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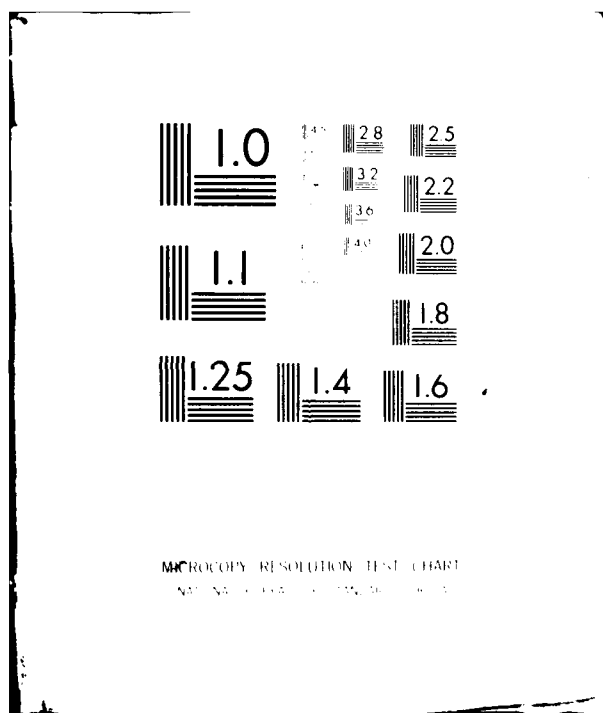
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MELBOURNE, VICTORIA

Systems Technical Memorandum 50

VISUAL PROBLEMS AND NIGHT LANDING GUIDANCE
OF THE CH-47 (CHINOOK) HELICOPTER

B.A.J. CLARK

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B.A.J. CLARK

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SUMMARY

Visual ergonomics problems in the Chinook helicopter were investigated in a study following an earlier, broader ergonomics study by ARL Cybernetics Group. Important visual problems do occur in the Chinook and solutions or further studies are suggested as appropriate. Brief trials of tactical night landing devices were observed, and these are discussed in the light of previous DSTO participation in the development of visual landing guidance systems. Improvements to the devices currently in use are necessary to improve operational effectiveness and flight safety.

POSTAL ADDRESS: Chief Superintendent, Aeronautical Research Laboratories,
 P.O. Box 4331, Melbourne, Victoria, 3001, Australia.

(14) ARL/SYS-TM-50

DOCUMENT CONTROL DATA SHEET

Security classification of this page: UNCLASSIFIED

- | | |
|--|---------------------------------------|
| 1. DOCUMENT NUMBERS | 2. SECURITY CLASSIFICATION |
| a. AR Number: AR-001-781 (9) | a. Complete document: UNCLASSIFIED |
| b. Document Series and Number: Systems Technical Memorandum 50 | b. Title in isolation: UNCLASSIFIED |
| c. Report Number: ARL-SYS-TECH-MEMO-50 | c. Summary in isolation: UNCLASSIFIED |

3. TITLE: (6) VISUAL PROBLEMS AND NIGHT LANDING GUIDANCE OF THE CH-47 (CHINOOK) HELICOPTER.

4. PERSONAL AUTHOR: (10) CLARK, B.A.J. /	5. DOCUMENT DATE: (11) November, 1979
	6. TYPE OF REPORT AND PERIOD COVERED:

- | | |
|--|---|
| 7. CORPORATE AUTHOR(S):
Aeronautical Research
Laboratories | 8. REFERENCE NUMBERS |
| 9. COST CODE:
73 4422 | a. Task:
89/113 |
| 10. IMPRINT:
Aeronautical Research
Laboratories, Melbourne | b. Sponsoring Agency:
AIR |
| | 11. COMPUTER PROGRAM(S)
(Title(s) and language(s)):
NIL |

12. RELEASE LIMITATIONS (of the document):
Approved for Public Release.

12-0. OVERSEAS:	N.O.		P.R.	1	A	B	C	D	E
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13. ANNOUNCEMENT LIMITATIONS (of the information on this page):
No limitation.

- | | |
|---------------------------|-------------------|
| 14. DESCRIPTORS: | 15. COSATI CODES: |
| Illuminating cockpits | 0505 |
| Instrument panels | 1707 |
| Reflection | |
| Night vision | |
| Human factors engineering | Helicopters |
| Aviation Safety | CH-47 aircraft |
| Visual aids | Chinook aircraft |
| Approach lights | |
| Approach indicators | |

16. ABSTRACT: Visual ergonomics problems in the Chinook helicopter were investigated in a study following an earlier, broader ergonomics study by ARL Cybernetics Group. Important visual problems do occur in the Chinook and solutions or further studies are suggested as appropriate. Brief trials of tactical night landing devices were observed, and these are discussed in the light of previous DSTO participation in the development of visual landing guidance systems. Improvements to the devices currently in use are necessary to improve operational effectiveness and flight safety.

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CONTENTS

	<u>PAGE NO.</u>
1. INTRODUCTION	1
2. VISUAL PROBLEMS AND SOLUTIONS PROPOSED	2
2.1 Reflections in Transparencies	2
2.2 Reflections in Instrument Cover Glasses	2
2.3 Instrument Panels	3
2.3.1 Lighting	3
2.3.2 Layout	4
2.4 Overhead Transparencies	5
3. NIGHT LANDING GUIDANCE	5
3.1 Historical Notes	5
3.2 Trials	7
3.2.1 Description of Devices	8
3.2.2 Results	8
3.3 Prospects for Improvements	9
4. CONCLUSIONS	9
REFERENCES	
TABLE	
DISTRIBUTION	

1. INTRODUCTION

In September and October 1975, a member of ARL Cybernetics Group visited RAAF Amberley on the invitation of CO 12 Squadron to make an ad hoc assessment of human factors in the CH-47 Chinook helicopter. A draft Technical Memorandum describing the findings and proposed solutions for some of the problems was sent to Air Force Office in June 1976 and a slightly revised version has now been published in the ARL series (Ref. 1). In the present writer's opinion, the passage of time has, in general, not diminished the need for the improvements suggested in Reference 1.

In November 1977, RAAF Operational Command requested further assistance from ARL on the cockpit lighting deficiencies in the Chinook, and an initial assessment of tactical night landing problems with the Chinook. The writer visited Amberley on 30 November and 1 December 1977. Comments on the night landing aspects were sent from ARL to OC RAAF Amberley under cover of a letter in July 1978; for completeness those comments have been expanded to form a section in this memorandum. The major content of this memorandum is a description of the writer's observations at Amberley together with some suggestions for improvements. The delay in producing this document has been unavoidable because of prior heavy commitments of Cybernetics Group to other ad hoc ergonomics tasks for the Defence Forces. Three of those tasks have relevance to the writer's observations in the Chinook:

- (i) a study of crashworthiness and comfort in Iroquois crew seats (Ref. 2);
- (ii) a study of a RAN Sea King night landing disorientation accident in which reflections of the instruments in the windscreen appeared to contribute to the disorientation (Ref. 3); and
- (iii) a study of the cockpit lighting problems in the Sea King (Ref. 4).

The first item has incidental relevance in that the writer occupied the crew seat behind the pilots during night flights in the Chinook and found it most uncomfortable. Subsequent inspection of that seat and the two pilot seats indicated deficiencies, many of which were mentioned in Reference 2 and which may eventually lead to chronic backache for the majority of Chinook pilots. The second and third items are directly relevant because the cockpit vision problems in the Sea King are broadly similar to those in the Chinook: many of the solutions offered in the case of the Sea King in fact are directly applicable to the Chinook. Operators of these two aircraft types appeared generally unaware of the similarity of their respective problems in cockpit vision, and inter-service conferences such as the Helicopter Aviation Medicine Seminar held at the Army Aviation Centre, Oakey in December 1977 appear worth fostering as a means, inter alia, of discussion of common problems and, hopefully, of appropriate solutions.

Table 1 gives a summary list of actions or trials suggested in the text of this document.

2. VISUAL PROBLEMS AND SOLUTIONS PROPOSED

2.1 Reflections in Transparencies

The centre console between the cockpit seats is visible to the pilots as a reflection in the central (flat) windshield and the adjacent curved windshields. Although pilots 'learn to live with' this type of deficiency and sometimes on questioning when away from the aircraft they even deny the existence of the reflections, there is no doubt that in both day and night conditions, the reflections always degrade the performance of the pilot-aircraft system. The amount of degradation varies, depending on the circumstances, from insignificant to hazardous (as in Ref. 3). Even though pilots can cope in most circumstances with the task of deciding what is a real part of the external scene and what is a reflection artifact, the extra perceptual load imposed always reduces the amount of cognitive effort available for the pilot to carry out his task of operating the aircraft. In an emergency, deficiencies of this sort may be crucial. The most practicable solution in the case of the Chinook appears to be an aftwards (sliding?) extension of about 300 mm to the coaming glare shield at its centre. The extension needs to be about 500 mm laterally. Some trimming of the outboard aft corners might be acceptable. Fitting would best be done on a trial and error basis with an observer looking from within the design eye point volume. The coaming itself is a source of undesirable reflections from its curved edge which wears to a shine: periodically it should be repainted matt black or have template-cut black flock contact adhesive lining attached.

Reflections were also seen in the chin windows. A septum (a thin sheet of black fibre or other suitable material in this case) was tried as a means of controlling the reflections (as mentioned in Ref. 1); although complete suppression cannot be achieved without some loss of useful external field, certainly a good practical compromise is possible. The septum should be edge on to the nearest pilot's line of sight and should extend vertically from the outboard edge of the outboard heel tray down to the chin window and up to the sideslip ports.

2.2 Reflections in Instrument Cover Glasses

Several pilots complained about reflections in instrument cover glasses. The objects mostly giving images were maps, harnesses and the pilots' clothing. As with the reflections in the cockpit transparencies, the effects can range from insignificant through increased perceptual

load to hazardous. Possible methods of overcoming the problem are:

- (a) In the case of the attitude indicator which is particularly badly affected, the problem occurs because the lighting system uses edge-lit lenses in front of the display. There are three strong reflections and at least two fainter ones visible in the cover glass/lighting lenses and as each air-glass or air-plastics interface reflects about 4%, the total reflectance is at least 12%. The solutions can be one or more of:
 - (i) remove the lighting lens and use external pillar lighting;
 - (ii) coat all reflecting surfaces with vacuum- (or chemically-) deposited anti-reflection layers;
 - (iii) tilt the cover glass (but not the instrument!) to an angle where the reflections are less apparent;
 - (iv) fit blackened horizontal louvres in front of or immediately below the instrument face so that only the louvres are seen in reflection; or
 - (v) fit a better instrument.
- (b) Solutions ii, iii and iv above could be applied where applicable to the remaining instruments on the panel. Some instruments could usefully be tilted together with their cover glasses.
- (c) Press for trial local production of negative (black) maps as the concept has already been demonstrated as valuable in reducing fluctuations in adaptation level in aircraft cockpits at night: the average luminance of the black maps is lower than for white maps under the same illuminance and their reflections in instrument glasses (and cockpit transparencies also) are therefore less of a problem.

2.3 Instrument Panels

2.3.1 Lighting

The Chinook instrument lighting system is basically red. Red was preferred over white as the colour of aircraft instrument lighting several decades ago on the basis of a demonstrable improvement in dark adaptation rates in laboratory experiments. Much effort has gone into attempts to optimize night lighting systems, sometimes with inadequate regard for the practical issues involved. Recently, the practical advantages of white light in the management of aircraft operation have been recognised as outweighing the rather narrow benefits of using red light, and US military aircraft are now tending to be produced with all-white systems. Further accounts of this topic have appeared in

earlier documents from ARL (Refs. 4,5,6). Unless an operational need can be demonstrated for aircrew to have extremely low absolute visual achromatic thresholds when flying the Chinook at night, a somewhat unlikely prospect, the lighting system should be changed to all-white. Red should be retained for warning or hazard indication purposes only.

Inspection of the aircraft and discussion with aircrew both indicated deficiencies in the brightness balance between instruments. For instance, the bearing distance horizontal indicator and the altimeter were considered too bright by comparison with the attitude indicator, and the airspeed indicator was too faint. This sort of problem was experienced in a Nomad N22 during evaluation at ARDU and individual trimming of the instruments was found to overcome the problem (Ref. 5). It is understood that certain recent overseas military aircraft have the lighting of every instrument controllable by screwdriver adjustment so that correct balance will be possible throughout the life of the aircraft. This might be too costly to arrange as a retrofit for the Chinook but some approach to this ideal could be achieved by fixed resistor trimming of individual instruments or groups of instruments.

A related problem was described by aircrew: the transmission oil temperature and pressure switches were not dimmable, nor was the fire warning indicator. The aircrew concerned suggested that the problem could be overcome by using the caution panel dimmer to control these items.

From the left seat, the internal lighting for the barometric pressure setting on the right-side altimeter is a discomfort glare source. It was found possible to shield this source by a technique described in Reference 5: the fitment of a small sheet of dark neoprene (about 30 mm wide and 45 mm high) mounted on edge and vertically, immediately adjacent to the left edge of the altimeter. This shield is small enough to allow the occupant of the left seat to see the altimeter indication by moving head and shoulders a little to the right.

2.3.2 Layout

At the time of the inspection, there was a proposal current to add a cruise guide indicator to the instrument panel. Some changes to the panel layout were envisaged to provide space for the new instrument, and aircrew present during the inspection thought that this would provide a good opportunity for rearrangement of some items on the panel and other minor improvements.

Rearrangement of panel layout would require some brief ergonomic studies to check on the proposed changes, or perhaps even to initiate other proposals. Examples of the minor improvements that seem worth consideration are:

- (i) repaint or replace the engine instrument dials to give upright numerals and legends where this is currently not so because of deliberate rotation of the instrument cases to give pointer alignment for quick check reading;
- (ii) reduce the contrast of the instrument functional grouping borders (as measurements indicated that the borders are more visible than the instruments); and
- (iii) remove the existing skid ball (because of unsatisfactory characteristics) and fit a new type of attitude indicator with a skid ball incorporated, as suggested by aircrew.

2.4 Overhead Transparencies

The overhead transparencies in the aircraft examined were clear, and aircrew questioned about excessive temperatures in the cockpit agreed that some improvement in the thermal environment could be expected by reducing or eliminating the solar radiant heat load through those transparencies. Permanently fitted or applied filters or shades would be undesirable, although some aircrew thought that a 'flow-on' type of filter or dye could be acceptable if not made too dark. Other aircrew suggested motor-operated roller blinds. Some brief practical trials should allow guidance on what further action, if any, should be taken.

3. NIGHT LANDING GUIDANCE

3.1 Historical Notes

Visual approach aids received much attention at ARL from 1956 to 1966. These efforts culminated in the joint development, by ARL and the then Department of Civil Aviation, of the Tee Visual Approach Slope Indicator System (T-VASIS) which, by pilot preference, has progressively displaced other visual approach slope indicators from use at major Australian aerodromes.

There are several ways in which optical devices or light sources on the ground can be arranged to indicate to a pilot of an approaching aircraft when the aircraft is positioned on the correct path for landing. For example, a thin beam of light, such as from a

laser, would suffice, but once an aircraft has departed from the correct path with this system, the pilot would have little or no guidance for regaining the path. (Notwithstanding this, a multiple beam laser landing system is under development in the USSR (Ref. 7).) A variety of systems has been developed to provide guidance information in recent decades. Most of these consist of one or more optical systems (similar to ordinary slide projectors) which project colour or pulse-coded light beams along the approach path. Thus a pilot might see a light which is red if he is low, white if he is on or near the correct approach path, and green if he is too high. Many persons, including the writer, have independently devised systems of this sort. The original inventor is not known. It may be that the idea was used in channel guidance for ships long before successful powered aircraft existed.

In general, projection-type systems give what could be termed 'corridor guidance', akin to a person walking along a corridor in complete darkness. Only on making contact with the boundary, i.e. by seeing a colour change in the projector case or by physically touching the wall in the walking case, is there any indication of position in the corridor. The usual result is that the actual path traversed tends to be oscillatory. Early work at ARL overcame this difficulty in the aircraft landing case with a device called the Precision Visual Glidepath (PVG). The PVG basically consisted of a row of lights on the ground on each side of, and perpendicular to, the runway at the desired touchdown point. Another row of lights, parallel to the first and mounted above ground on poles near the threshold defined the desired plane for the approach. The pole lights were coloured amber and situated further from the runway than the ground lights to help interpretation of the display. This arrangement was chosen to mimic the appearance of the aircraft artificial horizon instrument: if the row of ground lights appeared above the row of pole lights the pilot had to interpret this as indicating that the aircraft was high, and if the ground lights appeared below the pole lights the aircraft was low. The displacement of the pole and ground lights increased with departure from the approach path. Although the PVG is obsolete because of the success of T-VASIS, a system similar in principle (but quite different in origin and layout) is used as a landing aid on aircraft carriers.

The PVG and the aircraft carrier landing aids can be classed as parallax or alignment systems. Systems of this type have also been reinvented in various forms. (Reference 8 describes one of the most recent versions.) The basic principle is quite ancient, as directional indication by alignment of separated objects was used at least as long ago as megalithic times. Despite the good features of the PVG, it did not gain acceptance. Even though the poles were designed and demonstrated to be frangible, they were still thought to be a hazard near airstrips.

T-VASIS was devised to overcome these difficulties. Carefully shielded light sources low on the ground alongside the runway were arranged so that if the pilot is too high on approach, he sees an inverted 'T' which indicates 'overshooting, fly down', and if too low the 'T' is upright and indicates 'undershooting, fly up'. The 'T' shape can be thought of as an arrow which indicates direction to fly; it is therefore easy to remember. However, the continuous position and hence rate information indicated by the PVG is only approximated by the T-VASIS, depending on how many lights are used in the vertical parts of the 'T' and inverted 'T'. Usually three lights are used in each part so that the pilot can see at a glance whether he is in the narrow corridor centred on the approach path or in one or other of the three corridors above or below the approach path. The whole upright 'T' appears red if the pilot sees it from within the lowest corridor.

Other visual approach guidance systems have been developed, notably in the United Kingdom. These systems generally require the pilot to judge whether a pattern of ground lights is all red, all white or partly red and the remainder white, and the pilot has to interpret the display observed as indicating which one of three or more corridors he is currently positioned in, i.e. there is no 'natural' correspondence between the display and the position, unlike the T-VASIS. Recent modifications of the red-white system have improved it considerably (Ref. 9) but it still suffers from potential unserviceability in the not uncommon event of atmospheric haze which, as has happened, can make the white lights appear red: the red 'low' indication can be misinterpreted as a reddened 'high' indication, thus creating a hazard. A further difficulty with red-white or any other systems in which colour discrimination is a primary requirement rather than an additional or secondary cue is that not all pilots, service or civil, can be expected to have normal colour discrimination ability, regardless of passing the usual clinical tests for colour vision defects.

A need for night landing guidance in the tactical (minimal lighting) situation for helicopters and aeroplanes has been evident for many years. Numerous trials reports have appeared in the literature over the past twenty years, and the lack of real progress is evident in the repetition of the type of trial: the aircraft, personnel, units, location and countries change but the devices on test remain basically unchanged. The most extensive practical investigation of the problem to date in Australia appears to be the study by Fuller (Ref. 10) for the Army in 1968. There is little point in repeating any of the tests in Reference 10 except for purposes of comparison with new or improved systems.

3.2 Trials

The information under this heading is from Reference 11 supplemented by the writer's observations.

3.2.1 Description of Devices

The devices used for approach path guidance in the 1977 trials at Amberley were:

- (a) The Bardic Angle of Approach Indicator. This is a projector which shows a red light for 'low', a green light for 'correct' and an amber light for 'high'.
- (b) The McDonnell-Douglas Pulse Coded Optical Landing Aid (PCOLA). It also is a projector, and shows pulsing red for 'low', steady white for 'correct' and pulsing white for 'high'. An attempt has been made to give better position indication by having the pulse rate rapid at the upper and lower boundaries, and lengthening steadily to continuous at the 'correct' boundary.
- (c) 'T' pattern. This is a T-shaped pattern of five lights on the ground. Approach angle is estimated from appearance and experience. A Bardic system may be used in conjunction with this pattern. Note that the lights do not have sharp delimitation at the beam edges and the system is therefore quite unlike the T-VASIS in principle and operation.
- (d) Inverted 'Y' pattern. This also is a pattern of lights on the ground. Four lights are arranged as an inverted 'Y'. It is used like (c).
- (e) The Proportional Landing System (PLS). This system works on the alignment principle like the PVG. Three torches (flashlights) or pairs of torches are held on poles or by three soldiers who have to remain still during the approach.

3.2.2 Results

Not surprisingly, pilots favoured the PLS over the others because of its continuous position and rate display. The Bardic system was considered to present insufficient information. The PCOLA system (not seen by the writer) was thought good in principle by the pilots but further refinement of the presentation was required for the device to be of value as a helicopter night tactical approach aid. The 'T' and inverted 'Y' systems gave only imprecise qualitative information, and did not appear to be of much additional value for approach angle guidance when used with the Bardic system, although azimuth guidance was improved somewhat, especially with the inverted 'Y'.

3.3 Prospects for Improvements

From discussion with helicopter pilots, a night tactical approach guidance system should provide easily interpretable information about the azimuth and elevation deviation of the helicopter from a pre-selected approach path, together with a distance to go or closing speed indication. These requirements have to be met with man-portable, rugged, simple and inexpensive equipment. The difficulty of meeting these requirements to date appears to be one of the reasons why trials of inadequate equipment have been repeated. Even the best device in the trials described (the PLS) can hardly be claimed to provide adequate operational effectiveness and flight safety. It seems that a new approach or at least a considerable improvement on existing devices will be required to meet all or most of the desired logistics and ergonomics requirements. On ergonomics grounds, a variant of the PLS/PVG type of device seems more likely to succeed than derivations of the other devices described above. Having the centre light high instead of the two mounted high at present has obvious logistics advantages and also gives an arrow direction to fly, as in Reference 8. In considering an expansion of the PLS concept, it will be important to provide a means for avoiding the autokinesis illusion which has led to pilot disorientation on approaches to single lights or groups of lights at night. Lights on each side of the landing zone appear desirable for this reason and these could be arranged to give an indication of transit through at least one fixed waypoint on the approach.

It may prove worthwhile to try marks on the windshield for stadiametric ranging in conjunction with the lights at the edge of the landing zone. Although this system has shortcomings such as its sensitivity to yaw, and the need for (ideally simultaneous) observations of alignment error in substantially different directions, nevertheless it does have the virtue of great simplicity. There could also be some value in minimizing the number of lights on the ground by making use of retroreflectors in the landing aid. Light for these would come from the helicopter, thus reducing the logistics problem of battery-powered lights on the ground. The visibility of the helicopter landing lights seen from the ground outside the landing zone could be greatly reduced by the use of a spotlight baffle system recently developed at ARL (Ref. 12).

4. CONCLUSIONS

Inter-Service discussions on helicopter ergonomics problems appear desirable, as many of the visual problems in the Chinook parallel those in the RAN Sea King. Numerous ergonomics problems in the Chinook were investigated in an earlier ARL study and most of these appear still in need of resolution. Visual problems were the main item in the present study. Improvements and solutions are suggested in the aspects

of reflections in transparencies and instrument cover glasses, cockpit lighting, instrument panel layout and overhead transparencies. The requirements, history and some brief trials of tactical night landing guidance systems are discussed and possible improvements to present devices and characteristics required of new devices are suggested. Further trials of night landing guidance systems should avoid unnecessary repetition of earlier trials. Even the best of the systems currently in use cannot be regarded as satisfactory in operational effectiveness or flight safety.

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TABLE 1

ITEM	SUGGESTED ACTION/TRIALS
Inter-Service commonality of ergonomics problems	Hold inter-Service discussions/seminars
Reflections of cockpit interior in transparencies	Extend glare shield Maintain matt black finish on glare shield Fit septa to control chin-window reflections
Reflections in instrument glasses	Anti-reflection coatings on glasses Tilt glasses or instruments where practicable Use external pillar lighting on AI Fit louvres or shields to instrument panel Use blackened harness and clothing Use black maps
Cockpit lighting	Change to all white, leave red for emergency warning Balance instrument lighting, including warning lights Fit louvres or shields to instrument panel
Instrument panel layout	Investigate rearrangement Reorient dial legends and numerals Reduce contrast of functional borders Replace unsatisfactory instruments
Overhead transparencies	Investigate blinds, shades or filters
Night landing guidance	Investigate requirements, improve existing equipment or devise new equipment.

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