are on wooden or concrete poles.

2. Threshold Lighting

2.1 This is a High Intensity bar made up of 16 type LR 22-5D 'flush' mounted fittings, which actually protrude 1-1/4 - 1-1/2 ins. above the level of the concrete surface.

2.2 These fittings are equipped with 100 W 12V 8.33a lamps.

2.3 A Green Filter is fitted for the lamp facing into the approach and a red filter for the lens facing into the runway.

2.4 Extending on each side of the HI bar there is a wing threshold bar consisting of 4 LR/16 elevated fitting (i.e. 4 lamp fittings each side) with green filters.

2.5 These LR 16 fittings have 100 W 240V/12V lamps.

3. Runway Centreline Lighting

3.1 The centreline lighting consists of LB/33 fittings at 100 ft spacing.

3.2 Type LB/33 fitting is inset into the surface and protrude approximately 3/4 in. It is a bi-directional fitting insofar as it is equipped with two separately circuited lamps.

3.3 The LB/33 lamps are Typed EL/63 (200W) but under-run to give 175 W at 12V.

3.4 The last 900 metres (3000 ft) of the centreline is colour coded to give a distance to go information, i.e. from 3000 ft (910M) to 1000 ft (300 M) from the runway and lamps are alternately white and red; and the last 1000 ft (300M) the fittings are red.

3.5 There are four centre line lighting ciruits two of each being taken from sub-stations No 6 and No 9. These are arranged to provide inter-leaving circuitry. Normally only the lamps facing into the direction in use are energised, but it is possible to energise all four circuits so that the light facing the opposite direction can be lit for back tracking.

3.6 Five stages of brilliancy - 100%, 30%, 10%, 5%, and 1% are provided.

4. Touch-Down Zone Lighting

4.1 White touch-down zone lights extend 3000 ft (910M) from the runway threshold. These consist of 12 pairs of barettes of 4 fittings each, the lateral separation of the barettes being 75 ft (22.5m) and the longitudinal spacing being 250 ft. (68m).

4.2 The fittings are LB 32 inset fittings are uni-directional and contain a type EL/63 lamp which is under-run to give 175W at 12V.

4.3 Five stages (100%, 30%, 10%, 5% and 1%) of brilliancy control are provided.

5. Runway Edge Lighting

5.1 A double line of Type C11 bi-directional fittings is equally disposed about the centreline at a distance of 75 ft from it, giving a 150 ft (46M) guage runway. It has an omni-directional element, too.

5.2 The C.11 fittings are spaced at 80 ft intervals longitudinally, except where at certain positions they are replaced by RVR reference lights on the south side. The dome of this fitting protrudes about 2 in. above the surface.

5.3 The lamp in the C.11 fittings is a 36W 6V one, which has 3 stages - 100%, 30%, and 10% - brilliancy control.

6. Runway End Lighting

6.1 This consists of two barettes of 5 LR/22/55 fittings each space 37-1/2 ft from the centreline. They are equipped with 100W lamps and red filters.

6.2 The runway end lights are ciruited with the edge lighting.

7. Visual Approach Slope Indicators (VASI)

7.1 A 12 unit - 2 bar system is provided, and this will later become a 3-bar system for use by long bodied (747, Concorde) aircraft.

7.2 The units are of Research Engineers manufacture, provided with 200W 12V 16.6 amp lamps.

7.3 The downwind bar is 244 M (800 ft) and the upwind bar is 472M (1550 ft) from the runway threshold.

7.4 5 Stage - 100%, 80%, 30%, 10%, and 1% brilliancy control is provided.

8. Snow Lighting

8.1 A permanent system of snow lighting is installed along the edge of the concrete on both sides of the runway. This consists of GEC Type ZA 408 ground mounted frangible glass-fibre sodium fittings.

8.2 These sodium lights are circuited on two circuits independently from Sub-station no 6 and Sub-station no 9.

9. Fast Turn-Off Lighting

9.1 Fast Turn-off lighting is provided in Clock 81 to the north and Block 79 to the south.

9.2 The Fast-Turn off centrelines are made up of LB/44 uni-directional fittings which are equipped with green filters and 100W lamps.

HEATHROW AIRPORT - LONDON

GROUND MOVEMENT LIGHTING CONTROL SYSTEM

1. Introduction

The taxiway lighting system for ground movement control comprises approximately 1200 separately controlled lighting circuits for green centreline lighting, red traffic bars and daylight route board lamps. The remote control of these circuits gives the necessary operational flexibility and safeguards. The basic principles on which the system operates are described below as briefly as possible in general terms and without reference to the numerous detailed circuit functions.

2. Description of System

The control system comprises the following major items:-

(a) Controls in the Visual Control Room.

(b) Remote control system:-

    (i) Unit control A Centre in Tower Apparatus Room.
    (ii) Unit control B Centre at various points on the airfield.
    (iii) Direct wire controls between Tower Apparatus Room and B Centres.

(c) Route control apparatus in B Centres.

(d) Network of lighting control circuits to light fittings in the field. (The daylight route boards are now obsolete).

3. Manual controls in the Visual Control Room comprise mainly the route control selector switches, the various auxiliary controls to series circuits and also keys on the Air Traffic Controller's desk for over-riding control of selected runways. The remote control system operates on a system of digital codes and requires relatively few cable cores between the A Centre apparatus in the Tower and the numerous B Centres dispersed over the airfield. Route control apparatus situated at each of the B Centres receives the decoded route information from the unit control B Centre equipment

and translates this information into switching operations for the control of a variety of circuits in the field required for a particular taxiway route. The control of these services in the field is carried out over the network of control cables which radiate from each B Centre.

4. Principles of Operations

The switching of taxiway route lighting across the airfield is carried out on the block principle. The arrangement of blocks is such that ahe taxiways are divided up into a series of junctions and certain straight sections. All blocks are separated by red traffic bars and are equipped with green centreline route lighting which in junction is laid out in a variety of sections which, when suitably energized, is capable of indicating any possible route. The lighting fittings used for the traffic bars and centreline lighting give an approximately omni-directional output of light in azimuth and so are non-directional in character. Taxiway routes which are lit thus, serve for either direction of traffic flow. Selective control of the taxiway lighting circuits and suppression of traffic bars across any routes lit is an entirely automatic function carried out by the route control apparatus. Routes through a series of taxiway junctions are lit by introducing into the route control apparatus a selected pair of control signals per junction corresponding to the junction inlet and outlet between which the route is required to pass. These signals are derived from and selected by the appropriate pair of junction control switches on the control desk. There will clearly be a pair of characteristic signals for each route through a junction corresponding to the available positions of the two route selector switches. Taxiway lighting along straight sections is also switched automatically by the route control apparatus on the principle that whenever the directional sense of the signals used to switch a route in an adjoining junction is towards the straight section, the taxiway lighting in this section will be lit and the intervening traffic bar put out. Taxiway junctions on runways are under similar lighting control arrangements to those just described for non-runway junctions but additional factors must also govern the routes selected. Thus, the operational priority given to a runway for flying use by operation of the appropriate traffic bar selection (runway selector) on the A.T.C. control desk causes the route relay equipment to assume a more selective condition of route control. When the equipment is switched to this more selective condition, any route across or on to the particular runway is cancelled and the runway entrance traffic bars switched to red. Traffic bars along the runway are all suppressed. The only route which it is then possible to switch on is the one which turns off the runway. Any taxiway lighting cancelled in the manner just described remains stored in the system at B Centre level and is available for the reinstatement of routes immediately the runway is released from flying requirements by the use of the over-riding control keys on the Air Traffic Controller's desk. The over-riding control keys are connected into the direct wire system of runway control which governs the more selective operation of the route control apparatus in 'B' Centres described in the previous paragraph. The over-riding facility may, therefore, be brought into, or out of operation very quickly for any particular runway so as to allow for the maximum utilisation of the runway for flying and ground traffic requirements. Two over-riding control keys are provided for each runway. One key provides for the facilities just described whilst the second key provides for the release of the taxiway lighting interlocks at take-off junctions. When this second control is operated a taxiway route may be switched from the run-up area onto the runway and junction for the purpose of admitting aircraft for take-off purposes. Whilst the runway remains switched to the selected condition, no other "in" route may be switched at take-off junctions.

5. Summary

From the foregoing description it will be clear that there are certain essential in-built characteristics of the control system, the most important of which, are summarised as follows:-

(a) The lighting of taxiway routes through junctions and the extinction of traffic bars across such routes is carried out by a system of two specific codes for each available route through a junction. Individual lighting services in the field depend for their control on in-built logical processes within the system and cannot be directly controlled from a particular key on the desk. One small exception to this statement exists, however, in that certain blue edge lighting is provided with separate control on the desk.

(b) The direction sense of a route switched as determined by the relative positioning of the pair of junction control switches on the desk is available at B Centres but is used only for the control of:-

(i) taxiway routes at runway junctions;

(ii) control of straight section lighting.

ADDENDUM TO PART I:

Formal replies of the U.K. to written questions submitted by U.S. representatives.

Q. What are the results, if any, of wide aperture antenna deterioration, near-field/far-field monitor correlation tests and/or results of the STC computer study to look into this area.

A. The 24-element (165') array in operational service at Heathrow has antenna feeder lines which are terminated directly, by soldered joints, onto the balun at the rear of each dipole. For this reason it has been difficult, without seriously interrupting the operational service provided by the facility at Heathrow, to carry out a full and extensive programme of open circuit tests on each dipole. Nevertheless a series of short circuit tests has been undertaken and the results of correlated measurements made in both the near and far field are appended. A similar series of tests made on the 12 element (85') array at NAFEC show results which are not too dissimilar to those now obtained. The construction of the 24-element array and the spacing of the dipoles is similar to that of the 12-element array. Theoretical considerations, the similarity of the two arrays and the fact that both course and clearance signals are radiated in a like manner led to confidence that open and short-circuit tests on the 24-element array would yield results similar to those obtained on the 12-element array. Also, since equal RF power is distributed to adjacent pairs of antenna on the 24-element array it should be less susceptible to individual antenna faults. Theoretical considerations also indicate that the near field monitoring of the 24-element array would be more effective than that of the 12-element array.

A comprehensive computer study of the near field of the 12-element array was conducted by STC and a similar computer survey of the near field of the 24-element array was made to determine the optimum position for siting the monitor aerials.

Q. What is the ILS Critical Area for wide aperture (165') STAN 37 antenna? How was it established?

A. The Critical Area for the 24-element array is a rectangular area 400' wide extending from a line 100' behind the localizer aerial system up to the near end of the runway and symmetrically disposed about the extended centre line of the runway.

The area was established following experience with a number of sites on which a similar aerial structure of 12-elements (85') had been installed. Further indication of the adequacy of this area was obtained by calculation of the beam bend potential of the radiated signals over a sector 30 - 90 from runway centreline at distances of 300' and 400' from centreline.

Q. How does ILS Critical Area (localizer antenna area) intrusion alarm affect Category III operations? Who or what monitors the intrusion alarm? How are critical and sensitive area controlled on/over the airport?

A. No Critical Area intrusion alarm is provided in the UK. For Category II and III ILS systems the Critical Area boundaries other than on and very near runways and taxiways are marked by wooden pegs 12 inches high at intervals of 50 ft. In addition, suitably positioned notices warn against entering the areas without authority.

Measurements were made of the effect of a B747 aircraft at Heathrow. Results were reported in "Instrument Landing System for Category III Operation, Multipath interference effects due to a Boeing 747 aircraft on Heathrow Airport, London", published by the DTI in January 1971. From the results of these trials, the sensitive area for the localizer was defined essentially as a strip 450 ft. on either side of runway centre line. It was concluded that a jumbo sized aircraft within this area may be liable to affect the roll-out guidance of the Category III localizer. While a Category III approach and landing is in progress this area will be kept clear of aircraft.

One particular turn-off from the runway has been designated for aircraft making Category III landings. The point where this taxiway clears the localizer sensitive area is marked with occulting white lights to enable pilots to report clear. If this particular turn-off is missed alternative arrangements are available to enable confirmation to be given that the aircraft has cleared the sensitive area at another point.

Taxying aircraft, other than one just landed, will be held clear of the sensitive area as required by restriction of routes available and by use of the appropriate stop bars on taxiways in use.

Beyond the critical area no particular sensitive area has been defined for Glide Path sites. Where appropriate, arrangements are applied to ensure that taxying aircraft and vehicles do not cccupy positions where they are liable to affect glide path performance while the ILS is in operational use.

A variety of measures are being taken to prevent both persons and vehicles from straying on to the manoeuvering area. These measures vary according to individual circumstances and include, where appropriate, manned barriers across access roads. Additional fences are being erected and where practicable locked gates are and will be fitted and keys issued only to personnel having a need to enter.

Q. Location and number of antenna employed for the Far Field Monitor. Has a study been made to find the distribution of and duration of out-of-tolerance alarm conditions? Practical experience and effectiveness of the FF Monitor operation? Any ideas to improve the operation?

A. The Far Field Monitor at 28L Heathrow at present employs two antenna, one on the extended centre line of the runway 1400' from threshold, the other offset 400' from runway centre line 1150' from threshold. The output of the monitor receivers are transmitted by a data link to the Control Tower where they are continuously displayed and recorded on paper tape recorders as well as operating visual and aural alarms should any of the monitored parameters (RF level, Mod Sum, Course DDM, Width DDM) go out of tolerance. In addition the outputs are recorded on one channel of the station magnetic tape recorder for investigation at a later date if required.

The equipment is designed to use up to 6 antenna in line on the extended runway centre line but this facility has not yet been installed at Heathrow. Tests on a multiple antenna FFM of this type are at present being conducted at Birmingham.

The only out-of-tolerance alarm conditions which have been experienced are those caused by (a) landing aircraft overflying the monitor aerials (b) take-off aircraft interrupting the beam from the localizer. The duration of those out-of-tolerance conditions can be readily observed on the paper tape recorders and are of the order of 12 secs and 35 secs respectively. The FFM incorporates a time delay of 60 secs to prevent the alarm operating during these conditions.

Consideration has been given to the inclusion in the FFM of a doppler shift detection circuit which would detect the beat frequency caused by the doppler shifted signal reflected from an aircraft approaching the monitor antenna and would suppress the alarm circuits for this period.

Experiments have shown that such a detector is feasible and could be incorporated if required. It would not inhibit alarms due to aircraft taking-off.

The Far Field Monitor provides an accurate tool for measuring the performance of the ILS at or near threshold and is considered an essential means of obtaining independent confirmation that the ILS signal in the far field is within the Category III performance requirements. It is not the intention of the UK at the present time to use the FFM as a executive monitor.

Q. What plans, if any, are there to implement Category III/II automatic status indicators in the tower? If a computer is built to handle this, what inputs and conditions will have a bearing on the Category III operational status? Any time delays incorporated? Effect of the following: Loc, GS, Markers; Intrusion alarm; ASME; RVR; Power failure; Environmental conditions; FF Monitor; and other?

A. The present status indicators in the tower at Heathrow indicate only the availability of the ILS equipment. For the Category III system on 28L these indicators are being changed to ones which will provide remote indications in the control tower on the operational state of the ILS localizer, glide path and marker beacon installation. The information will be displayed on lamps with a warning device providing an aural alarm. The operational state of the localiser will be indicated by the illumination of one of four lamps,

LP1 Green - System UK
LP2 Yellow - Standby fail
LP3 Yellow - Standby radiating
LP4 Red - System Fail

A similar set of lamps is used for the glide path. The operational state of each marker is indicated by the illumination of one of two lamps (red and green). An alarm circuit provides an aural alarm whenever a change of state takes place within the Loc, GS, or markers. This type of status indicator fully satisfies the present UK Category III requirements. A similar status indicator will be provided at Dulles International Airport for the STAN 37/38 ILS facility on Runway 01R.

To meet possible future requirements a provisional specification has been prepared for an Operational Control Facility and initial discussions with industry have taken place. It is intended to procure a pilot scheme for evaluation within the next year and this pilot model would provide the basis of an operational system for Heathrow if found acceptable.

The Operational Control Facility will be computer controlled and will provide the following facilities:

a Status Display
b Reliability analysis
c Stability recording and analysis
d Automatic Test and Inspection facilities

The ILS Status Display in the control tower will provide ATC personnel with information on all the facilities associated with the ground elements of the landing system. It will indicate whether the system is available for unrestricted use, for use by committed aircraft only, for Category II operations only, for Category I operations only or not available. Existing sensors will be used to provide data to the Facility from the ILS Localiser and monitors, ILS Glide Slope and monitors, ILS Marker Beacons, Far Field Monitor and Instrumented RVR. This information will then be processed and presented in suitably condensed form to the air traffic controllers.

In conducting a reliability analysis the facility will continuously monitor and assess the failure rate of the equipments connected to it to ensure that a service of adequate reliability is being provided.

The stability recording and analysis will provide a statistical record of equipment performance in terms such mean and standard deviation. The information will be obtained from the executive monitors and other sensors.

Finally, the test and inspection facilities will, by the use of purposely built sensors located within various sub-assemblies of the localizer, glide path etc., enable periodic inspection of the operating state to be made and will indicate trends or drifts within the equipment as well as printing out the location of any sensor which has detected out of tolerance conditions.

Q. Any plans to report ILS performance status to pilot other than voice from controllers?

A. No. The present methods of reporting ILS performance status are considered adequate.

Q. Describe Localizer and GS actual monitor alarm limits for Heathrow.

A. 1. LOCALIZER

1.1 ALIGNMENT

±17.4 feet at threshold. Average of four measurements with course line displaced either side of runway centre line. Course shift measured at far field monitor 1590 ft from runway threshold. In each case amount of shift is that required to displace the NF1 and NF2 monitors to alarm. Actual shifts ranged between 15.4 and 20.7 ft.

1.2 WIDTH

±11%. Average of sharp and wide setting for NF1 and NF2 alarms. Change of DDM measured at far field monitor expressed as percentage of nominal.

1.3 RF LEVEL

3db reduction measured at the transmitter.

2. GLIDE SLOPE

Angle Low 0.15° from normal
Angle High 0.06° from normal
Width Wide From 0.61° to 0.90° = 0.29° increase.
Width Narrow From 0.61° to 0.54° = 0.07° decrease.

In each case settings were for NF1 and NFs at alarm, Measurements made by CAFU aircraft using slice method.

RF Level 3db reduction measured at transmitter.

3. COMMENT

The possibility of reducing the localizer alignment monitor alarm bracket is being considered. Any change would be decided from analysis of recorded stability data so as to obtain an optimum setting requiring the lowest frequency of monitor recalibration consistent with maintenance of a suitable margin with the Annex 10 tolerance.

Q. Extent of localizer and glide slope monitor drifts experienced at Heathrow.

A. The position monitor returns have been fed int a computer controlled data logger for periods up to 66 days. The mean and standard deviation were calculated. These measurements do not separate monitor drifts from equipment drifts.

Results are as follows:

G/S Internal Position Monitor

Mean = 0.017°
Standard Deviation = 0.0047°

G/S NF1 Position Monitor

Mean = 0.02°
Standard Deviation = 0.012°

G/S NF2 Position Monitor

Mean = 0.0054°
Standard Deviation = 0.022°

LZZ Internal Position Monitor

Mean = 0.15ft
Standard Deviation = 0.98ft

LZZ NF1 Position Monitor

Mean = 3ft
Standard Deviation = 1.6ft

LZZ NF2 Position Monitor

Mean = 3.4ft
Standard Deviation = 1.2ft

The measurements for the localizer refer to the deviation in feet at threshold.

Q. Performance Assurance. What facilities will be used for flight inspection of the Category III ILS? What procedures will be used? How frequently? What calibration standards are planned to be used?

A. FACILITIES

UK Flight inspection facilities for Category III are HS 748 turbo-propellor aircraft fitted with aerial designed and sited to avoid propellor modulation nnd with modified Marconi AD 260 ILS receivers. Position fixing is done by a combination of air to ground photography and the telecroscope system described in Doc 8071 Vol II Ch 7.

CALIBRATION STANDARDS

The calibration standards will be those described as being suitable for Category II ILS work in Appendix 1-B to Agenda Item 1 in ICAO Report of the Informal Meeting on Flight Testing of Radio Navaids, Melbourne, 3 May 1971.

PROCEDURES

UK procedures for flight inspection of ILS are described in Flight Inspection Instruction No. 3, copies of which are available at the meeting.

FREQUENCIES

Frequencies for ILS flight inspection together with applicable tolerances are specified in Telecommunications Field Services Headquarters Memorandum No 2 (TFM No 2). Copies of this document also are available.

Q. Are independent measuring systems being used (e.g. ALMS) to determine performance of ILS from performance of airline aircraft on approach.

A. The ALMS as such determines the performance of the aircraft on approach, i.e. it is not capable of separately determining the performance of the ILS during the approach period. ILS ground performance at the time of approach can be determined from the Far Field Monitor and guidance system performance from recordings made in aircraft (e.g. Tridents). It is intended at a future date to correlate data from these and any other suitable sources.

ALMS was originally intended to monitor and provide measured data on the landing performance of aircraft whose operators have been allowed to operate in the lower visibilities associated with Category II conditions and compare this performance with that achieved in good weather. From the statistical information so provided it is intented to make a qualitative assessment of the risk of a fatal accident. This should enable soundly based decisions to be taken when allowing aircraft to be operated in progressively lower weather minima.

ALMS is designed to detect and record the precise speed and vertical and horizontal positions of aircraft from about 200ft (60 metres) above runway level to a point on the runway about 6,000ft (2000 metres) beyond the threshold. It also locates the touchdown point and gives some indication of touchdown characteristics. The information is obtained by a network of optical, seismic and infra-red detectors distributed in the approach area and along the runway. Results are produced in the form of punched paper tape for subsequent computer analysis. The system requires no cooperation from the aircraft, and is intended to function automatically by day and night in visibility conditions down to and including Category IIIA.

The basic aircraft position and velocity information from ALMS can be combined with other data describing the aircraft and the environmental conditions, thereby permitting more detailed analysis of landing performance.

ALMS is currently being installed on Runway 28 Left at Heathrow, and suitable computer programs have been designed to analyse the data to give statistical measures of performance, and to detect unusual individual landings, and trends affecting any particular group of landings.

Q. Any experience of approach lights affecting localizer signals?

A. No. In the UK the approach light fittings sited in front of a localizer antenna are required to be ground mounted. This results in a maximum overall height of light fitting in front of the antenna of about 30 inches. The minimum distance from localizer antenna or from monitor antennae is required to be not less than 20'.

Q. What is the MTBF of the ILS.

A. All faults or outages which have occurred since the installation of the STAN 37 at Birmingham and Heathrow have been recorded. From these figures a MTBF has been calculated and a summary of results over a number of years is appended. Also attached to this reply is a record of every known fault or outage since the equipment was first installed.

It is necessary to exercise a certain amount of caution when interpreting these figures since:

(a) many of the faults recorded have since resulted in modifications to the equipment, and

(b) the outages and hence the MTBF figures include peripheral equipment such as control lines, etc. For example, if one considers the four uncontrolled shutdowns recorded at Heathrow during 1970 we find;

(i) In only one instance was the fault on the ILS equipment. In this case a fuse (FS2) required to be replaced on the Common Control Unit. This was thought to be due to an extraneous voltage being applied to the remote control lines. These lines are now being isolated from other telephone and control circuits. The equipment MTBF in this case could, therefore, be considered to be 5848 hours.

(ii) In one instance the fault was due to grass cutting machinery being taken into the restricted area around the monitors. Tighter control has since been exercised over the ILS compound which is a fenced area.

(iii) A local electrical storm caused the equipment to trip on one occasion. Surge suppressors have now been fitted to the remote control lines and these should prevent a recurrence of this type of failure although statistical proof is hard to come by. It can be said nevertheless that no trouble has been experienced during electrical storms since these suppressors were fitted.

(iv) The fourth uncontrolled shut-down during 1970 was due to a faulty remote control line bringing information from NF2 to the Data Logger. Isolation circuits have since been fitted to all the peripherals which are connected to the ILS.

CATEGORY III ILS EVALUATION

SUMMARY OF RESULTS

LONDON (HEATHROW) 28L STAN 37

	1968	1969	1970	1971 (Jan to Mar)
Total operational hours	1678	5527	5848	1378
Out of Service Time (all causes) (hours)	80	306	154	16
Number of uncontrolled outages	8	15	4	0
MTBF (uncontrolled outages) (hours)	210	368	1462	-
Availability (all outages)	95.43%	99.44%	97.42%	98.86%

CATEGORY III ILS EVALUATION

SUMMARY OF RESULTS

BIRMINGHAM 33 STAN 37

	1968	1969	1970	1971 (Jan to Mar)
Total Operational Hour	4347	8642.4	8618.5	2140.6
Out of Service Time (all causes)	40.43	64.53	141.45	19.37
Number of uncontrolled outages	10	9	2	0
MTBF (uncontrolled outages)	434.7	960.3	4309.25	-
Availability (all outages)	99.08%	99.26%	98.4%	99.1%

Q. What are the results, if any, of wide aperture antenna deterioration, near-field/far-field monitor correlation tests and/or results of the STC computer study to look into this area?

A. The 24-element (165') array in operational service at Heathrow has antenna feeder lines which are terminated directly, by soldered joints, onto the balun at the rear of each dipole. For this reason it has been difficult, without seriously interrupting the operational service provided by the facility at Heathrow, to carry out a full and extensive programme of open circuit tests on each dipole. Nevertheless a series of short circuit tests has been undertaken and the results of correlated measurements made in both the near and far field are appended. The headings and format of the table are directly comparable with those published for a similar series of tests made on the 12 element (85') array at NAFEC which show results which are not too dissimilar to those now obtained. The construction of the 24-element array and the spacing of the dipoles is similar to that of the 12-element array. Theoretical considerations, the similarity of the two arrays and the fact that both course and clearance signals are radiated in a like manner led to confidence that open and short-circuit tests on the 24-element array would yield results similar to those obtained on the 12-element array. Also, since equal RF power is distributed to adjacent pairs of antenna on the 24-element array it should be less susceptible to individual antenna faults. Theoretical considerations also indicate that the near field monitoring of the 24-element array would be more effective than that of the 12-element array.

A comprehensive computer study of the near field of the 12-element array was conducted by STC and a similar computer survey of the near field of the 24-element array was made to determine the optimum position for siting the monitor aerials.

Integral monitoring systems using slotted pickups which are considered superior to loop type pick-up elements are being developed for future application to the standard arrays.

Q. What is the ILS Critical Area for wide aperture (165') STAN 37 antenna? How was it established? What is the ILS Sensitive Area? How was it established?

A. The Critical Area for the 24-element array is a rectangular area 400' wide extending from a line 100' behind the localizer aerial system up to the near end of the runway and symmetrically disposed about the extended centre line of the runway.

The area was established following experience with a number of sites on which a similar aerial structure of 12-elements (85') had been installed. Further indication of the adequacy of this area was obtained by calculation of the beam bend potential of the radiated signals over a sector 30° - 90° from runway centreline at distances of 300' and 400' from centreline.

The Sensitive Area of the 24-element array is essentially an area ±45' from C/L extending from a point 1000' upwind from the threshold to the stop end of the runway.

The area was established following measurements made of the effect of a B747 aircraft as noted under the reply to Question 3. An attached plan of Dulles Airport shows the sensitive area applied to Runway 01R.

Q. What are the crew procedures used by operators who are practising Category III A operations?

A. The crew procedures used in BEA Trident operations are based on the well-tried and proven monitored approach concept. The crew complement comprises three pilots and the aircraft is flown by P2 through the autopilot, the operation being monitored by the Captain and P3.

An essential feature of the low-minima operation is the allocation of specific duties to each crew member throughout the approach, and the need for each pilot to know exactly what is expected of him at each stage, particularly in fault cases, is emphasised during training.

The procedures for Category 3A were developed as extensions of those for Categories 1 and 2 but significant changes to the latter were also necessary in order to standardise the method of use of the additional equipment (the autopilot integrity indicator, for example) in both good and bad visibilities and to cater for reversion to higher minima in fault conditions.

The use of a decision height based on visual reference is retained for Category 3A but the choice of a figure of 12 feet requires some explanation. At one time it was proposed to use the height at which flare is initiated, namely 65 feet, but ut was argued that the lowest possible height consistent with a high probability of not making contact with the ground during the overshoot was to be preferred since a low decision height would improve the landing success. 12 feet was chosen because the associated height loss is about 6 feet and also because the green progress lights (head up and head down), illuminated at this height to indicate kick-off drift, provide P2 with an excellent indication of the latest point for initiation of the missed approach. The procedure also incorporates an alert call of '30 above' (30 feet above decision height,) and Captains are expected to respond without undue delay with the work 'land' if they are satisfied with their visual reference of 'overshoot' if they are not. In practice, therefore, overshoots will occur slightly before the aircraft reaches 12 feet.

As was found with Category 2, experience of the procedures on the simulator and during line practice served to emphasize the importance of simplifying the procedures. For example, since transmissions from the ground tend to interrupt the close monitoring of the approach, it has been suggested that the Captain should request the RVR at, say, 700 feet and thereafter the controller should pass only essential information relating to the integrity of the ground system. 2 sets of pages of the Operations Manual dealing with the Flight Control System and its operation are available.

Q. What visual simulation capabilities do they have? How is restricted visibility simulated? Are they satisfied with present restricted visibility simulation?

A. The BEA Trident simulator is equipped with a visual attachment of conventional design and is the best that is currently available. The TV camera has a sky plate of translucent perspex acc rately positioned by a servo system to provide a cloud base from zero to 1500 feet and visibility zero to 4 miles. The situations which are required to trigger a response from the crew are reproduced sufficiently well for us to have been satisfied with its usefulness for this aspect. However, we have thought is desirable to supplement this with film of actual approaches and landings in Category 3 conditions and an up to date version is presently being made up from film taken by BLEU during last winter.

BEA has also benefited from particiaption in two simulator exercises at BLEU; one last year which investigated problems of Category 2 and one this year dealing with the BEA proposed procedures for Category 3. BLEU reports on both these exercises are in course of preparation.

Since the BLEU simulator was specifically designed for research into low visibility problems, this experience was invaluable to BEA.

Q. How are flight directors employed in Category III Operations?

A. In the Trident Flight Control System the cross-pointer flight director is fed by the same sensors which drive the third sub-channels of the pitch and roll axes of the autopilot. Since they are not independent, therefore, the flight director is switched off for final approach.

BEA does not believe that flight directors, even with the required integrity, have a role to play in Category III except possibly in the landing roll out and take-off run (see below). This is because of the difficulty of training pilots and of ensuring their standard is maintained.

The BEA Trident is fitted with a para visual (coaming-mounted) display (PVD) of azimuth director demands for use during the landing run in event of failure of the duplex rudder channel, and below 80 knots when the rudder channel is automatically disengaged. The PVD is also used for take-off but, because it is only simplex, pilots are instructed to make use of the centre-line lights as the primary guidance source and only revert to PVD when fog patches obscure the lights.

Q. What ground school and flight training programme are required for Category III approval?
See also DTI reply/Draft Provisional Requirements

A. In BEA ground training for Category III is divided into three parts:

1. Technical lecture on additional equipment, namely; MEDU (monitor equalisation and display unit), integrity indicator, automatic rudder operation, PVD roll out, ground roll monitor (groundspeed and distance-to-go).

2. Operational lecture on basic philosophy and programme. Discussion of items contained in handbook 'Preparing for Cat. III'

3. Simulator programme briefing - include showing of fog film, and discussion of operating rules as well as aircraft operating procedures.

Programme for Category III training on the simulator and the aircraft is available (Incorporated in differences course for Trident 3).

Initial Trident 3 conversion training on the aircraft included much that is now carried out only on the simulator. Use is also made of line training where possible.

Q. What is their concept for using an 'excess ILS deviation alarm' in the aircraft? Is it required? If so what alarm limits are used? During what phase of the approach is it used?
See also ARB reply.

A. The Trident is fitted with an excess deviation warning system which flashes the AZM window of the mode indicator whenever the deviation from localiser exceeds 25 microamps (Cat. II) or 12 microamps (Cat. III). (The LOC switch on the coaming is spring-loaded to the Cat. III position and can only be switched to Cat. II after Prime Land has been selected).

The GP window flashes if the deviation from the glide-path centre-line exceeds 90 microamps (Cat. II and Cat. III). The GP deviation warning is inhibited at 133 feet when 'attitude-hold' starts. In the Cat III position, however, if the window was flashing prior to arrival at 133 feet it will continue to do so for three more seconds.

The warnings are activated at about 1200 feet on selection of Prime Land and may be ignored above 300 feet or if visual reference has been established.

Q. Have U.K. published approval procedures for Category 3 - for aircraft, operators, crews, airports? If so, can we get copies of documents describing these procedures.

A. The ARB has published BCAR Paper 367 which describes the procedures by which an airplane and its system are certificated for Category 3 operations. This has roughly equivalent status to an FAA Advisory Circular. The DTI has in the final stages of perparation a document describing the procedures by which the operator of certificated Category 3 airplane can obtain approval to conduct Category 3 operations.

Copies of the ARB document are available, and a copy of the DTI document should be available in the near future.

Q. What tests have they conducted of a complete Category 3 airport/airplane complex to confirm suitability of the total system?

A. The analysis of any individual component of the system or procedure is always done in the contest of the total system. The yardstick of acceptability is the 10 overall risk requirements. This not only affects such things as minimum standards of touchdown dispersion, but also equipment reliability, check periods, etc. Flight testing has, as far as possible, been carried out in conditions representative of the class of operation being approved, and has included a significant number of landings at Heathrow with Trident aircraft in visibilities of the order of 100m.

Q. What methods or procedures do they contemplate for approving Category 3 operations after a determination that ground and airborne systems are acceptable?

A. The ground and airborne systems are not finally determined to be acceptable until a long period of operational proving has been completed. Then the aircraft operator is required to make a submission establishing to the satisfaction of the DTI that the operating requirements are met. He must also specify whether minima at each runway where the operation is intended together with evidence that the ground facilities provided will support the operation.

Q. What are the crew procedures used by operators who are practicing Category 3A operations?

A. The safe operation of the system relies on certain essential procedures. These are worked up and defined during the certification programme by the manufacturer and the ARB in consultation with the operator. The procedures are specified in the Flight Manual for the airplane and therefore may not be changed by the operator. Any changes to the essential procedures can only come as a result of the manufacturer and the ARB reviewing the safety analyses and establishing that no degradation of safety would result. The procedures for the Trident operation will be described by BEA during the FAA visit to the simulator.

Q. Have tests been made to establish utility of Category 3A reported RVR for rollout steering?

A. The answer to this question falls into two parts. Firstly, rollout tests have been done using screens in Trident aircraft to simulate RVRs as low as 35m. Pilots report no difficulty in holding the centreline with this order of visibility, but corrective manoeuvres to regain the centreline are generally regarded as requiring greater visibility. Secondly, visibility measurements, both from operational transmissometers and from research instruments are being analysed to establish the correlation between reported readings and the minimum visibility that is likely to be encountered on the runway. This work has yet to be completed but is not currently considered a holding factor for this winters operation of Trident 3 airplanes in 300m.

Q. What is their requirement (or anticipated requirement) for rollout steering by automatic means or by manual/ instrument means?

A. Until the correlation between reported RVR and minimum runway visibility is better know, automatic or directed/ manual rollout steering will be required for any reported RVR minima significantly lower than Category 2 (400m). Minimum equipment for the Trident 3 12 ft/300m. operation will be a serviceable paravisual director system. The provision of this equipment on the airplane appears at this time to be a suitable route for securing lower take-off minima.

Q. Have tests been made of aircraft response to potential ILS signal faults?

A. ILS signal faults of two kinds have been considered, those originating in the transmitter and those arising due to interference with a correctly transmitted signal. Analysis of transmitter failures has included failures of the transmitter and its monitors, as well as failures inside the monitor limits. Testing of both kinds of signal faults has been carried out, mainly using an "iron-bird" simulation but also flight. The tests and analysis of particular systems have demonstrated satisfactory flight path errors and aircraft attitudes (e.g. bank angle near the ground) taking account of the warnings available in the airplane, the defined procedures, monitor delay times and likely delays in pilot reaction.

Q. Do they have any efforts underway to further refine the ILS signal quality standards in relation to airborne system capabilities?

A. The Annex 10 standards for beam bends are considered to be adequate for safety. "Interference" and reliability are under review.

Q. Have they developed any reliability data on fail operative autoland systems?

A. Systems are only certificated for Category 3 after a period of proving in service use in fair weather. One of the objectives of this proving phase is to establish that the reliability of the system in service is adequate to ensure that a malfunction or disengagement of the system in a critical phase of the land is sufficiently unlikely. The reliability numbers so established can normally be regarded as specific to the particular system under consideration.

Q. What is their concept for using an "excess ILS deviation alarm" in the aircraft? Is it required? If so, what alarm limits are used? During what phase of the approach is it used?

A. The excess ILS deviation alarm is most particularly a Category 2 requirement and it is intended to give positive warning to the pilot of poor performance or some types of system failure. It is retained in Category 3 operations for similar reasons even though the systems are more capable and better protected. The glide slope warning is retained only until the airplane ceases to use glideslope information whereas the localizer warning is retained through touchdown. The warning thresholds are set so as to minimize the likelihood of a spurious warning, but the values are not laid down, since they depend on the performance which the system can achieve. Localizer limits between 12 add 20 microamps and glide slope limits between 75 and 90 microamps have been accepted.

Q. How are flight directors employed in Category 3 operations? Is there any R. & D. effort toward improved flight directors for Category 3?

A. Flight directors are not considered to be suitable either as the source of primary guidance or as reversionary aid in Category 3 operations. For an approach using a fail-operative autopilot, flight directors are considered to be a potential hazard since the director is a simplex device, and if it fails it might cause a pilot to unnecessarily disconnect the correctly functioning autopilot, and commit himself to a manual landing in bad visibility, or a go-around from low height. Since it is a requirement that the monitoring of the autopilot system should be complete without reliance on flight director information, it is also a requirement that flight director information should not be displayed during the final stages of a Category 3 approach and landing.

3.0 THE NETHERLANDS: AMSTERDAM

3.1 Schiphol Airport[2]

Schiphol airport in Amsterdam is the home base of KLM, the major Dutch airline, and an important European en-route traffic control center. In support of this latter function it operates and maintains the most impressive semi-automated control system the U.S. representatives had occasion to see during the trip. Although the time spent observing operations in the center were of short duration, most of the group came away with the wish that at least some of the equipment could be transplanted in the U.S. It was especially significant then, when the group learned that much of the hardware, built by Phillips, was in the process of being replaced by even better equipment.

Relative to ILS, Schiphol is unique in the sense that it operates both the British STC and French Thomson CSF equipment. The former, consisting of a STAN 7 localizer and STAN 8 glidepath, is maintained on runway 01. The latter (LS 371) systems are maintained on 19 R, 27 L, and 06. The Thomson equipment has been converted to solid state (including the modulator); the STC localizer has a mechanical modulator. The French systems have been in place for little enough time so that operations and maintenance data has only begun to accumulate. It was noted, however, that there have been several failures of the solid state modulators. The STC equipment has been in place for some time and no difficulties with its operation were reported. Another installation of STC, in this case a STAN 37/38, at Beek has also operated well up to this time.

At present, Schiphol does not have color coding on its centerline lights but by January, 1972, lighting proposed by the ICAO Visual Aids Panel (white/red for 600 meters, red for 300 meters and red for end lights) will have been installed. The current system uses 100 watt lamps on 15 meter centers. Alignment is such that center and edge lights appear to be equal in brightness. The airport has red approach barrettes, the new international runway markings and green coded taxiways. Currently there are dual transmissometers operating on 150 meter baslines on each of the runways indicated above, but plans are being made for installation of three on each (at the touchdown zone, mid-point and end). RVR at the touchdown zone is routinely relayed to the pilot but it is a matter of individual (airline) company policy

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[2] Quoted material in sections 3.1 and 3.2 are taken from a follow-up letter sent by W. M. A. van Rossum, Ministerie van Verkeer en Waterstaat, to A. B. Winick, FAA/SRDS.

whether that value is sufficient for landing; no airport policy exists.

Schiphol has a system of dedicated take-off and dedicated landing runways. Two runways currently meet Cat II requirements (though the ILS monitors serving them do not meet the delay time requirements). It is contemplated that a single runway will be developed for Category III operations.

3.2 KLM Royal Dutch Airlines

On the basis of climatology studies performed by the Dutch meteorological institute in 1966, it was ascertained that "RVR's below Cat I minima occur at Schiphol 2.3% of the time and below Cat II minima 1.2%." Despite these seemingly low percentages, KLM has made the decision to purchase Category III equipment for its fleet of DC-10's and B-747's. Their reasons are as follows:

(1) "Since Schiphol is KLM's home base and given the above weather statistics it is imperative for the company to ensure the best possible regularity of service into Amsterdam."

One day of fog upsets the crew and aircraft scheduling for a number of days.

(2) "The presently required (AC-120-29) and existing Cat. II equipment is felt to be marginal for long-haul bottom of Cat. II operation."

(3) "The financial consequences of diverting a wide-body aircraft are considered severe enough to warrant purchase of costly Cat. III equipment for the service life of the aircraft. This argument is applicable to all airports used by KLM."

(4) "Regularity of service is considered of utmost importance in the competition amongst airlines and therefore KLM wishes to be equipped with up to date equipment. This again is applicable to all operations and not only at Amsterdam."

KLM's implementation plan for Category III operations is as shown in the table on the next page (see footnote 2 above).

KLM Category II and Category III
Implementation Schedule

Aircraft \ Period	1971	1972	1973	1974	1975	
DC-8 old version	CAT I 600 60					FA/AP→DH
DC-8-63	CAT I 600 60	CAT II? 500 45				FD/AP→DH/15
DC-9	CAT II 400 30					AP→DH/15
B-747 Fail-passive	CAT I 600 60	CAT II 500 45				First three AP→touch down AIDS
B-747 Fail-Ops	CAT I 600 60	CAT II 500 45	400 30	CAT IIIa 300 0		Vierde en volgendo AP→touch down Auto G.A. AIDS
DC-10			CAT II* 400 30	CAT II 400 30	CAT IIIb 50 0	*Beam data req. AP→full stop Auto G.A. PAFAM Douglas rec/ crit AIDS

Significant aspects of this plan are that (1) there is no intention to utilize the B-747 under Category III B and C conditions, and (2) DC-10 utilization proceeds directly from Category II to Category III B.

PART II

1.0 ON THE JUSTIFICATION FOR CATEGORY III PROGRAMS[1]

Although there is undoubtedly a certain academic satisfaction to be derived from meeting the various challenges posed by a technical development program, it seems clear that the major justification for embarking on such a program must, in the end, be economic. In order to develop such a justification, it is highly desirable that the benefits expected to accrue to the proposed development be able to be compared to those of a currently functioning alternative prior to the start of the program and that these benefits be able to be measured incrementally against that alternative as the program proceeds. Unfortunately, opportunities in which both of these desires can be satisfied seem to be rare. The European all-weather-programs reviewed in this report appear to have progreesed within such a context and it may be as a result of this that they exhibit the degree of coherence that was observed.

Both France and the U.K. have well-developed passenger/freight rail systems which cover much of the same area as that covered by the airlines. Since the railroads are not similarly limited in operation by the occurence of low visibility conditions, they stand ready to pick up any goods or people which the air carriers cannot move. Thus, the air carriers essential task in the justification of an all-weather-landing capability is to estimate what proportion of their current business they can maintain with such a capability, what they can win back and what in the way of new trade they can attract. And this analysis can be carried through with the alternative mode as the major argument, rather than with the frequency of poor visibility, per se, or a less quantifiable concept such as customer "convenience" as rationale.

With the type of equipment currently in use, the incidence and type of low visibility conditions encountered and the "threat" represented by alternative modes of transportation, the French government and airline industry seem fairly certain that, for present internal operations, a favorable economic position can be reached with 50' decision height, 150 meter RVR operations. With very much the same sort of criteria, BEA in England has opted for 12' decision height in the very near term and zero decision height in the longer term.

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[1]Note: The opinions expressed in sections 1.0 and 2.0 of Part II are those of the author and do not necessarily reflect the views of the other American visitors or those of the European representatives contacted.

Our impressions, then, are as follows:

(1) The programs in both countries have considerable momentum. They have the impetus provided by day-to-day competition with an established form of transport.

(2) Neither country appears to care greatly whether its accomplishments and goals converge on the ICAO concept of Category III A, B or C. Though the British scheme does, in fact, so converge, one has the feeling that this is an additional (though politically satisfying) benefit to a program which has a firm economic rationale.

(3) A very close relationship exists between R&D, (airline) operating personnel and the government. This materially aids the process of defining goals, generating procedures by which every day operating experience can be exploited in the programs, drafting aprropriate certification requirements, etc.

It is possible that the Category III program in the U.S. might be further enhanced if it could integrate some of the (alleged) positive characteristics of European programs in an effort to accumulate experience. We would recommend the following as an experiment:

(1) Locate areas of the U.S. which are supplied with competing modes of transportation (not competing carriers within the same mode) on a more or less point-to-point basis.

(2) From this set, select one or two areas in which air carriers are authorized and airports are equipped to handle at least Category II operations.

(3) Identify an air carrier whose current interest is in eventual Category III B authorization and who has the interest and wherewithall to enlist for a period of one or two years in experimental low decision height operations on regularly scheduled runs.

(4) Authorize the carrier to conduct operations at a (non-zero) decision height corresponding to the safety limits of its aircraft. Aid in publicizing the effort.

(5) Require the carrier on a continuing basis to submit reports of the following varieties: (a) passenger/freight loadings under all-weather conditions, (b) schedule variances, (c) technical operating data.

(6) Determine the pattern of customer activity overall and over periods of poor weather, if any.

(7) Require airports within the area of operations to submit reports of facility availability, traffic activity, delay times, etc., on a continuing basis.

(8) Solicit from the carrier and from other interested parties opinions regarding the soundness of ICAO requirements in light of the data gathered during the operation.

(9) Participate in development, if necessary, of revised all-weather landing goals.

2.0 ON SYSTEMS AND PROCEDURES

2.1 Head-Up Displays and Independent Landing Monitors

We find it interesting that such disparate views exist between the U.K. and France relative to the importance of head-up display and independent landing monitor systems. The French quite evidently consider devices of this sort to be highly desirable for their 50 ft. decision height operations and are taking positive steps toward their development. The British, on the other hand, regard the devices as "sales tools to pilots" and "pacifiers".

This apparent disparity may stem from a difference in philosophy regarding what types of autopilot configurations are acceptable for low decision height operations.[3] On the one hand, the British have argued almost from the very beginnings of their all-weather program that fail operational (triplex or duplicate-monitored) systems are an absolute requirement for low decision height operations and that systems must be so reliable (i.e., fail survivable) that manual control is unnecessary. On the other hand, the French are, at the moment, convinced that fail passive systems are satisfactory if an element of redundancy can be provided by the pilot. The British, then, seek to keep the pilot out of the control loop and attempt to avoid a situation in which his perception of the performance of the aircraft based on marginal visual cues might be brought into conflict with the status as indicated by monitors of the automatic system. And the French seek to keep the pilot in the loop and to enhance the degree and quality of his awareness through the provision of an ILM. In a nutshell, the respective attitudes toward displays of this type appear to be consistent with the respective philosophies regarding necessary degrees of redundancy in automatic systems.

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[3] These differences in philosophy may, in turn, be the result of the differences in types of poor visibility conditions encountered in the two countries.

A portion of this is academic, since (quite correctly, we think) the decision has been made in the U.S. to employ fully automatic fail-operational configurations in at least the first generation of Category III aircraft. What may not be academic is that the importance of and necessity for head-up displays and independent landing monitors has not yet been decided. We are convinced that, given the first decision, an attitude toward HUD's and ILM's similar to that of the U.K. is appropriate.

2.2 Cockpit Procedures and Warning Systems

At this point, we are unfamiliar enough with the details of the new Trident cockpit procedures to comment on their merit. We are, however, impressed with two things:

(1) the procedures clearly reflect the notion that the pilot's traditional role may require redefinition when he is to become an element in an automatic system;

(2) the removal of traditional initiatives or at least a restructuring of those intitiatives can be accomplished with relatively little difficulty, given adequate training procedures.

BEA experience seems to suggest that, contrary to characterizations sometimes attempted, the airline pilot is as pragmatic as any other professional: Once convinced of the validity of a given procedure and of the security it offers vis a vis alternative procedures, he will become a staunch supporter.

The redrafting of crew responsibilities in the context of a new total system philosophy is a ticklish task and one that deserves considerable attention. Many new aspects of procedure can be developed, taught, and exercised in simulators, but some "loopholes" will go undetected and will be ascertained only under actual operating conditions. This makes all the more desirable an experiment such as that proposed earlier and also underlines the need for continued development of techniques, such as those involved in fault-tree analysis.

We consider the Air Inter Caravelle concept of a single alarm representing the synthesis of all airborne failure data and requiring an immediate go-around without assessment to be a good one. There may be some advantage to an auditory (rather than visual) signal, such as the standard warning horn, but the basic simplicity of the situation is appealing, in that decision and action selection times are minimal. The desirability might be further enhanced if a fault output array similar to that used in the Marconi RVR system could be accessed after the go-around was completed.

2.3 Ground Equipment and Procedures

It is premature to judge the relative merits of the ILS systems observed during the visit. Data permitting such judgment should be forthcoming in 1972 as a result of evaluations at Dulles, NAFEC and San Francisco. Both the Thomson and STC systems appear at this point to be capable of supporting Category III operations in an environment in which ground traffic and overflight are carefully controlled. In addition, the Thomson unit appears to have been designed with ease of trouble-shooting and maintenance in mind, most components being readily accessible in roll-out drawers.

The Marconi RVR system is very impressive to the extent that a carefully controlled environment is maintained within tranmissometer housings, processing of data is handled completely automatically and system failure analysis is simplified through the provision of a fault light array. We are inclined to think, however, that a major limitation of all RVR systems to date is preserved in this system. That is the limitation of the validity of the conversion from radiometric data to visibility data. We would argue that development of the physical (hardware) aspects of the RVR system may shortly reach the point of diminishing returns and recommend that effort be allocated to finding another algorithm for translating transmission values to values meaningful in terms of the human eye.

A question on the Marconi System: The system operates on a much shorter baseline than its forerunners (10 meters versus, typically, 50 meters). This results in higher degree of measurement accuracy within the volume scanned, but it is not clear to us that, except for homogeneous conditions, information is not lost. Is it possible that with a patchy fog unequally distributed along the runway surface, the total net validity of the system scanning the greatest volume is highest?

Finally, at the risk of overstating our point of view, we would repeat the proposal that immediate action be taken to implement a Category III experiment with a commercial airline. It seems to us the most direct way to accumulate the critical mass of data necessary to develop meaningful economic justification and to answer the many preliminary questions concerning airborne and ground system design.

PART III

APPENDIX 1.0 AVAILABLE ON REQUEST

APPENDIX 2.0 AVAILABLE ON REQUEST

APPENDIX 3.0:

3.1 List of American Visitors
3.2 List of Foreign Contacts
3.3 Itinerary

3.1 LIST OF AMERICAN VISITORS

J. Nelson	FAA	RD-322
R. Noltemeier	FAA	FS-403
E. Hanlon	FAA	OP-4
R. Flint	FAA	Brussels Office
G. Van Gundy	FAA	Brussels Office
T. Croswell	Mitre Corp.	
J. Andersen	TSC	PG
C. Feehrer	TSC	TIF

3.2 LIST OF FOREIGN CONTACTS

FRANCE

Secretariat General a l'Aviation Civile
(Ministere des Transports) - SGAC

Messrs.	Desindes Durgeat	Direction des Transport Aeriens Bureau des Operations - DTA/0
	Affray Richard	Direction des Transports Aeriens Bureau de Materiel Volant - DTA/M
	Provost Dedryvere	Direction de la Navigation Aerienne - DNA LeBureau (Telecommunications) - DNA/3
	Levlin	Direction de la Meteorologie Nationale - DMN
	Musiedlak	Centre Technique de la Meteorologie - DMN/CTM
	Buck	Organisme de Controle en Vol - OCV
	Montel	Centre d'Experimentation de la Navigation Aerienne - C.E.N.A.
	Presh Ordas Mace	Science Technique de la Navigation Aerienne - S.T.N.A.

Direction Technique des Constructions Aeronautiques
(Ministere la Defense Nationale) - DTCA

Messrs.	Gibaud de Beachene	Service Technique Aeronautique (Equipments) - STAE/Eq
	Galan Michot	Centre d'Effair en Vol (Bretigny) - CEV
	Aubry	Direction de la Navigation Aerienne (Aerodromes) - DNA/A
	Galbe	Service Technique de la Navigation Aerienne Balisage)
	Klopfstein	Experimental Flight Test Center (Bretigny)

3.3 ITINERARY

October 18 - October 22 (France)

October 18, 19:	Discussions with Secretariat General de la Aviation Civile (SGAC) and other government authorities on history of all-weather landing in France and current concepts and requirements for Category III.
October 20:	Discussions with Thomson CSF, Dassault Int., SFENA and Aerospatiale on equipment design concepts.
October 21:	Discussions with Air Inter, UTA and Air France on operational plans for Category III, visit to Thomson CSF installation at Orly; nighttime round trip flight with Air Inter to Toulouse.
October 22:	Visit to Experimental Flight Test Center at Bretigny. Discussion and flight demonstration of new angle of attack HUD installation in NORD 262.
October 23:	(Schiphol Airport - Amsterdam). Discussions with Dutch government authorities on airport facilities and KLM operational plans for Category III; observations of Schiphol IFR room and Tower Facilities.

October 25 - 29 (United Kingdom)

October 25:	Discussions with DTI and other officials on problem areas and implementation plans for Category III.
October 26:	Discussions with Air Registration Board officials on certification and approval procedures for upcoming BEA petition.
October 27:	Discussions with BEA management and operating personnel on crew procedures; demonstration in Trident 3B simulator.
October 28:	Discussions with British Airports Authority at Heathrow; observation of Heathrow guidance RVR and ATC facilities.

October 29:	Discussions with DTI, BLEU and Hawker-Siddey personnel on Cat III R&D plans.