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TECHNICAL EVALUATION REPORT ON THE GUIDANCE AND CONTROL OF HELI--ETC(U)
MAY 79 G C HOWELL

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AGARD ADVISORY REPORT No. 142

Technical Evaluation Report on the 27th Guidance and Control Panel Symposium on The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility

NORTH ATLANTIC TREATY ORGANIZATION

ADVISORY GROUP FOR AEROSPACE RESEARCH AND DEVELOPMENT

(ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD)

AGARD Advisory Report No. 142

TECHNICAL EVALUATION REPORT

on the

GUIDANCE AND CONTROL PANEL SYMPOSIUM

on

THE GUIDANCE AND CONTROL OF HELICOPTERS AND V/STOL AIRCRAFT AT NIGHT AND IN POOR VISIBILITY

by

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Royal Aircraft Establishment
Clapham, Bedford MK41 6AE
UK

CONTENTS

The 27th GCP Symposium was held in The Hague, The Netherlands, 9–12 October 1978. The programme as presented at the symposium is appended to this report. The complete compilation of papers has been published as Conference Proceedings CP. 258.

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- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

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TECHNICAL EVALUATION REPORT on the 27TH GUIDANCE AND CONTROL PANEL TECHNICAL MEETING Symposium on THE GUIDANCE AND CONTROL OF HELICOPTERS AND V/STOL AIRCRAFT AT NIGHT AND IN POOR VISIBILITY

1 INTRODUCTION

The 27th GCP Symposium was held in The Hague, The Netherlands, 9-12 October 1978. The programme as presented at the symposium is appended to this report. The complete compilation of papers has been published as Conference Proceedings CP 258.

The technical evaluation for each session has been done partly by the session chairmen and edited into its final form by the programme chairman. In particular this report includes a summary of the final Round Table discussion made by the programme chairman.

The evaluation includes most of the comments and recommendations which were received from the participants in the symposium.

2 THEME AND OBJECTIVES

The desire of operators of all three services of the NATO nations to extend the use of helicopters and V/STOL aircraft into night and conditions of poor visibility has caused an expansion of activity in various technological fields, but most particularly in the electro-optical and radar sensors of various kinds. The integration of these new sensors into modern navigation, flight control and display systems is an important aspect - particularly in helicopters where space and weight are at a premium. Also, the pilot workload is already high in helicopters and V/STOL aircraft near the ground and any new technology must be introduced in a manner to keep the workload within bounds so as not to lose the benefits of the new sensors.

The aims of the conference were to assess where we have reached in trying to meet the stringent operational requirements and whether the new technologies that showed such promise in the Guidance and Control Panel Symposium in Stuttgart, Germany in May 1974 have matured to the extent that they are now offering significant improvements in operational capabilities.

The organisation of the technical programme was arranged to logically progress from the Keynote Address by a very senior service officer to Session I on Operational Requirements through various sub-system aspects to Session VI on System Implementation and finally a Round Table Discussion with the theme, "Have the promised advantages of New Systems, such as electro-optic sensors, led to significant improvements in all weather capability of helicopters and V/STOL aircraft now in the development stage? If not, why not?"

3 TECHNICAL EVALUATION

3.1 Keynote Address

The keynote address was given by Rear Admiral A P Comrie, C.Eng, FIEE, Deputy Controller Aircraft (B), Ministry of Defence (Procurement Executive), UK. It was an extremely good overview of all three armed service requirements to operate Helicopters and V/STOL aircraft at night and in poor visibility and was well received by all participants. The main issues raised in this speech became the thread right through the conference proceedings. He stressed the need to address the man/machine interface aspects when studying new helicopter systems since workload was already high in good daylight conditions in some operations such as nap-of-the-earth flying. He pointed out the need now of the Operational Requirement staff to make decisions on what night vision sensor to go for in the next development programme for Army helicopters for reconnaissance, liaison and anti-armour roles. This urgency for practical information on the state of the art highlighted the relevance and timeliness of the symposium. He paid special attention to the Naval requirements and stressed the need for Helicopter/V/STOL compatibility. He mentioned the way ahead for the Sea Harrier, the first all-weather maritime V/STOL aircraft. In summing up, he stressed the need to extend the helicopter operations into very low visibility and for the Army to fly low. For the Navy the problem is to land on the moving decks of ships and he again stressed the need to make the pilot's task easier not harder. He expressed the opinion that technological developments since 1974 have not been matched by equipments entering service and this apparent shortfall was taken up again in the round table discussion at the end of the symposium.

3.2 Session I Operational Requirements

The paper on "Tactical and Technical Requirements for Guidance and Control of Anti-Tank Helicopters at Night and in Poor Visibility" gave a comprehensive shopping list of Avionic sub-systems which appeared to most delegates to be formidable to the extreme. For instance separate EO aids for the Pilot and Weapon Systems operator, terrain avoidance systems using FLIR/TV plus Laser plus Pilots Night Vision aid based on a modular FLIR system. The authors needed to have looked for ways in which to integrate the functions and address the problems of size and weight.

Col Tirre gave a very good paper on the US Army requirements for Helicopter Flights at Night and in Poor Visibility conditions with special emphasis on the role of crew training. He highlighted the trade-off between system ergonomic design (and hence crew workload) and the training programmes required and even crew selection. With his front line experience (2 tours in Vietnam on Helicopter operations) he made a strong impact on the delegates and punched home the message that the helicopter crews must have better and simpler to use aids to extend the weather minima.

3.3 Session II Controls and Displays

This session addressed two guidance and control system areas, controls and displays, which are both playing an important role in poor visibility operations. As a result of the actual outcome of the call for papers, the scope of all papers, except the last one, was more or less limited to specific system design aspects and components rather than to the performance benefits that the system elements (both controls and displays) can bring about by combination and by use of advanced sensor devices.

The first two papers dealt with helicopter autopilot systems. The first paper reported on a triplex digital autostabilization system as an experimental system which was installed and flight tested in a Sea King helicopter. Much emphasis was given to the evaluation of system behaviour after failure occurrences. The second paper described typical autopilot modes for Naval purposes, the automatic transition and the sonar deployment modes. Design and development aspects were presented.

The next paper which reported on a skewed inertial sensor system, was a little bit remote with respect to the topic of this Symposium. There was no additional paper on navigation. Although it was a paper of high quality, the discussion on this paper suffered from this deficiency.

There were two papers on display aspects in this session, one on a modular raster display system and the second on a night vision system. The latter paper was apparently the best presented one of the session and triggered a very lively discussion. It reported on interesting trials for low-level flight at night investigating a directly viewed television picture on the instrument panel and a pair of passive night goggles mounted on the pilot's helmet. It appeared that this kind of paper was extremely relevant to the overall scope of the symposium.

3.4 Session III Forward Looking Sensors

This session was seen by the Programme Committee to be a key one in that the technological developments of Night Vision and Radar Sensors for piloting aids and weapon aiming in helicopters is a vital area in order to meet the new operational requirements. Five out of the six papers were of high standard and the film and video recordings used as visual aids by authors of papers 31, 32 and 36 showed how the state-of-the-art has progressed in the last few years in the field of FLIR video quality and temperature resolution as well as the novel rotating radar development in the UK.

There was disappointment by the delegates that the latest US capability in FLIR was not presented in this session, whereas the UK produced some very recent trial results. However, the paper 33 by the US Army Avionics centre on the Wire detection capability of a laser sensor and Charged Coupled Devices(CCD) using pattern recognition algorithms was very interesting and promising for the future, The CO_2 laser paper 34 showed promise of better poor weather capability by using 10.6 μm wavelength.

The overall impression of this session was that, in spite of the conference being classified NATO Confidential, only the UK put forward latest test results and the technical state of the art was not really exposed in the presentations. This led to lively discussions which in turn did allow delegates to get a better feel as to where the technology of Forward Looking Sensors had reached relative to the Operational Requirements. The problem of wire detection still seemed to be dominant as far as the nap-of-the-earth flying is concerned although the technology in performance terms showed great promise. The integration of the piloting and weapon aiming requirements still is a problem as is the size and weight. Not enough information was made available on the physical size and weight of development and production type equipment.

3.5 Session IV Man/Machine Aspects

This session was considered to be rather disappointing in relation to the importance of this topic seen by the programme committee and the Keynote Speaker. Two of the papers were on straightforward ergonomic design techniques and did not address the real problems. Paper 42 on Subjective Assessment techniques based on a logical development of structured questionnaires was very well received and provoked a lively discussion including the merits and demerits of the Cooper Harper pilot ratings. The paper 43 on the programmable, multifunction control display unit was interesting and instructive but it was a pity that the author was unable to show a working model as he had planned.

3.6 Session V Landing Operations and Systems

This session on "Landing Operations and systems" of the symposium may be compared with a similar session "Navigation and Guidance" of the 18th meeting of the Guidance and Control Panel held in Stuttgart, Germany in May 1974.

The first paper of the session presented an excellent description of the project "NAVTOLAND." This is the US Navy's approach to improve the helicopter and fixed wing V/STOL aircraft operational capabilities. An integrated development of the aircraft flight control and display system and shipboard and ground based guidance systems and visual landing aids is applied to reduce the operational weather limitations for helicopters and V/STOL aircraft. The ultimate goals for the NAVTOLAND project are zero ceiling and ¼ mile visibility and operation from small ships in a rough sea (sea state 5).

The second paper described a guidance and control unit to be used for all weather approach of aircraft. The unit, consisting of a digital data processor and associated electronics, generates data for a flight director or an autopilot based on MLS- inertial- and barometric data. Flight trials showed, that a preselected curved flight path, both in azimuth and in the vertical plane, can be flown manually with high accuracy using the guidance unit.

The third paper was classified NATO Confidential and it dealt with the recovery of helicopters to small ships. Results of flight trials on the deceleration and approach under instrument meterorological conditions were presented. It was concluded, that operating weather limits can be reduced using presently available radio aids and making better use of displays and autopilot modes.

The fourth paper was also classified NATO Confidential. This paper reported on simulator and flight investigations on the recovery of fixed wing V/STOL aircraft to small ships. An improved approach guidance format on a head up display, developed in conjunction with a suitable approach path profile, was discussed. Further more, the effects of improved visual glide slope indicators on the final visual deceleration of the aircraft was investigated. Also the last paper, presented in this session, dealt with the reduction of weather minima. This paper presented the results of a study to find ways to enable the AV-8B Harrier to operate from ships and forward sites in weather conditions as low as 100 ft ceiling and ¼ mile visibility. This goal should be achieved by application of an attitude hold autopilot, landing aids and displaysand visual aids for ship landings, and forward site landings, thus agreeing with the results of the UK paper.

The papers of this session were of high technical quality and were professionally presented. The presentations of the papers were followed by a moderate to very lively question period. Four out of five papers, presented in this session, dealt with the reduction of the operational weather limits, for helicopters or V/STOL aircraft primarily by improving the handling qualities of the aircraft using autopilots, improving the presentation of data to the pilot through the displays and improving the guidance in the final flight phase after break out through visual aids.

Only the second paper dealt mainly with aircraft guidance at longer distances from the airfield.

In the similar session of the symposium, held in Stuttgart in 1974 all papers were concerned with the development of (approach) guidance systems and radio landing aids.

Comparing these sessions, it may be concluded, that at present the guidance systems for poor weather appraoches are available and now the attention is focussed on the visual deceleration and the actual landing of the aircraft. On the other hand, it may be learned from this session, that the integration of the guidance systems with the aircraft displays and control system has to be improved in order to obtain the required poor weather operational capabilities.

3.7 System Implementation

This session was intended to include papers which addressed the problems of sub-system integration and give practical examples of complete systems in advanced development or even actually in-service. A paper on the Application of Electro Optical Technology to Helicopters was withdrawn, which was a great disappointment to the Programme Chairman. However the three papers that were presented were of a very high standard, both in technical content and presentation. Mr McElreath's presentation was particularly good.

The first paper gave a very thorough insight into the practical problems of integrating a full-time redundant digital fly-by-wire system into a digital data bus based on MIL STD 1553A. This was an excellent treatment of the subject and gave the delegates plenty to think about for future integrated systems. The second paper gave a good account of an excellent piece of precision system engineering design combining a TV Camera with long focal length, laser range finder and a twin focal-lenth FLIR using a mirror stabilisation system. The third paper gave an excellent account of the system thinking behind the actual design of an advanced guidance and control system for Rescue Helicopters.

The discussion period was lively for each paper and in fact could have been longer with effect.

3.8 Round Table Discussion

The Programme Chairman, Mr G C Howell, UK, chaired this session and four Guidance and Control Panel members formed the "round table" or "platform party". They were:

Charles Elliott, Commander US Army Avionics R&D Activity, Fort Monmouth
Ronald Vaughn,Commander Naval Air Development Center
Ir P Ph van den Broek, Department of Aerospace Engineering, University of Delft
Prof Walter Hollister, Department of Aeronautics & Astronautics, MIT

The round table discussion was started by some challenging questions and comments from the platform which were commented on and added to by delegates from the floor. All three Services seem to have some challenging new requirements for Helicopter and V/STOL aircraft operations in the near term: are these likely to be met by the technology in the R&D phase now? Can the Electro-Optic sensors for piloting, weapon aiming and surveillance be integrated or do we have to accept the large weight and space penalty of separate systems? Linked with this question, can E/O sensors be used for NOE (nap of the earth) operations and also for covert landing operations in forward sites? Where is E/O technology going and in particular FLIR? This picked up the question in Admiral Comrie's keynote speech - what can we offer to the small army helicopter in the near future bearing in mind the weight, size and cost constraints? The display of the E/O information on HDD or Helmet displays has yet to be optimised and there are very different conditions to cater for in Night and Day operations.

It was generally felt that the technology is now very good and has matured. For instance LLTV and Image Intensifiers are in service and FLIR is well on the way. Some integration has been attained such as Laser/IR combinations and the requirements of E/O systems for flight control is becoming well-established. However, there is a tendency for technological solutions to be chasing problems! There are some difficult problems that have no immediate solutions available, eg NOE and contour flying. Helicopters need to be flown at 3 to 5 metres altitude and at the moment 100 feet is difficult over known terrain in some cases. Another problem is the Field of View of these sensors and we still need to confirm that the introduction of symbology of flight parameters in the two dimensional video scene can replace the real outside scene. IR sensors cannot see through cloud and so Night/Cloud capable sensors in the nose may be necessary but these can be costly (the rotating blade radar shows a promising alternative).

Wire detection has still not been demonstrated in an operational system and so helicopters are still forced to fly high. Laser solutions show some promise but the technology is still very short from meeting the real operational requirements.

There is still a lack of low cost and low weight navigation aids. Simple systems should be sought and could be a spin off from work on more complex solutions but there is some opinion that systems such as simpler doppler radar should be explored.

The V/STOL aircraft all-weather operational requirements range from 100 ft ht/¼ mile visibility (UK Sea Harrier) to zero/zero (US ultimate requirement). The difficulties arise during the transition phase in IFR. Night and low visibility systems for V/STOL aircraft need more work to reduce minima and keep pilot workload at a reasonable level. Payload/fuel consumption trade-offs need exploring to optimise transition manoeuvres and the pitching decks of air capable ships present a formidable problem for landing systems. More information on actual pitching is required.

Other points which were aired in the general discussion were:

1 Should we seriously consider aircrew dedicated to certain missions (easing training and system problems) and even more controversial - should we go towards aircraft systems dedicated to specific missions rather than the current trend to ask for the near impossible by defining multi-role requirements?

2 Displays for the new sensors seem to be lagging behind the sensor developments.

3 Small helicopters need special consideration because of space and weight constraints.

4 Multiple uses of lasers, etc is a MUST to get the best out of these new sensors.

5 Fields of View of the EO and Radar Sensors for piloting and weapon aiming need reconciling but Laser designators and rangers neet to have narrow FOV but need to be integrated with EO sensors if possible. New developments in this integrated concept need to be supported.

4 CONCLUSIONS, RECOMMENDATIONS AND GENERAL COMMENTS

This section has been produced by extracting general and technical observations made by observers, speakers and session chairmen based on a Proforma (Appendix 2).

In general the quality of the papers was good and the delegates found the structure of the sessions good and the round table discussion at the end was very good. In fact the question times were a bit too short and the number of papers perhaps too great. On a number of occasions, the discussion was just getting properly underway when the session chairman had to terminate it through lack of time. The classification of NATO Confidential was justified in that it allowed freer discussion. However, a number of the papers were produced as Unclassified and consequently did not give enough up-to-date technical and operational information. The subject was obviously of great interest to the NATO nations since the limited seating capacity in the conference room meant that each nation was

rationed to a certain total number of attendees and the UK for example, had twice the number wishing to go than the allocation. Other nations were in the same situation. With a full house, the observers joined in discussions vigourously and the formal and informal exchange of views was very effective. Most delegates found the conference very well worth attending although there were some significant criticisms.

The operational issues were foremost in a lot of observers minds and the Keynote speech was particularly good and formed the background to the rest of the conference. The severe requirements set by the military were challenged in that to meet them, very expensive technological solutions were necessary. It was felt that some trade off of cost/effectiveness should be done.

The key technology in the conference was Electro Optic sensors and it was disappointing to many delegates that the US did not give much information on an area in which they are known to be doing a lot of work. In contrast, the UK did produce some up-to-date information. One area that was weak was the target acquisition aspects of the use of FLIR in terms of required resolution, FOV, FOR, etc of the EO Sensors/radar. The impact of such target acquisition requirements on the display design requirements (HUD, HDD and Helmet sights) in terms of format, size, viewing distance etc, were not touched on very much and this would have forced discussion of the man (pilot/weapon aimer) as an integral component of the overall weapon system. In fact the session on man/machine interface was the most disappointing. The general feeling was that technology has progressed a long way since the last conference on this subject in 1974, but it was not necessarily being directed properly to meet the real operational requirements. It is vital to reassess some of the current R&D programmes with a view to producing practical systems that are small enough and light enough to fit in small helicopters.

The major challenge now is to get the system performance of current experimental hardware in more compact form and to reduce pilot workload during nap of the earth operations.

There is room for debate on how far to go in all-weather landing minima for V/STOL operations on small ships. The ultimate zero/zero system is very expensive and there was a view expressed that some reduced capability between current Sea Harrier (100 ft ¼ mile visibility) and the NAVTOLAND target of zero/zero might be optimum. In any case the problem of ship motion in high sea states still needs tackling as part of the all-weather V/STOL aircraft recovery package.

There is still plenty of scope for more system integration with a view to simplifying the overall system and making it easier to use by the crew. It was clear that this difficult area is being worked on by a number of nations and it is to be hoped that a common digital data bus in the form of MIL STD 1553A will be used in future to ensure interoperability and some standardization.

Most delegates felt that the topic of this symposium should be addressed again in three years time with a view to discussing the systems in service or advanced state of development rather than basic technology.

The host country, The Netherlands, must be congratulated for such a good location and logistic and social arrangements. It was just a pity that the conference room was limited to about 130 seats. In future the C&C Panel should aim for 200 minimum capacity with 230 or so possible. Some of the authors still ignored the instructions from AGARD with regard to oral presentations, visual aids etc. It is to be hoped that shorter, simpler and definite guidelines should be given in the future to make the oral presentations better with good visual aids. Some of the presentations were very good indeed in this respect and these are the papers that are remembered.

APPENDIX 1

'FINAL PROGRAMME

OPENING CEREMONY — Reference

KEYNOTE ADDRESS by Rear Admiral A P Comrie, MOD(PE), UK

MONDAY 9 OCTOBER

SESSION I - OPERATIONAL REQUIREMENTS
Chairman: G C Howell, UK

TACTICAL AND TECHNICAL REQUIREMENTS FOR GUIDANCE AND CONTROL OF ANTI-TANK HELICOPTERS AT NIGHT AND IN POOR VISIBILITY
by U Walther, S Attlfellner, H Kilger, MBB-UD, Ottobrunn, FRG — 11

US ARMY REQUIREMENTS FOR HELICOPTERS FLIGHTS AT NIGHT AND IN POOR VISIBILITY CONDITIONS
by Colonel J C Tirre, US Army Training & Doctrine Command, Ft Monroe, UK — 12

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by J Meadows, Smiths Industries, Ltd and P Robinson, RAE, Farnborough, UK — 21

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by K Snelling and M V Cook, Marconi Elliott, UK — 22

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by R E Ebner, Litton Systems Inc, and W E Howell, NASA Langley, US — 23

SCAN CONVERTERS AND RASTER DISPLAY CONTROLLER FOR NIGHT VISION DISPLAY SYSTEMS
by H W Killiam, and W Voswinckel, Dornier, FRG — 24

NIGHT VISION PILOTING SYSTEMS FOR LOW LEVEL HELICOPTER OPERATIONS
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Chairman: M Powley, UK

AN EXPERIMENTAL WIDE FIELD OF VIEW THERMAL IMAGER FOR INVESTIGATING THE POTENTIAL USE OF FLIR'S AS HELICOPTER PILOT AIDS
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by D Griffiths and D J Young, RSRE, and M I Bell and R A Browning, Barr and Stroud Ltd, UK — 32

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by A Kleider, US Army Avionics R&D Activity, US — 33

HETERODYNING CO_2 LASER RADAR FOR AIRBORNE APPLICATIONS
by R L Delboca, US Army Avionics R&D Activity, and R J Mongeon, United Technologies Research Center, US — 34

A SELF-CONTAINED COLLISION AVOIDANCE SYSTEM FOR HELICOPTERS
by S Bloch, G K Hoefgen and D Zur Heiden, Standard Elektrik Lorenz AG, FRG — 35

A HELICOPTER ROTOR BLADE HIGH DEFINITION RADAR - DESCRIPTION OF SYSTEM WITH FLIGHT TRIAL RESULTS
by C M Stewart and J M Robinson, Ferranti Ltd, UK — 36

WEDNESDAY 11 OCTOBER

Reference

SESSION IV - MAN/MACHINE ASPECTS
Chairman: W M Hollister, US

SESSION V - LANDING OPERATIONS AND SYSTEMS
Chairman: P Ph van den Broek, NL

THURSDAY 12 OCTOBER

SESSION VI - SYSTEM IMPLEMENTATION
Chairman: M Pelegrin FR

ROUND TABLE DISCUSSION

Theme: Have the Promised Advantages of New Systems, such as electro-optic sensors, led to significant improvements in all weather capability of helicopters and V/STOL aircraft now in the development stage: If not, why not?

APPENDIX 2

COMMENTS ON AGARD GCP 27TH SYMPOSIUM

THE GUIDANCE AND CONTROL OF HELICOPTERS AND V/STOL AIRCRAFT
AT NIGHT AND IN POOR VISIBILITY

THE HAGUE, NETHERLANDS 9-12 OCTOBER 1978

TO ALL ATTENDEES

Considerable time and effort was expended by a number of countries in the organization and hosting of this symposium. As a result, the Program Committee Chairman is obligated to prepare an evaluation report. To aid him in preparing a timely, meaningful report, and since we have assembled here leading technical experts in the field, we solicit any feedback or comments you may desire to submit. These may be handwritten notes, and anonymous. If you have any questions, please contact the AGARD staff, the Program or Panel Chairman.

The following are typical examples of areas in which observations, comments and assessments are desired:

(a) General Observations

1 Quality, and relevance of papers, sessions and questions

2 Did papers support the theme?

3 Did symposium live up to your expectations?

(b) Technical Observations

1 Views on operational issues and requirements

2 Assessment of technology (state-of-the-art)

3 Views on pacing technology or critical need for R&D

4 What do you see as major challenges and trends?

5 Views on systems integration aspects

6 What area or problem(s) are unresolved?

7 What future or further action should NATO and AGARD undertake in this area?

(c) Suggested improvements for symposium (new or special topics, procedures for enrolment, authors' instructions, logistics, etc).

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14. Abstract

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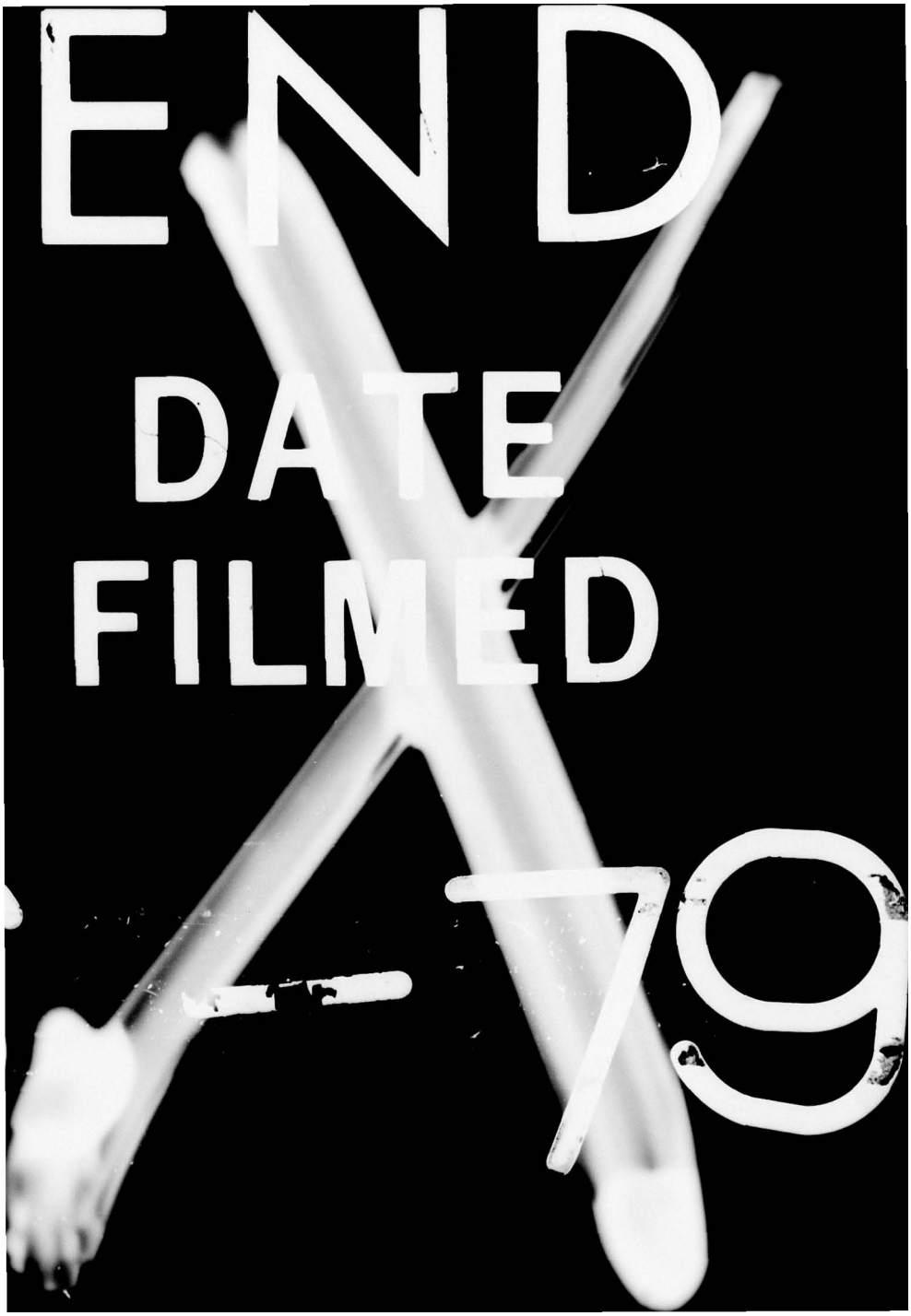
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E R R A T U M

to AGARD Advisory Report No 142 entitled Technical Evaluation Report on the 27th Guidance and Control Panel Symposium on The Guidance and Control of Helicopters and V/STOL Aircraft at Night and in Poor Visibility.

The above publication should be amended as follows:

Page 4: Paragraph 6, should read:

"The V/STOL aircraft all-weather operational requirements range from 200 ft ht/½ mile visibility (UK Sea Harrier) ....."

Page 5: Paragraph 5 should read:

"There is room for debate on how far to go in all-weather landing minima for V/STOL operation on small ships. The ultimate zero/zero system is very expensive and there was a view expressed that some reduced capability between current Sea Harrier (200 ft.ht/½ mile visibility) ....."

AGARD
August 1979