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ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT
7 RUE ANCELLE 92200 NEUILLY SUR SEINE FRANCE

AGARD ADVISORY REPORT 284

Technical Evaluation Report on Knowledge Based System Applications for Guidance and Control

(Application des Systèmes à Base de Connaissances au Guidage-Pilotage)

NORTH ATLANTIC TREATY ORGANIZATION

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Technical Evaluation Report on
Knowledge Based System Applications for Guidance and Control

(Application des Systèmes à Base de Connaissances au Guidage-Pilotage)

by

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The Guidance and Control Panel's 51st Symposium was held at the Instituto Nacional de Industria, Madrid, Spain from 18th to 21st September 19
All papers presented at the Symposium were compiled as Conference Proceedings CP 474.

North Atlantic Treaty Organization
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Preface

The combination of increasing military system and task complexity, in the face of inherent human limitations has set the stage for development of innovative system integration approaches involving the use of knowledge based technology. The field of Artificial Intelligence (AI) is becoming solidified as a science and the technological aspects are developing rapidly. The implications for guidance and control are enormous. Practical applications of AI are critically dependent on advanced architectures, computer processing techniques and integration concepts. Recent advances in digital computation techniques including data base management, represent the core enabling technology necessary for the development of highly innovative design concepts, which will ultimately lead to major new military capabilities. Efficient tactical information management and effective pilot interaction are essential. Pilot decision aiding, combat automation, sensor fusion and on-board tactical battle management concepts offer the opportunity for substantial mission effectiveness improvements. Although real-time tactical military applications are relatively few in number, several exploratory and advanced development efforts are underway. Practical military applications of AI technology are of primary interest. Projected military capability enhancements along with AI limitations were considered. Operational implications, and critical design trade-offs were also emphasized. This symposium provided a timely forum for assessing the overall state-of-the-art of AI applications in the guidance and control area.

A round table discussion to identify application issues and opportunities was held.

Préface

La complexité croissante des tâches militaires et des systèmes d'armes face aux limites inhérentes aux capacités humaines, a préparé le terrain pour le développement d'approches novatrices recourant aux techniques des systèmes à base de connaissances. Le domaine de l'intelligence artificielle s'affirme en tant que science dont les éléments technologiques évoluent très rapidement. Les conséquences pour le guidage et le pilotage sont considérables. Les applications pratiques de l'intelligence artificielle sont directement tributaires des améliorations des architectures, des techniques du traitement des données par ordinateur et des concepts d'intégration. Les progrès récents dans le domaine des techniques de calcul numériques, y compris la gestion de bases de données, représentent le noyau technologique indispensable au développement de concepts hautement novateurs, qui déboucheront, à terme, sur de nouvelles et importantes applications militaires. La gestion efficace des informations tactiques et la bonne interaction pilote-système sont essentielles. L'aide à la décision pour le pilote, l'automatisation du combat, la fusion des capteurs et les concepts de la gestion tactique de la bataille par des moyens embarqués ouvrent la voie à une amélioration substantielle de l'efficacité opérationnelle. Bien que les applications temps réel soient encore relativement rares, un certain nombre de projets de développements, tant exploratoires qu'avancés, sont en cours à l'heure actuelle. Les applications militaires des technologies de l'intelligence artificielle sont d'un intérêt primordial. Les améliorations attendues de l'efficacité des moyens militaires ont été examinées conjointement avec les limitations prévisibles de l'intelligence artificielle. Les implications opérationnelles et les compromis critiques établis lors de la conception des systèmes ont fait l'objet d'une analyse particulière. Ce symposium a été ainsi l'occasion pour faire l'évaluation de l'état de l'art des applications de l'intelligence artificielle dans le domaine du guidage et du pilotage.

Une table ronde s'est tenue dans le but de faire émerger les applications potentielles.

Guidance and Control Panel

ACKNOWLEDGEMENTS/REMERCIEMENTS

The Panel wishes to express its thanks to the Spanish National Delegate to AGARD for the invitation to hold this meeting in his country and for the facilities and personnel which make the meeting possible.

Le Panel tient à remercier le Délégué National de l'Espagne près l'AGARD de son invitation à tenir cette réunion dans son pays et de la mise à disposition de personnel et des installations nécessaires.

Contents

1 - Introduction

The 51st Symposium of the Guidance and Control panel on KNOWLEDGE BASED SYSTEMS APPLICATIONS FOR GUIDANCE AND CONTROL, was held in Madrid from 18th to 21st September 1990.
In spite of the prevalence of military aspects the Symposium also dealt with the civil applications of G&C. The focus was on the problems for the management of IFR operations.
The goal was to achieve an advanced automation of the Air Traffic Management systems both in the direction of the Air Traffic Control and on-board systems for navigation and decision aiding.
In the military systems, complexity is becoming so high that it exceeds the possibility of being directly managed by the human component.
G&C problem solving requires complex split-second decision making based on a vast amount of rapidly changing, incomplete and conflicting information in an environment in which threat intensity is quickly growing.
In these conditions, the psyco-physiological capabilities of human being are inadequate for the full exploitation of modern systems potential.
One way to overcome these limitations is to put into the "man-machine system" those functions which cannot be performed (by the human) with the required speed and efficiency.
A.I. technologies, and knowledge processing in particular, have reached a development and consistency level which makes it realistic for us to think about systems capable of solving the problem.
This appears to be possible in two ways.
The first one is the capability to manage the complexity arising from the quantity and variety of information generated by modern sensors technology.
The second depends on the fact that it is now possible, in a meaningful measure, to handle problems which usually require judgement, interpretation and reasoning about facts and circumstances.
These kind of topics, quite difficult to represent and treat with algorithmic techniques, can be tackled with KR technologies.

2 - Objectives

One way for describing the contribution of KR technologies to the solution of the problem is to underline the possibility to segregate the symbolic from the algorithmic computation.
In the conventional SW, parts of code presiding at control and decision logics, are deeply interconnected with coding dealing with the execution of procedures and algorithms.
This generates a rapid increase of SW complexity which imposes severe limits to their design.
Using A.I. technology, it is possible to extract the former putting them in sections of SW representing the knowledge needed for the problem solving process and leaving the latter performed by separated algorithmic and procedural sections of conventional SW.
The results are not only less complex and more easily maintainable SW, but also a better performance in solving problems for which conventional SW found its limits (non-existence of algorithms; algorithms possible, but too difficult to design nd handle; simple problems but requiring unacceptable computing times etc).
Use of A.I. technology in military applications dates back to about 1984.
Since then several programs in several areas have been started for proving the effectiveness of this technology.
The objective of the symposium was to have an overview on the results achieved up to the present day and focus on their meaning as regards the real problem solving capacity in the G&C field. The key point was the potential of reducing the pilot workload, due to excess of information, and helping him to make quick decisions in a highly hostile environment.
A side goal of the symposium was the focusing on special problems forecasted just at the beginning of AI applications and now more clearly defined owing to the more substantial results achieved.
The symposium organization was well tailored for these purposes, having been divided into sessions emphasizing both the practical applications and a broad spectrum of KRT topics associated with the G&C problems.

Session 1 - Representative Applications.
The systems associated with the four papers of the session are consistent applications which problem solving capacity, at different levels of completeness and integration, has been tested on simulators and/or by extended tests by domain experts.
Technologies used include the representation of knowledge about mission and mission management (navigation, tactics, interpretation of information patterns aimed at diagnosis and situation assessment) cooperating expert systems, image interpretation, real-time expert systems, path planning, etc.

Session 2 - Design concepts and systems techniques.
AI technologies associated with the paper of this session are: image segmentation, KB for their interpretation and test of hypotheses developed by models of object representation, decomposition of planning problems into algorithms and management functions, techniques for the simplification of AI architectures to reduce computational needs for real-time performance, methods and techniques of knowledge draining and real-time systems validation.

Session 3 - Related methods and techniques.

speed on standard hardware. As an example, a KB generator encodes the interpreted rules and facts into procedural code speeding up the inferencing process by several orders of magnitude, a clever sophisticated simplification indeed.
An interesting example of interdisciplinary approaches which can be used for knowledge collection was given by paper 25. Knowledge about particular systems is not only obtainable by human experts but also by observing and describing the system behaviour using advanced automatic control technologies (as Kalman filters) to deduct general rules from quantitative information.
A less technical but by no means less relevant paper is no. 26 which gave a review of general methodologies and a "semi-sequential" approach for knowledge draining from human experts, selecting domains for applications, and dealing with knowledge engineers and expert pre-requisites. The topic is strictly connected with the need of developing standard procedures for knowledge engineering and the KBS life cycle.
More technically but about the same topic paper no. 27 dealt with the standard methodology for testing and validation of real-time expert systems. This problem arises when the prototype phase is finished and the goal is to produce an industrialized system. A methodology for testing and validating the system at the end of each meaningful phase of the development (initial, feasibility, development, delivery) was proposed and analyzed in this paper.

3.3 - Session 3 : Related methods and techniques

The papers of the session are not strictly associated with the G&C problem but they are nevertheless remarkable for showing the progress of specific technologies which can be used in the G&C.
The use of fuzzy logic was treated by paper 31 for fuzzy controllers construction. Neural networks were used for the analysis of aircraft test data (paper no.33) showing how this technology can be used for the more general problem of extracting information by data confirmation.
Object oriented view of software (paper 34) provides a framework for integrating KBS with control systems simulations.

3.4 - Session 4 : Information processing and system architecture

Two papers only (no. 41 and no. 42) were presented in this session.
Paper no. 41 is associated with the problem of assisting the pilot during the mission but differing from papers 11, 13, 23, 24 it does not deal with a partially or totally developed prototype but with the study of an architecture enabling several "expert agents", dedicated to specific problems, to cooperate for the solution of a complex problem. This paper confirms the combination architecture/technology already established by the previous papers. The multi-agents architecture is implemented by the use of knowledge and metaknowledge representation, cooperating expert systems technology, communications between them, resources management and conflict resolution.
Paper no. 42 presented an algorithm for evaluating the optimal homing point for missile guidance.

3.5 - Session 5 : Mechanization and integration issues

Paper no. 51 presented SEAN, a prototype of an ES for navigation aid onboard combat aircraft. It addresses a specific function of the navigation problem, providing advice of available choices while monitoring the inertial navigation system. An advanced method based on object oriented programming has been used for collecting and modeling knowledge. The method is based on the structural decomposition of the knowledge objects, on their modeling in taxonomies related to specific functions.
Paper no.52 wasn't presented.
The state of the art of McDonnel Douglas project ICAAS was presented by paper no. 53. The topic once again is the real-time aid to the pilot of a combat aircraft and the purpose of the project is to demonstrate the power of AI technology in building systems able to permit the fighting and survival of tactical fighters when outnumbered by as much as four to one by enemy aircraft during air combat engagement. Problems addressed by the system are again focused on the integration of "intelligent systems" with on-board systems, sensors control, data correlation of real-time performance, reasoning to evaluate expected reaction to each tactics and advanced man machine interface. This paper presented a different approach from paper 24. In this case the choice has been to fully exploit the potential of advanced AI aspects solving the computational problem not by the semplification of AI structures but developing new powerful hardware (risc architecture and with enough MIPS to handle the computational demand). The accomplishment level of the system can be better appreciated by the fact that an F15 test bed aircraft is being modified to incorporate the system. Initial flight testing is forecasted for 1991.
The main goal of the project described by paper no.54 is the transferring of knowledge about flight control systems from the designer to the personnel who has to test and maintain them. The presented system is a knowledge-based tool able to collect knowledge used in the system, hardware and software design and prepare intelligent manuals for diagnosis helping. The system includes model of behaviour and functioning of the system being developed.
Integration is again the main topic of paper 55; it is applied to inertial and image sensors for long range missiles guidance. Information gathered by sensors can be used for navigation updating and target reconnaissance. KB are used for image interpretation while the final extraction of navigation data from th processed and interpreted IR image information, (and their combination with the inertial sensors data) is based on conventional optimization and filtering techniques.

4 - Conclusions

4.1 - The technology status.

By the stand point of technology status assessment, the objectives of the program committee have been fully achieved.
The symposium has represented in a meaningful way most of the aspects of AI applied to G&C.
A striking fact has been the evidence of real, effective experience of merging AI and domain competence.
This means that in a brief time span of 5-6 years AI technologies have definitely left the AI Lab environment and have been incorporated in the conceptual and pratical "tools" of the active users.
The complexity of presented systems and their degree of evolution are the evidence that AI technologies are now understood, diffused and used with a meaningful uniformity through the different environments which produced the presented applications.
They can be considered as established technologies at least as regards how much has been produced by AI research.

4.2 - Integration.

A second goal achieved by the congress is the evidence of the progress made not only by the capability of transforming the conceptual models generated by AI in real objects, but also that of integrating, in a surprising variety of ways, AI technologies themselves.
The broad spectrum of topics presented at the congress ranges from highly integrated systems to KR use for specific problems and offers a good point of view for evaluating one of the major evolutions of AI technology, i.e. the integration between its technologies and its integration with "conventional" technologies.

4.2.1 - The integration between AI technologies.

Complex problems can be treated by KBS able to "use" other KBS, each one dedicated to a specific task in which the main problem has been decomposed.
This is a high-level integration which is followed by the integration of specific technologies used in the solution of single tasks associated to each KBS.
Examples can be given by the combination of different reasoning (about time, space, causal or fuzzy reasoning, reasoning about event and actions etc.).
Communication structures between different ES (blackboard system) have been developed to meet the requirements of designed KBS architectures.
Further integrations between AI technologies have been caused by the need of creating effective interface with KBS.
Speech processing (to communicate with the system) and cognitive process representation (for decision making about information to be shown to the pilot according to the circumstances) are remarkable examples.
Interesting perspectives not yet fully explored are arising from the integration between KBS and neural networks.

4.2.2 - Integration between AI and conventional technologies.

It can be assumed that AI structures not connected with conventional systems are not meaningful in terms of industrial applications.
The industrial exploitation of AI technology is strictly associated with the combination of both technologies into the so called "hybrid systems".
They are systems in which the part difficult to be implemented using conventional technologies is contained in the section based on AI (reasoning processes and decision making) while the conventional sections takes care of the algorithmic processing of information.
A typical approach is represented by KBS able to recognize the type of problem, select models and algorithms coherent with the current problem, locate and extract data to be used, feed and activate the models and use the result for continuing the inference process.
The whole process is quite general and well known even if relatively easy to implement only in reasonably low complexity systems.
The integration between AI and conventional technology is not to be intended only as software integration but also as an integration between hybrid systems and physical equipment.
Because AI offers the possibility to process the enormous volume of information produced by sensors, it is reasonable to think that sensors themselves may be re-designed for the purpose of generating more or different information which can be processed by AI technology now.
The congress permits us to draw some conclusion at least about some basic points of view:

- KR technology is established and diffuse enough to be considered a reality.
- All the projects presented suggest that it is worth continuing to use AI and develop its technologies.
- Projects based on AI established technology are not risky anymore. At least they are not more risky (perhaps even less) than conventional large software projects.
- Practical limits exist however, and they depend on the still scarce knowledge about specific technological areas.
- No general and/or defined solutions are available on these areas and project risks can be managed by "ad hoc" solutions only.
- Research and applications in these areas are worthwhile anyway because the collected experience can contribute to reasonably established solution methods.

5 - Recommendations

A first general recommendation arises from the fact that AI can be seen as a "twofold technology".
AI, itself is more a set of problem-solving technologies than a branch of the computer science.
The focus of AI is on the domain problems not on the computer science tools, it merely uses them.
Considering this aspect it can be worthwhile to diffuse AI problem solving capability through the G&C world in a more organized and systematic way.
The G&C Panel WG/11 on the "Knowledge based G&C functions" can be the convenient tool for implementing a cross-fertilization process between these ideas and experiences.
More specifically most of the advanced topics require research which can be more effectively performed through the common work between groups already active in the G&C field.
Some advanced topics are:

a) Real time systems.
AI applications in domains requiring real time performance create a set of new and unexplored problems different from those KBS which operate on static information, and solution time is not a critical issue
As examples of problems posed by the real-time needs it is possible to list:

- the need to recover dynamically input data from a variety of sensors
- the need of continuing to operate even if a part of the system fails, (monitoring systems should operate indefinitely until the intervention of a human operator)
- the need to manage asyncronous events
- real time systems should accept input data generated by unforseen events, process them according to their importance even if the current input analysis has to be interrupted and re-programmed
- the need to reason concerning temporal data and therefore have models of knowledge about time
- the need to concentrate the reasoning on specific events when the time factor becomes critical
- the consequence may be the need to consult specialized konwledge sources, to modify the sensor subset currently considered by the system and/or to change the frequency with which the data are considered
- the need to have, at any moment, the best possible answer.

The reasoning system should have the capability to find answers using a trade-off between the time constraint and the answer accuracy

b) Neural network
Neural network (NN) potential is now investigated as regards its typical applicative areas (pattern recognition, solving of combinatorial optimization, data classification).
Really interesting is the extension of pattern recognition to the more general meaning of recognition of patterns of information such as data from sensors, information produced by simulation models etc.
This permits us to think about NN like pre-processors able to assert facts (function of the recognition process) to be used by KBS
In other words NN can be used to extract higher level information from low lwvwl information even not being able to explain the recognition process.

c) Machine perception
For the purpose of G&C problem solving a set of advanced AI topics can be labelled under this title and, for this paper, they can be loosely divided into machine sensing and man-machine interface.
Both share the same fundamental issues, the first being particularly associated with behaviour which we are used to consider typical of consciousness, and in the second case perception is aimed at a better interaction with the human being.
As regards machine sensing it can be summarized by the capability of perceiving the external world from environmental stimulis and its reaction to them.
This involves capabilities like collecting information by sensors, interpreting results of their processing, and using them to make the more or less autonomous decision required by current circumstances.
In some sort of way this kind of process is already evident in the systems presented at the congress.
In the area of situation assessment computer vision could aid in the identification of the objects in a scene and the perception of the environment in a given period of time or space. It can also be used to determine the causal relationship between objects (an example can be the corresponde5nce between maps and sensed data, range finding, terrain following and path planning).
General purpose vision systems are not available and a good deal of research and technology should be developed to process visual data, extracting physical data from the image, labelling significant objects and describing them symbolically.
One of the main goals of vision research seems to be how high-level knowledge and inferential procedures contribute to the vision process and how to implement algorithms that will allow an interaction between the lower image data and the high-level symbolic knowledge.
Man machine interface also involves many perception problems, in two ways particularly.
The first one is in making the communication with the computer fast and reliable avoiding the need of stylized and formal languages. This is the area of natural language and speech understanding.

The difficulties lie in the fact that understanding what is said depends considerably on the information and the context which is now available to the computer only in too limited way for such a purpose.
Speech understanding is also difficult because of problems with grammatical errors, accents, noise, separation of words etc.
The second one is associated with the fact that the goal of sending to the end user the correct information under the correct circumstances, requires some knowledge about the mental processes activated by the man.
Stated in other words knowledge about why and how man reacts to external stimuli, what kind of errors he makes and why, how the reasoning changes in stress conditions etc. should be extended. It is essential to know more about what and how to send to the pilot according to the circumstances.
This is an important part of the knowledge about cognitive processes which needs to be deeply investigated with the aim of designing and producing sound and reliable interfaces.

d) Knowledge engineering methodologies
The current status of software development concerning KBS is reasonably satisfactory as far as research and the first stages of demonstrators goes.
Concerning the further stages of development, from prototypes to operational systems, the production of KBS and systems incorporating KBS still faces many new and unsolved problems in order to meet industrial quality standards.
The final quality of the produced software depends obviously on the quality of knowledge engineering process, i.e. the way in which the human expertise is collected, expressed and formalized. The process itself is strongly impacted by the choices made in the very early stages of development.
It is worth, therefore, to promote the growth of standard engineering procedures for KBS.
The main topics of the question seem to be:

- consistency and completeness of knowledge bases
- their validation and maintainability
- their portability from one hardware and software environment to another
- the reduction of knowledge engineering process costs
- the reduction of the bottleneck represented by the high specialized and prized personnel (knowledge engineers).

From the technological point of view, the development of a standard methodology should involve:

- a review of the state of the art on the subject
- the identification of development and life cycle model for systems embedding KB technologies
- the identification of standard development tools and interfaces
- investigate the structure of a knowledge base with emphasis on its consistent maintenance and efficient use
- investigate how to implement methods for porting and re-using of knowledge bases
- develop standard procedures and methodologies for integration of KBS and conventional tools and systems
- investigate the methodologies for quality control and maintenance of KBS.

6 - Glossary

AI :Artificial Intelligence
ES :Expert System
IR :Infrared
IFR :Instrumental Flight Rule
G&C :Guidance and Control
KB :Knowledge Base
KBS :Knowledge Base System
KR :Knowledge Representation
KRT :Knowledge Representation Technology
MIPS :Million Instructions Per Second
NN :Neural Network
RISC :Reduced Instruction Set Computer

7 - List of presentations

Session 1 - Representative Applications
Chairman : Dr. H. Winter (GE)
(11) The Pilot's Associate exploiting the intelligence advantage. D.I.HOLMES et al. - Lockheed Aeronautical Systems Company, CA, US.
(12) SCI3 : A knowledge based system for on-board assistance with the interpretation of infrared images. D.MORILLON et al. - SAGEM, FR
(13) Path generation and evaluation for a mission planning expert system. F.LUISE et al. - Aeritalia, Defense Aircraft Group, Torino, IT.
(14) Knowledge based Cockpit Assistant for IFR Operations. R.ONKEN - Universität der Bundeswehr, München, GE.

Session 2 - Design Concepts and Synthesis Techniques
Chairman : Mr. B. CHAILLOT (FR)
(21) An automatic target acquisition system. P.VALERY - Thomson-CSF (FR).
(22) Constraint management requirements for on-line aircraft route planning. U.TEEGEN - DLR, Institut für Flugführung, Braunschweig, GE.

(23) Planning and planning management for autonomous and semi-autonomous vehicles. M.B.ADAMS et al. - The Charles Stark Draper Laboratory.
(24) Intelligence real time knowledge based inflight mission management. G.F.WILBER - Boeing Military Airplanes, WA, US.
(25) Knowledge acquisition for expert systems using statistical methods. B.L.BELKIN et al. - AT & T Bell Laboratories, Middletown, US.
(26) Knowledge extraction methods for the development of expert systems. M.PEREZ et al. - Directorate of Aerospace Studies, Air Force Systems Command, NM, US.
(27) A methodology for producing validated real time expert systems. S.CROSS et al. - Royal Aerospace Establishment, Farnborough, UK.

Session 3 - Related Methods and Techniques
Chairman : Dr. A. BENOIT (BE)
(31) A review of some aspects on designing fuzzy controllers. E.TRILLAS et al - Instituto Nacional de Tecnica Aerospacial, Madrid, SP.
(32) Paper 32 Withdrawn.
(33) A neural network for the analysis of aircraft test data. J.B.GOLDEN III et al - the University of Tennessee Space Institute, Ai Lab., TN, US.
(34) An ADA framework for the integration of KBS and control system simulations. M.J.CORBIN et al. - Royal Aerospace Establishment, Farnborough, UK.

Session 4 - Information Processing and System Architecture
Chairman : Professor J.T. SHEPHERD (UK)
(41) The multi-agents' problematic in the electronic co-pilot. G.GILES et al. - Avions Marcel Dassault, Saint Cloud, FR.
(42) Evaluation of the optimal homing point for missile guidance. B.MIDOLLINI et al. - Fiar, Milan, IT.
(43) Design and simulation of an advanced airborne early warning system. C.Y.HUANG et al. - Corporate Research Center, Grumman, NY, US.

Session 5 - Mechanization and Integration Issues
Chairman : Dr. P. SANZ ARANGUEZ (SP)
(51) SEAN: a navigation aid expert system for combat aircraft.
D.MORILLON et al. - SAGEM, FR
(52) Paper 52 withdrawn.
(53) Integrated control and avionics for air superiority: A knowledge based decision aiding system. D.J.HALSKY et al. - McDonnel Aircraft, St Louis, MO, US.
(54) A knowledge based system design/information tool for aircraft flight control systems. D.A.MACKALL et al. - NASA, Ames Research Center, EDwards, CA, US.
(55) A study of integrated image and inertial sensor system. R:KOCH et al. - Bodenseewerk Gerätetechnik GmbH, Überlingen, GE.

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14. Abstract

Technical Evaluation Report on the Guidance and Control Panel's 51st Symposium held at the Instituto Nacional de Industria, Madrid, Spain from 18th to 21st September 1990.

In all, 21 papers were presented including the Keynote Address covering the following headings:

- Representative applications;
- Design concepts and synthesis techniques;
- Related methods and techniques;
- Information processing and system architecture;
- Mechanization and integration issues.

All papers presented at the Symposium were compiled as Conference Proceedings CP 474.

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AGARD-AR-284

AI
Combat automation
On-board tactical battle management
Pilot decision aiding
Sensor fusion
Tactical information management

AGARD Advisory Report 284
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TECHNICAL EVALUATION REPORT ON KNOWLEDGE BASED SYSTEM APPLICATIONS FOR GUIDANCE AND CONTROL
by Dr Franco Canepa
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