

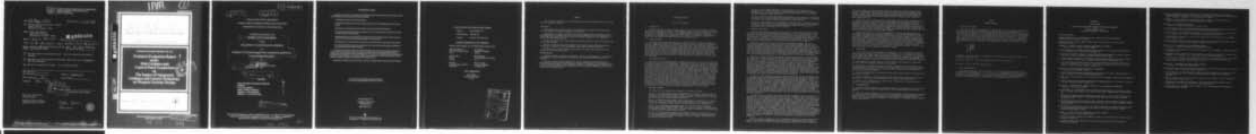
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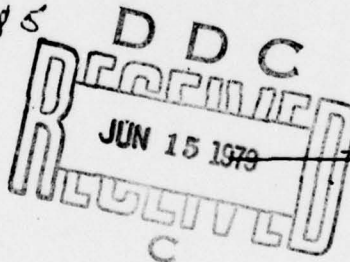
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AGARD ADVISORY REPORT No. 140

**Technical Evaluation Report
on the
26th Guidance and
Control Panel Symposium
on
The Impact of Integrated
Guidance and Control Technology
on Weapons Systems Design**

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AGARD Advisory Report No.140

6

TECHNICAL EVALUATION REPORT
on the
26th GUIDANCE AND CONTROL PANEL SYMPOSIUM
on
THE IMPACT OF INTEGRATED GUIDANCE AND CONTROL TECHNOLOGY
ON WEAPONS SYSTEMS DESIGN

by

10 A. Ostgaard
Air Force Flight Dynamics Laboratory
USA
Morris

9 Advisory rept.
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The 26th GCP Symposium was held in Sandefjord, Norway, 9-12 May 1978. The program as presented at the symposium is appended to this report. The complete compilation of papers has been published as Conference Proceedings CP-257.

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- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- 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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SUMMARY

The following summarizes the significant conclusions and recommendations resulting from the Technical Evaluation.

CONCLUSIONS

There appears to be heavy reliance on well-defined requirements and operational concepts before technology innovations are stimulated.

Technology will support increased functional integration and standardization for interoperability as evidenced by the use of a common Kalman filter for several positioning systems and multiple use of the horizontal station display for both command and control and map display purposes.

Mission tailored control laws properly supported by mission display information can reduce pilot workload.

Missile systems are critically depended upon positioning systems and functional integration to satisfy critical performance cost, weight, volume constraints.

Multiple use of common sensors, particularly for control and positioning, were shown to be technically practical.

RECOMMENDATIONS

Consider holding a symposia or specialists meeting on advancements in visualization techniques for multi-mission and multi-function use of common display devices and controls.

Establish a panel working group on functional integration of positioning and guidance and control systems to determine a structure or framework for implementation and use of common elements, with particular emphasis on defining areas of standardization of architecture that will permit introduction of new systems of technology without complete system reconfiguration.

EVALUATION REPORT

by

Morris A. Ostgaard

1. INTRODUCTION

The 26th Guidance and Control Panel Symposium on the Impact of Integrated Guidance and Control Technology on Weapon Systems Design was held at the Park Hotel, Sandefjord, Norway, from 9 through 12 May 1978. The program Chairman for this meeting was Mr. Morris A. Ostgaard from the Air Force Flight Dynamics Laboratory. The program as presented at the symposium is appended to this report. The complete compilation of papers will be published as AGARD Conference Proceedings CP-257.

2. SYMPOSIUM THEME

The rapidly developing technologies in navigation sensors, target identification sensors, command and control, and computation capability are structuring a command network that demands increased functional integration of the crew station and control configuration to permit effective use of that technology. This technology when combined with the advancing technology in guidance and control, the driving forces of acquisition and life cycle cost, needs for operational and tactical flexibility, survivability/vulnerability, and critical volume and weight constraints dictates the need for integrated guidance and control at a higher functional level than heretofore considered. This higher functional level involves an effective blend of the sensor, vehicle, and kill mechanism that can provide a multi role capability for advanced and present operational vehicles.

3. THE PURPOSE AND SCOPE

The purpose of this symposium was to address the subject so as to insure effective employment of the advancing technologies. Furthermore, when one considers a large array of sensors available and the fundamental commonality of functions and control algorithms for different missions, it appears logical that these capabilities should be utilized to augment each other to achieve flexibility and growth capability. Discussions were held after each paper unless similarity in subject but different approach suggested holding questions until both points of view were presented. These discussions quickly identified some of the critical issues and did open up some controversial areas. However, time was insufficient to deal with all these controversial areas in detail. In addition, there was considerable discussions after the meetings and during various breaks between the various authors and observers involved in the meeting which were found to be extremely beneficial. In addition there are, however, traditional discussions in this area that have been published and argued for years. This evaluation will discuss the conference from the viewpoints of views on operational issues and requirements, state-of-the-art assessment of technology, identification of pacing technology or critical needs for research and development, major challenges and trends, integration concepts and issues and problems or unresolved areas of concern, and finally provide an assessment of the technical material presented and formulate recommendations for future action.

4. SYMPOSIUM PROGRAM

The program of this symposium was arranged in 7 specific sessions:

Session I, *Functional Design Concepts Requirements and Trends*, included papers on concepts for future airborne weapon systems in the air to ground missions, advanced navigation and targeting technology, terrain-following system design, and cost design advantages for standard electronic modules.

Session II, *Weapon Delivery Flight Control Integration*, included papers on global positioning concepts, dual mode guidance system schemes, use of lasers as a low flying aid, and digital flight control system architecture and implementation.

Session III, *Communications/Command/Control (C³) and Sensor Data Integration*, included papers on integrated flight trajectory control concepts, strapdown navigation guidance systems, multi function inertial reference assemblies, and application of parallel filters for malfunction detection.

Session IV, *Crew System Configuration and Display Concepts*, included papers on control display concepts for combat aircraft, effects of advanced navigation display on system design, interactive color graphics system for display, and methods for validating synthesized images.

Session V, *Pilot System Interaction*, included papers on considerations for implementation of integrated mission tailored flight control modes, pilot/missile interaction for low cost missiles, target marker placement and cockpit designs for high performance combat aircraft.

Session VI, *Data Processing and Distribution System*, covered topics on microprocessor application in tactical missiles, realizable software architecture for guidance and control, and expanded digital computers in tactical missiles.

Session VII, *Development and Test Experiences*, included areas of dynamic simulation of multi sensors, use of RF homing guidance for control simulation, laser designator weapon system simulation, display assessment simulation, and flight test experiences with the Toronado Avionic System.

5. TECHNICAL EVALUATION

Because of the scope and duration of the session, and the fact that it was classified, no notes could be taken during the presentation. It is extremely difficult for one person to assess and address all issues and concerns which were discussed. In an attempt to aid the evaluator in gathering necessary data and providing a consensus of the conferees, a "Reviewer's" form was developed which is attached as Appendix 2 of this report. This approach has been quite successful in providing many of the comments, observations, and assessments in the various technical areas of this report.

The keynote address entitled, "The Impact of Integrated Guidance and Control Technology on Weapons System Design", was delivered by Colonel Eugene DeNezza of the European Office of Research and Development. This address stressed potential areas for future developments, and opportunities for functional integration of these functions to increase capability and reduce the equipment complement. This address was very well received by the participants and was discussed in considerable length throughout the meeting. The address also stressed the urgent need for cooperative R&D efforts among NATO countries to reduce national costs by minimizing duplication but also to provide a mechanism for increasing standardization and interoperability of functions and equipment.

Session I covered, primarily, functional design concepts, trends, and requirements. The papers were presented by military leaders or their representatives from the various NATO countries. As you would expect, the requirements discussions were largely conceptual and, in most cases, not well defined; however, there was a consensus and general reaction that increased functional integration is needed to insure well designed application of advanced technologies. Several new weapons concepts for advanced navigation and guidance and targeting technology were presented in terms of the weapons themselves which were extremely interesting and did provide some insight into some future potential capabilities. An assessment of the effect terrain following system can have on reducing aircraft vulnerability illustrated the need for low altitude operation to assure survivability in the intense ground defense environment. This paper was probably the highlight of the session and identified specific areas for terrain following system designs that have needed integrity and acceptable performance.

Session II dealt primarily with weapon delivery and flight control integration. Two of the papers dealt with the application of global positioning systems as a positioning information capability for tactical missile guidance which was of extreme interest because of the high precision of the global positioning system capability. A dual mode guidance scheme which achieves a desired impact condition for terminal homing was also of interest indicates that with proper integration dual mode guidance can be achieved in small tactical missiles. The concept of a more global system architecture and implementation was presented to show a method of efficiently integrating the weapon delivery and guidance and control system capability. Finally, the use of laser as a low flying aid was presented. The highlight of this session was the interest and need for further investigation of global positioning systems for tactical missile guidance and a distinct need for system architecture implementation that can efficiently provide precision weapon delivery capability.

Session III dealt primarily with sensor and data integration and, in particular, the benefits that can be achieved by multi use of sensors. The first paper dealt with a demonstration of an integrated flight trajectory control concept that can provide precise time-space positioning for guidance and weapon delivery. This paper was of considerable interest because it described a method where a common Kalman filter could be used with several positioning systems and a common display for horizontal selection and the joint tactical information distribution systems. Two other papers dealt with strapdown navigation and guidance for control configured vehicles and a multi function inertial reference assembly which integrates information from both inertial and air data sources and intrinsically provides the information sources vehicle for stabilization and navigation in one unit. And finally, the conceptual paper on the application of filters as observers to provide a means of malfunction detection and alternate mode capability. The highlight of this session was the potential capability for effectively employing the command and control network by superimposing this information upon an autonomous inertial navigation capability aboard the vehicle to assure both cooperative and autonomous operational capability.

Session V dealt predominantly with visualization concepts and pilot systems interaction. Of particular interest here was the concept of integrated mission tailored flight control modes to reduce the pilot workload and enhance pilot control capability,

and a new concept for pilot interaction with low cost missile control concepts; and finally, an instrument capability for evaluating cockpit and high performance combat aircraft capabilities. The significant area of concern and one of a high degree of interest was the implication and performance capabilities that could be achieved with mission tailored flight control modes, particularly for weapon delivery capability with reduced workload.

Session VI dealt primarily with data processing and distribution systems with the predominant interest on the application of microprocessors to guidance and control problems of tactical missiles. Of particular interest was the conceptual paper on an effective and reliable hardware/software architecture for guidance and control on missiles and the capability to achieve an expandable computer capability by appropriate trade-offs between system software and hardware. The particular item of concern and of keen interest in this session was the trends and trade-offs between software and hardware and the capability to validate these concepts.

Session VII provided a review of development and system test experiences with development and production concepts of integration. This session stressed two parts of the overall development and test experiences, the first being dynamic simulation of multi sensor communications, the application of radio frequency homing as a simulation technique, and a mission simulation as an aid to assess various display capabilities. Most significant, and probably the highlight of this session, was the excellent presentation of flight testing of the Tornado Avionics System and the extensive integration that had been performed in the system to provide the multi role capability. In essence, this session tended to show the potential increased performance and cost reduction capabilities that can be achieved by appropriate functional integration of sensors, the data processing, with the guidance and control systems.

6. CONCLUSIONS

One of the most difficult aspects in establishing a set of conclusions is to base these conclusions solely on the results of a conference. In a classified conference of this type with a large number of disciplines represented, it is difficult to maintain the necessary objectivity. The following conclusions and recommendations represent the best summation possible by the author but may not necessarily contain an awareness of other issues that may, or may not, be gleaned from the conference proceedings themselves.

6.1 There appears to be heavy reliance on well-defined requirements and operational concepts before technology innovations are stimulated.

6.2 Technology will support increased functional integration and standardization for interoperability as evidenced by the use of a common Kalman filter for several positioning systems and multiple use of the horizontal station display for both command and control and map display purposes.

6.3 Mission tailored control laws properly supported by mission display information can reduce pilot workload.

6.4 Missile systems are critically depended upon positioning systems and functional integration to satisfy critical performance cost, weight, volume constraints.

6.5 Multiple use of common sensors, particularly for control and positioning, were shown to be technically practical.

7. RECOMMENDATIONS

7.1 Consider holding a symposia or specialists meeting on advancements in visualization techniques for multi-mission and multi-function use of common display devices and controls.

7.2 Establish a panel working group on functional integration of positioning and guidance and control systems to determine a structure or framework for implementation and use of common elements, with particular emphasis on defining areas of standardization of architecture that will permit introduction of new systems of technology without complete system reconfiguration.

ANNEX

GENERAL COMMENTS

1. SELECTION OF PAPERS

Over 40 abstracts were received in response that called for papers, some of which were received too late for consideration at the meeting of the program committee. A committee had a difficult task in selecting approximately 25 papers which was considered to be the optimal number for a 4 day symposium, and was obliged to reject a large number of the abstracts submitted. The objectives were to provide a selection of high quality papers for each of the sessions that would fit well within the theme of the meeting and give a good impression of the range of interest and quality of work in the countries participating. In a few cases it was found possible to combine a small number of individual proposals into a joint paper. The distribution of papers per country is shown below:

1	Canada
1	France
2	Germany
1	Norway
8	UK
15	US

Attendance: The total number of participants was 157 including 24 panel members. The National distribution was:

Belgium 2; Canada 3; France 19; Germany 19, Italy 8; Netherlands 4;

Norway 23; UK 42, US 36; NATO Organizations 1.

2. LOCAL ARRANGEMENTS:

The symposium was held in the Park Hotel. The facilities were excellent and the Norwegian host coordinator, Mr. F. A. Ostern, is to be congratulated on the thoroughness and success of the arrangements. Mr. H. K. Johansen, Norwegian National Delegate, presented the opening address. Participants were entertained at an official reception hosted by the Norwegian Defence Establishment and Norwegian aerospace industry.

APPENDIX I
FINAL PROGRAM

THE IMPACT OF INTEGRATED GUIDANCE AND CONTROL TECHNOLOGY
ON
WEAPONS SYSTEMS DESIGN
Sandefjord, Norway, 8 - 12 May 1978

Opening Ceremonies.

Opening Address by Mr H K Johansen, National Defence Research Establishment,
Norwegian National Delegate to AGARD.

Keynote Address by Colonel Eugene DeNezza, USAF, European Office of Research and
Development, London.

SESSION I - FUNCTIONAL DESIGN CONCEPTS, REQUIREMENTS AND TRENDS

Chairman: Mr G C Howell, United Kingdom

- The Requirements for Future Airborne Weapon Systems in Air-to-Ground Attack Mission
by A C Machin, Royal Aircraft Establishment, UK;
- New Weapon Concepts Developed for Advanced Navigation Guidance and Targeting Techno-
logy, by H E Brown, Armament Development and Test Center, USAF;
- An Assessment of the Effects of Terrain Following System Design on Aircraft Vulnerabi-
lity to Ground Defences, by P R Laughton, Royal Aircraft Establishment, UK;
- Cost and Design Advantages Derived from the Standard Electronic Modules Program, by
D Gold, US Department of the Navy, J M Kucharski, EG&G Washington Analytical Services
Center, Inc, and D R Bates, Raytheon Company, US;

SESSION II - WEAPON DELIVERY/FLIGHT CONTROL INTEGRATION

Chairman: Mr A Schjetne, Norway

- Global Positioning System Tactical Missile Guidance by F W Hardy, Hughes Aircraft Co,
and C D DePriest, Air Force Armament Laboratory, US;
- The Use of a Laser Ranger as a Low Flying Aid, by P R Laughton, Royal Aircraft Establish-
ment, UK;
- Digital Flight Control System Architecture and Implementation, by G Belcher, P A Daniell,
E M Scott, Marconi Elliott Avionics, UK;

SESSION III - COMMUNICATIONS, COMMAND, CONTROL (C³) AND SENSOR DATA INTEGRATION

Chairman: Dr H Sorg, Germany

- Development of the Integrated Flight Trajectory Control Concept, by M W Bird, L Addis,
and G L Comegys, Lear Siegler, Inc, and W L Young, USAF Flight Dynamics Laboratory/FGL,
US;
- Redundant Strapdown Navigation, Guidance, and Control of a Control Configured Vehicle
by W J Kubbat, Messerschmitt - Bölkow-Blohm GmbH, Germany and G A Napjus, Teledyne
Systems Co, US;
- Preliminary Feasibility Assessment of Multi-Function Inertial Reference Assembly (MIRA),
by J M Perdzock, Air Force Flight Dynamics Laboratory, and R C Burns, McDonnell Douglas
Corporation, US;
- Application of Parallel Filters for Malfunction Detection and Alternate Mode Capability
in an Integrated Navigation System, by T Smestad and O Ørpen, Norwegian Defence
Research Establishment, Norway;

SESSION IV - CREW STATION CONFIGURATIONS AND DISPLAY CONCEPTS

Chairman: Mr L J Urban, United States

- Control and Display Concepts for Combat Aircraft, by R H Holmes, Marconi Elliott Avionic
Systems, Limited, UK;
- An Advanced Navigation Display and Its Effect on System Design, by W H McKinlay,
Ferranti Limited, UK;

- Design Consideration for an Interactive Color Graphics System for the Display of Situation/Command Information, by H G Bown, and W Sawchuk, Department of Communications, and W T MacKenzie, Department of National Defence, Canada;
- Methods for the Validation of Synthesized Images in Visual Flight Simulation, by G Dörfel, Forschungsinstitut für Anthropotechnik, Germany;

SESSION V - PILOT/SYSTEM INTERACTION

Chairman: Professor W M Hollister, United States

- Design Considerations for Implementing Integrated Mission-Tailored Flight Control Modes, by J K Ramage, and F R Swortzel, USAF Flight Dynamics Laboratory, US;
- A New Concept in Pilot/Missile Interaction for the Low Cost Lightweight Missile (LCLM) by J L Johnson, and G Ritsi, Ford Aerospace and Communications Co, US;
- Target Marker Placement for Dive-Toss Deliveries with Wings Non-Level, by J S Ausman, Litton Systems, Inc, US;
- An Instrumented Mockup for Evaluating the Cockpit of a High Performance Combat Aircraft, by J W Lyons, and G Roe, Hawker Siddeley Aviation Limited, UK;

SESSION VI - DATA PROCESSING AND DISTRIBUTION SYSTEMS

Chairman: Ingénieur Principal B Vandecasteele, France

- The Impact of Microprocessors on Tactical Missiles, by K D Dannenberg, Computer Sciences Corporation, US;
- Expendable Digital Computers in Tactical Missiles, Trends and Tradeoffs in Software and Hardware, by H A Maurer, and K S Kongelbeck, Hughes Aircraft Company, US;
- A Reliable and Survivable Data Transmission System for Avionics Processing, by D R Powell and J C Laprie, Laboratoire d'Automatique et d'Analyse des Systèmes du CNRS, and, P Romand and G Alcouffe, Société Crouzet, France

SESSION VII - DEVELOPMENT AND SYSTEM TEST EXPERIENCES

Chairman: Mr P Kant, The Netherlands

- Dynamic Simulation of a Multi-Sensor Communication and Navigation System, by J N Frisina, W J Steele, and J I Schlenger, Singer Kearfott, US;
- Radio Frequency (RF) Homing Missile Guidance and Control Simulation Techniques, Facilities and Experiences, by G D Swetnam, Boeing Aerospace Company, and F M Belrose, MIRADCOM, US;
- Mission Simulation as an Aid to Display Assessment, by P Beckett, and D E A Houghton, British Aircraft Corporation, UK;
- Development and System Test Experience on the Light Airborne Multipurpose System (LAMPS) MK-III H-3 E/M, by J H Crenshaw, IBM Corporation, US;
- Flight Testing of the TORNADO Avionic System, by E S Hagen Lamatsch, Messerschmitt-Bolkow-Blohm GmbH, Germany.

APPENDIX II
(EVALUATION FORM)

COMMENTS ON AGARD GCP SYMPOSIUM
Sandefjord, Norway, 9 - 12 May 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

Views on operational use and requirements;
Assessment of technology (State-of-the-Art);
Views on pacing technology or critical need for R&D;
What do you see as major challenges and trends?
Views on systems integration aspects;
What area or problems are unresolved?

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

Please write your comments overleaf and hand them in
to the Authors' Desk before the end of the Symposium.
Thank you for your contribution and cooperation.

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