

**DISTRIBUTION STATEMENT A**  
Approved for Public Release  
Distribution Unlimited

---

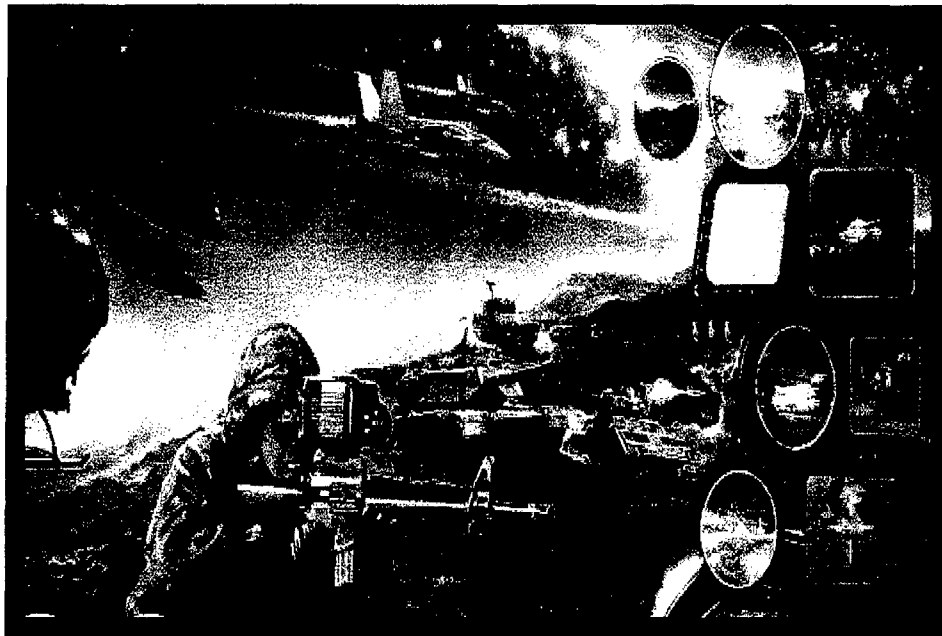
**NORTH ATLANTIC TREATY ORGANIZATION**



**RESEARCH AND TECHNOLOGY ORGANIZATION**  
BP 25, 7 RUE ANCELLE, F-92201 NEUILLY-SUR-SEINE CEDEX, FRANCE

---

# HIGHLIGHTS 1999



20000308 057

# The Research and Technology Organization (RTO) of NATO

RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote cooperative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective coordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also coordinates RTO's cooperation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of initial cooperation.

The total spectrum of R&T activities is covered by 7 Panels, dealing with:

- SAS: Studies, Analysis and Simulation
- SCI: Systems Concepts and Integration
- SET: Sensors and Electronics Technology
- IST: Information Systems Technology
- AVT: Applied Vehicle Technology
- HFM: Human Factors and Medicine
- MSG: Modelling and Simulation

These Panels are made up of national representatives as well as generally recognised 'world class' scientists. The Panels also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier cooperation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.



Published December 1999

Copyright © RTO/NATO 1999  
All Rights Reserved



Printed by Canada Communication Group Inc.  
(A St. Joseph Corporation Company)  
45 Sacré-Cœur Blvd., Hull (Québec) Canada K1A 0S7

# Highlights 1999

The former AGARD published every six months a 'house magazine' called "Highlights" which contained news of members of the AGARD 'Family' and articles of general interest, sometimes resulting from presentations to Board meetings, sometimes submitted directly to the editor. DRG also published an information newsletter, although rather less regularly. These newsletters proved to be a good method of binding members of each 'family' together, so RTO is continuing to publish a house magazine.

In the 'RTO Family' and subsequent sections, we feature news of members of the RTO 'Family', including former members of DRG or AGARD, and we will warmly welcome items for future issues. Such items can include information about awards, appointments, other distinctions and, regrettably, deaths. Wherever possible, please send a draft text (up to one page) with a photograph of the individual. We also welcome photographs of Panels or Committees.

In this issue, for instance, we record the honouring of a long-time member of the 'Family', news about liaison with another NATO body, and with great regret the life and death of three former prominent members of AGARD and a former close associate of von Kármán and contributor to this magazine. We have received no news (joyful or sad) of members of the former DRG Family, so please help us to correct the balance by sending any such items for the next issue - they will be gratefully received. Contributions may of course be edited for reasons of space. Please send items for the 'RTO Family', or complete articles, to the editor at the following address:

IPP Executive  
RTA  
BP 25  
7 rue Ancelle  
92201 Neuilly-sur-Seine Cedex  
France

fax: +33 (0)1 55 61 22 99  
e-mail: hartg@rta.nato.int



## RTO Web Site

Please visit this at [www.rta.nato.int](http://www.rta.nato.int), and send us your comments  
(to [webmaster@rta.nato.int](mailto:webmaster@rta.nato.int))



## Cover illustration:

An artist's impression of the land battle in twenty years time. A short summary of the outcome of a major NATO RTO study on Land Operations in the year 2020 is given at page 14.

# Highlights 1999

## Contents

<b>A Note from the Director</b>	
Building on .. and Settling in ..	1
<b>The von Kármán Medal for 1999</b>	
Professor Paolo Santini	2
<b>Scientific Achievement Awards for 1999</b>	
Dr. Roger K. Moore	3
Dr. Herman Steeneken	3
<b>Reflections on Theodore von Kármán</b>	
by Peter Hamel	4
<b>Replacing Anti-Personnel Mines</b>	
by Brig Gen John Brown	8
<b>One Man's Vision for the RTO</b>	
by John Maberley	13
<b>Land Operations 2020</b>	
by Albert B. Garcia	14
<b>Alternative Control Technologies</b>	
by Alain Léger and Don Jarrett	23
<b>The Future of RTO's Publications</b>	
by George Hart	25
<b>Athenian Atmosphere, September 1998</b>	27
<b>Greek National Day</b>	30
<b>Belgian National Day</b>	32
<b>The Board in Brussels, March 1999</b>	34
<b>RTO Family</b>	
Tribute to Dr von Gierke	37
Liaison with NAFAG	37
Panel photographs	38
<b>Farewells</b>	40
<b>In Memoriam</b>	
Major General Edgard Evrard	41
Professor Corrado Casci	42
Dr Leonard Roberts	43
Col. Tom Weldon	43
<b>Twenty Years Ago</b>	
A look at Highlights 79/1 and 79/2	44
<b>This Really is the End</b>	46

## A Note from the Director . . .

### Building on .. and Settling in ..

It is about a year ago that the previous 'Highlights' was produced. At that time I wrote that we were 'On our way...', or if you like, 'Up and running towards a promising future'. Time flies by, and progress has been made. Indeed, the RTO is now a recognised player in the field of R&T co-operation. In 1998 we undertook the challenging task of formulating a NATO-wide Research and Technology Strategy with the aim of finalising that in just over one year. Now, towards the end of 1999, we are close to harvesting the fruits of that effort. As I write this, the NATO R&T Strategy, agreed upon by the Conference of National Armament Directors and the Military Committee is on its way to the North Atlantic Council and to the meeting of Ministers of Defence. We have good expectations that before the year is over, the Council will endorse this Strategy and thereby make it a cornerstone on which we can continue to build. I would like to honour all those who have given all their energy to make this happen, in particular my friend Ken Peebles of Canada, who is also my successor, and of course Teddy Houston who recently left the RTA to go to other duties in the US Department of Defense. It is a remarkable achievement of which the whole of the RTO can be proud.



Having produced this Strategy, another challenge awaits us: implementing it! The continuous build up of relations with the other players within NATO in the R&T domain is a complicated, but also a rewarding activity. None of them is in a static situation, all are moving into the reality of the information age. Customer relevance is important for all, and identifying one's customers may be a little challenging in the first place. For the RTO there are quite a number of customers: the nations, and in particular military as well as armaments communities, but also the researchers; apart from the nations, one could say that also there exist international customers: NATO communities, again both military and armaments oriented, Partner nations and Science communities. While nations provide most of the assets of the RTO, the international aspect is important for RTO's added value. The RTO can in fact provide valuable inputs into the Defence Capability Initiative, and we are already providing such inputs. With the network that the RTO has developed, the RTO can play a significant role in the balancing of technological know-how in the Alliance. This balancing can be realised through information exchange, often as part of the various Panel activities, or it can be a focussed effort in the domain of Education and Training. This latter part is also of particular importance for the Partner nations. With the joining of the NATO Modelling and Simulation Group to the RTO, the capability for such training activity is significantly enhanced. Even if the start-up of the Simulation Co-ordination Office has been slowed down because of lack of funding, the perspective is encouraging. Simulated training and exercises and the use of virtual groups and venues offer great potential for enhancing the efficiency of our operations.

So, while we are expanding into the new millennium with all kinds of initiatives, the building blocks that were put into place earlier are settling in. The Programme of Work that was recently presented to the R&T Board contains much of the new broad approach of NATO R&T and less of an automatic continuation of the past. Based on these considerations I think that our future looks bright, and that the RTO is ready for the next century.

A handwritten signature in black ink, appearing to read 'E. van Hoek'. The signature is written in a cursive, somewhat stylized script.

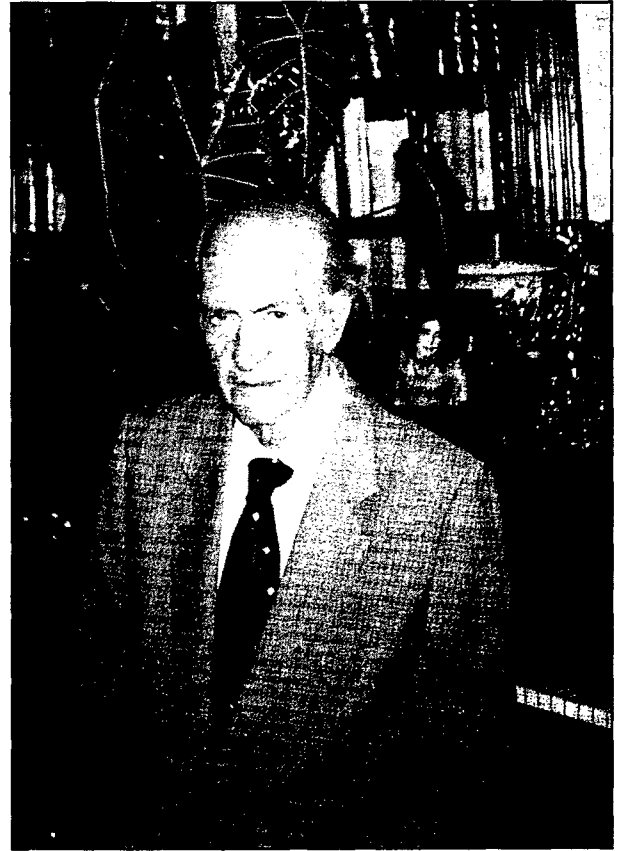
Ernst A van Hoek  
Director RTA  
15 November 1999

# The von Kármán Medal for 1999

*The von Kármán Medal was instituted in 1972 in AGARD in memory of Dr Theodore von Kármán, the founder of both AGARD and the Defence Research Group (DRG), the constituent bodies of the RTO. It is awarded for "exemplary service and significant contribution to the enhancement of progress in research and technological cooperation among the NATO nations carried out in conjunction with RTO activities".*

The von Kármán Medal for 1999 was awarded to Professor Paolo Santini of Italy. Professor Santini was born in Rome in 1923 and holds a degree in Electrical Engineering and a post-graduate degree in Aeronautical Engineering. He entered the University of Rome as Assistant Professor in 1950 and became a Full Professor in 1961, being appointed Professor Emeritus in 1999. He became a member of the AGARD Structures and Materials Panel in 1975 and was its Chairman from 1986 to 1988. He has received many awards, including the IAA Award for Science and Engineering. Some others are listed in the citation. He has been the author of many scientific publications in different fields of aeronautical and space engineering. Outside his professional work, he has also been the author of two books on the history and art of Rome and the author of a film (in 1998): "Sense of Humour in the Art of Rome".

The official citation is given below.



## CITATION

Professor Paolo Santini was involved in the early formation of the former AGARD and remained a very active Member until 1992. From 1986 to 1988 he was Chairman of the Structures and Materials Panel.

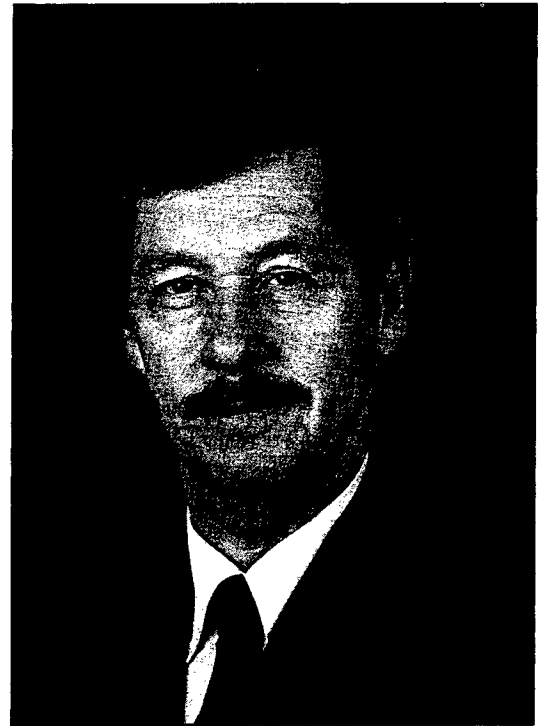
He was co-founder of the International Council for the Aeronautical Sciences in 1958, and was its President from 1990 to 1994. He also contributed to the creation of the International Council for Adaptive Structures and Technology (ICAST) in 1992. Leadership of events, invited lectures in many countries, and more than 200 peer-reviewed papers in aeronautics technology and related fields further prove the international importance of his 51-year career.

In Italy, Professor Santini has been a Director and also a founder of scientific institutes, as well as Member of numerous committees. He was President of the AIDAA, the most important Italian Aerospace Society from 1976 to 1983 and from 1987 to 1991, and was its Honorary President in 1993. His contributions have been recognised with many distinctions, amongst them the Florence and Daniel Guggenheim Award and the Commendatore dell'Ordine al Merito della Repubblica Italiana.

Professor Santini is awarded the von Kármán Medal for 1999 for his remarkable achievements in promoting international co-operation and information exchange in the aeronautical sciences. This is accompanied by the recognition of his leadership in the education of aeronautical sciences in Italy and in addressing problems of national importance.

# Scientific Achievement Awards for 1999

*The Scientific Achievement Award of AGARD, one of the constituent bodies of RTO, was instituted in 1990. It is awarded for "An outstanding contribution to defence science and technology or systems application of technology, carried out as part of a RTO activity". Two recipients were selected for 1999: Dr R.K. Moore (UK) and Dr. H. J. M. Steeneken (NL), and the citations for their awards are printed below.*



## CITATIONS

**Dr. Roger K. Moore** has been an active contributor and visionary leader of NATO technical advisory studies for almost twenty years. Under NATO, he led DRG Panel 3 RSG 10, the first international collaboration in the field of speech processing, and galvanized a range of collaborative projects across the breadth of military requirements in this field. The group's work on "Automatic Speech Recognition in Noisy Military Environments" has fuelled significant progress towards meeting military targets, and illustrated how the mainstream research community could be directed to address military specific issues at very low cost. Since relinquishing the Chair of the group, he has been influential in persuading it to undertake projects of significant military importance, such as "Speech Recognition under Stress" and the current topic on "Multilingual Interoperability of Speech Technology".

Dr. Moore has also facilitated and advanced scientific exchange and cooperation through the publication of 8 NATO Advanced Study Institute Reports, 3 NATO DRG Reports, and the presentation of 39 lectures and keynote talks, and 8 radio and press reports.

**Dr. Herman Steeneken** has been continuously involved as an active contributor and leader of NATO technical advisory studies since 1976. His primary contributions were as Chairperson, and subsequently member of the former DRG Panel 3 RSG 10 and member of the NATO Working Group on Narrowband Speech Coding. As part of the work on "Automatic Speech Recognition in Noisy Military Environments", he developed and calibrated the first CD-ROM with military noises. This CD-ROM is still a standard for many military and civilian speech research projects. As Chairperson of the group, he initiated projects on the "Effect of Noise", "Speech Recognition under Stress" and the current topic on "Multilingual Interoperability of Speech Technology". He strongly promoted international cooperation between research groups in the NATO Community. During his leadership, all countries in the task group contributed to all projects. His personal expertise in active noise reduction systems, speech communications and speech recognition has benefited the activities of NATO greatly.

Dr. Steeneken has been the author of 8 DRG Reports and 6 DRG Dissemination Activities. He has also made a presentation at an AGARD Lecture Series and given 5 papers at AGARD meetings.

# Reflections on Theodore von Kármán

by

Peter Hamel

*As reported in the last issue of Highlights, one of the von Kármán Medals for 1998 was awarded to Professor Dr.-Ing. Peter Hamel of Germany. When the RTB Chairman, Dr Yarymovych, presented him with the Medal at the Board meeting in Athens in Fall 1998 - photo below - Professor Hamel made a speech of thanks, which we are pleased to print because of its insights into von Kármán (and in order to satisfy the curiosity of those people who were present and did not know the answer to the conundrum Professor Hamel posed). The citation for his Medal was printed in the previous issue.*



Mr. Chairman, distinguished National Delegates and Guests!

Thank you for this great honour! Awards are not important – but they are extremely flattering when you receive one. I received permission from our Chairman, *Dr Yarymovych*, to say some words about the man whose name is imprinted on the Medal. But the Chairman is not aware of what I want to tell you. So, if you have ever had the impression that RTO requires long decision processes - here is the proof that this is not so!

I will not try to answer the question who was *Theodore von Kármán* - this would take hours - maybe days - so overwhelming are his accomplishments as an international scientist, leader and diplomat. I will also not refer to his after-dinner speeches except to say that they were sometimes concerned with a lion in ancient Rome who refused to eat a Christian in the arena, and the reasoning for this - you may guess what the Christian whispered into the ear of the lion\* - and I will not try to convince you that

- due to the recent changes - I no longer feel an AGARDian.

But let me try with a few sentences to indicate some historical scientific events which have to do with the information age of these days. Information depends on **observations** - hopefully as accurate as possible. How did it all begin?

Two mathematicians became world scientists and their theories are indispensable for **observations** (Fig. 1)<sup>1</sup>: *Carl-Friedrich Gauss* who was teaching at the Braunschweig Technical University (TU BS) and *Norbert Wiener* who was doing the same some 140 years later at the Massachusetts Institute of Technology (M.I.T.). And I am proud to say that 25 years later I received my academic education from both of these Universities. Both *Gauss* and *Wiener* were also doing teaching and researching in Göttingen - the famous German scientific location of *Ludwig Prandtl*, “the leading genius in the early development of modern aerodynamics”<sup>2</sup>.

<sup>1</sup> P.G. Hamel, International Aspects and Aeronautics, M.I.T., Cambridge, September 16, 1989

<sup>2</sup> Th. von Kármán, Some Significant Developments in Aerodynamics since 1946, First I.C.A.S., Madrid, September 8, 1958



You can realize from the '1989' in the frame of the Figure 1 that in this year of global political changes M.I.T. was celebrating the 50<sup>th</sup> Anniversary of its Department of Aeronautical and Astronautics (A & A).

Now turning to *Theodore von Kármán* (Fig. 2): his personal and very accurate observation after World War II made it clear to him that the aeronautical scientists of West **and** East needed an adequate forum which finally became in 1958 the **International Council of the Aeronautical Sciences (ICAS)**, and that NATO needed a 'brain bank'<sup>3</sup> which as early as 1952 became the **Advisory Group for Aerospace Research & Development (AGARD)**, and he further formed in 1961 the **Defence Research Group (DRG)**. Finally, he founded the multinational Aerodynamic Research and Teaching Centre in Belgium, the well-known **von Kármán Institute**.

Coming back to *Carl-Friedrich Gauss*: In appreciation of *Theodore von Kármán's* personal achievements the Braunschweig Scientific Society (BWG) awarded to him in the year 1960 the *Karl-Friedrich-Gauss-Medal* in recognition of his scientific contributions in the field of Applied Mechanics and his efforts of fostering international collaboration. Citing the late *Hermann Blenk*, the former Honorary President of the German Aerospace Society (DGLR), the international aeronautical societies rendered homage to *von Kármán* as the "Lord of the Empire of Flight Sciences"<sup>4</sup>. During this time I still was a student living in a simple room without heating, kitchen or bath room! I was not aware that *von Kármán* was residing in the historic Braunschweig Hotel 'Deutsches Haus', some hundred meters from my 'apartment'.

Let me share with you another three unpublished photos of *Theodore von Kármán*. And - perhaps I should apologise - I will not show some well-known photos of *von Kármán* surrounded by beautiful women. Very recent events in the public and political world told me not to do so. The first picture (Fig. 3) comes from the first ICAS Meeting in Madrid in the year 1958. I think this is one of the most impressive photos of *von Kármán*. His intellectual mimics are unique.

The next picture (Fig. 4) illustrates *von Kármán* in Braunschweig during the *Gauss Medal* ceremony in 1960, accompanied on the left side by *Otto Lutz*, the former Hypergol fuel specialist and at that time President of the German Aeronautical Research Establishment in

Braunschweig (DFL, now part of DLR) and *Hermann Blenk* on the right, the re-founder of DFL Braunschweig after WW II. From the last picture (Fig. 5) you get a feeling of the warm personal relationship between *von Kármán* and *Blenk*. As both were enthusiasts of innovative toys for children and - may be - for adults also, you can imagine what they were talking about.

Let me conclude with three statements which are as true today as they were then:

50 years ago the historical **Berlin Air Lift** was installed by the Allies, and *von Kármán* stated in 1948<sup>5</sup>: "For engineers and scientists it becomes paradoxical if **calories** in terms of aircraft fuel is expended to airlift **calories** in terms of coal. This is only another proof of reality that the *homo politicus* is still far behind the intellectual state of *homo sapiens* who was put on earth in order to explore the physics of nature and to control the forces of nature".

US Air Force Lt. General *L.C. Craigie* addressed AGARD in the year 1953, saying<sup>3</sup>: "AGARD is an organization with a tremendous growth potential and a great capacity for making a significant contribution to the NATO defence". This view was seconded by the USAF Chief of Staff General *N.T. Twining*: "The return from the Advisory Group has been well worth its investment"<sup>3</sup>. In 1972, the then AGARD Director, *Michael I. Yarymovych*, referred to a former Chairman of the NATO Military Committee who had said at the 20<sup>th</sup> Anniversary Commemoration of AGARD: "AGARD is the best bargain NATO ever had".

Further, following the lines of *M. I. Yarymovych* which he published about 25 years ago<sup>6</sup>, I would like to modify his final statement by saying: "The RTO of today is the right answer for tomorrow!"

Let me conclude with a final view about *von Kármán*. His sister *Pipö* took care of him in his late years, and he dedicated his book **Aerodynamics**<sup>7</sup> to her, stating that he owed deep gratitude to her because she gave him the pace of mind which is indispensable for scientific work. If I look around, observing all the charming and sympathetic woman with us today - is this not true for all of us?

Again, thank you very much!

---

\*The answer: "If you want to devour me you are obliged to make an after-dinner speech!"

<sup>3</sup> Th. von Kármán, Air Research-NATO Brain Bank, Air Force, Vol. 37, No. 5, 1954

<sup>4</sup> H. Blenk, Presentation of the Carl-Friedrich-Gaub Medal to Th. von Kármán, Braunschweig, April 30, 1960

<sup>5</sup> Collected Works of Theodore von Kármán. Vol. IV, London 1956, pp. 394-395

<sup>6</sup> M.I. Yarymovych, AGARD Today, NATO's Fifteen Nations Dec. 1972 - Jan. 1973

<sup>7</sup> Th. v. Kármán, Aerodynamics: Selected Topics in the Light of Historical Developments, Interavia S.A., Geneva, 1956

## Dealing with Inaccurate Observations

### Historical Innovations :

● **Deterministic Least - Squares Estimation ( Paper & Pencil )**

⇒ Orbit Prediction of Celestial Bodies  
( circa 1800 )

Collegium Carolineum ( Technische Universität )  
Braunschweig, F.R.G.

Carl-Friedrich Gauß



Göttingen  
( circa 1840 )

● **Statistic Least - Squares Estimation ( Digital Computation )**

⇒ Statistical Optimal Filters  
( circa 1940 )

Massachusetts Institute of Technology  
Cambridge, U.S.A.

Norbert Wiener



Göttingen  
( circa 1925 )



1989 — 50th Anniversary Department of Aeronautics & Astronautics

DLP 44M 100

Fig. 1

## Transatlantic Aeronautical Cooperation after WW II

**Three important Initiatives by Theodore v. Kármán :**

- International Council of the Aeronautical Sciences ( I. C. A. S. )
- Multinational Aeronautical Research Center ( Belgium )  
( now : v. Kármán Institute - V. K. I. )

● Advisory Group of Aerospace Research and Development ( A.G.A.R.D. )



Theodore v. Kármán receiving C. F. Gauß Medal in Braunschweig ( 1960 )



1989 — 50th Anniversary Department of Aeronautics & Astronautics

DLP 44M 96

Fig. 2



Fig. 3



Fig. 4



Fig. 5

# Replacing Anti-Personnel Mines

by

Brigadier-General John Brown

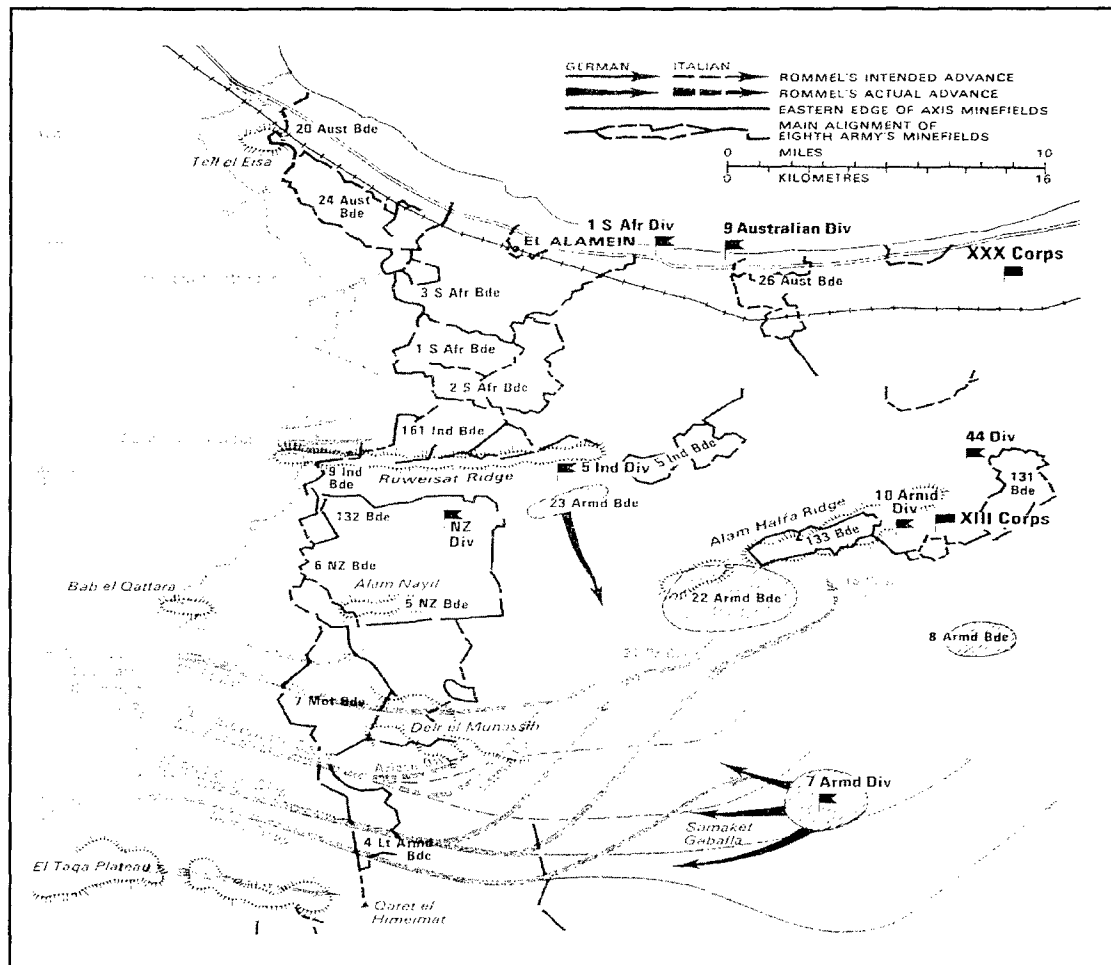


Fig. 1

This issue is of critical importance to the Alliance and particularly to the military. I want to explain why it is absolutely imperative to seek a technical solution to the problem of anti-personnel land mines. This is the single most contentious and ugliest issue within the Alliance. The simplest forces we have, the low technology infantry, are those most in need of your help right now.

I intend to answer three questions:

- what will we be giving up when the anti-personnel mines treaty comes into effect?
- what are the alternatives?
- what should we do?

## What is the role of battlefield Anti-personal mines?

The casualty-producing effect of both anti-tank mines (ATM) and anti-personnel mines (APM) is collateral: to shape the battlefield in such a manner as to deny terrain to the enemy. The verbs we use are:

**disrupt, turn, deny, fix, block, protect, warn.**

These all show that it fits into a larger scheme of manoeuvre that does not feature the lethality of the mine as being particularly important. In fact, in battlefield statistics, casualties due to mines are negligible.

## A historical example

The battle of Alam Halfa Ridge (near El Alamein) in North Africa during World War II, Fig 1, is an example of the use of mines. At the start of the battle, the British and Commonwealth forces under Montgomery had a screen of mines to their front. In particular, in the south, although thinly held, the mines were sufficient to disrupt the German and Italian attack led by Rommel to the point that although it was not stopped, it was delayed and he did not break through the outer positions until 9.00 am, when he had planned on being through at dawn. This forced him to make a long daylight attack in the direction of Alam Halfa. Thus these mines had *disrupted* his attack.

As he reached Alam Halfa Ridge, the mines were thicker there and the 22nd Armoured Brigade and 133rd Brigade were in positions to *deny* Alam Halfa, so Rommel had the choice either to turn and continue his attack further to the east, in which case he would have been exposed to Commonwealth gunnery along the entire length of the axis of Alam Halfa Ridge, or to assault Alam Halfa. But the mines there were so thick that they served to *block* such a purpose, and he chose instead to withdraw. There were very few German or Italian casualties to the mines themselves. However, sizeable casualties were produced by the effect of *fixing* his attack long enough on the foot of Alam Halfa that the other weapon systems could be brought into effect, and so their casualties were largely through tank fire and artillery and not through mines.

When the battle was going the other way, six weeks later, Montgomery had a similar problem to deal with - the German minefields. He was able to punch through only on a narrow axis, and because that was true Rommel was able to pull all his forces off at once, whereas Montgomery's attack was embarrassed by the narrowness of his passage through the minefields and he was never able to develop sufficient mass beyond the minefields to catch up with Rommel before the latter moved to Tunisia.

This example shows how minefields are not designed to produce casualties in themselves but serve the purpose of denying terrain in such a manner that the other, more lethal and more effective, systems can be brought into play by the virtue of fixing a target long enough to make it a target. That having been said, the technical substitute for mines must serve a similar purpose. There's a collateral argument that we are talking about a distinction between anti-personnel mines and anti-tank mines.

## The differences between anti-personnel and anti-tank mines

In the view of those who haven't signed the anti-personnel mine treaty, ATMs and APMs are indistinguishable as issues. They both serve the same purpose of denying terrain, to tanks or personnel respectively. Furthermore, the APMs preclude a cheap and easy breach of an

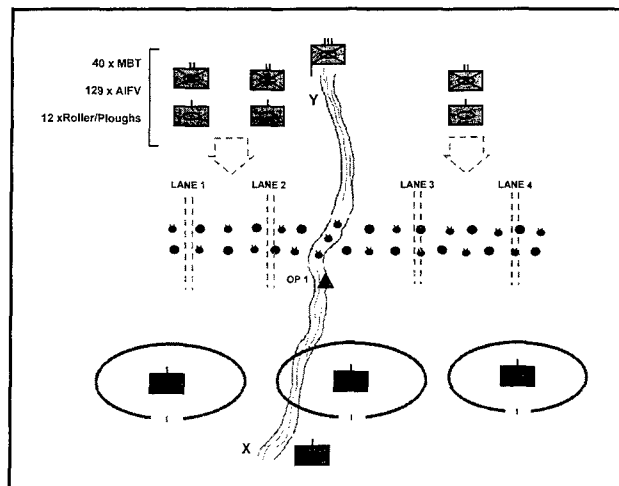


Fig. 2

Anti-tank minefield. Fig 2 shows a war game scenario with a motorised rifle regiment attacking a minefield defended by a battalion. There is a fascination with the notion of a mechanised breach that would not require dismounting. In fact, against a determined opponent, that would probably work about half the time. The reason is that the breaching vehicles are limited in number. In this case, there are only 12 breaching vehicles in the entire regiment. This means that the defender only needs to have 12 good shots. In our war games that means that there is about a 50% probability that a breach would not occur at all with 3rd generation tanks taking out all the breaching assets. However, there is always a dismounted avenue of approach. In this case, we have drawn in a stream bed; it could be a line of woods; it could be a built-up area; it could be buildings. There is always a way for infantry to approach, giving the option of a dismounted breach or even a surreptitious breach which is even more dangerous because the defender doesn't know that they are in his minefield until it has already been breached. If the infantry knows that he doesn't have APMs, they can simply walk through the ATM field, put explosive on each of the ATMs and blow them up, and then clear the lane.

## The delaying effect of APMs

Fig. 3 shows the numerical effect of this. The figures show the comparative times for infantry not under fire to clear a breach, with and without APMs, both with buried mines and surface-laid ones, which is the normal case when they are remotely-delivered. The substantial extra time to grapple in this case is caused by the lay of the threads connecting the trip wires. The amount of time gained may seem small, but when the defender has 30 minutes longer in which an identified target is fixed, the results to the target are catastrophic. But in the absence of APMs it is very easy for the infantry to surreptitiously breach and be through the minefield before the defender knows that they are on it.

Estimated time for dismounted breach (minutes) (5-m wide)				
Dismounted Task	Buried		Surface	
	AT/AP	AT only	AT/AP	AT only
Grapple	20	0	80	0
Sweep (two operators)	15	12	8	4
Mark/place charges	1	1	1	1
Back-out/detonate	3	3	3	3
Check line	2	2	2	2
Total	40 minutes	17 minutes	94 minutes	10 minutes

Fig. 3

We have been surveying studies that give a tangible feel for the degree of degradation caused by not having APMs. Fig. 4 summarises them. One is Danish, three are US, and one is a commercial one by a US author, Dupuy, but using international sources. QJM is the Quantitative Judgement Model (Dupuy). USES is the US Army Engineer School, with Lawrence Livermore Laboratory, the Danish study was an attempt to identify offsets with respect to munitions and forces, Campaign Analysis is a historical analysis carried out by SHAPE, CAA is the Center for

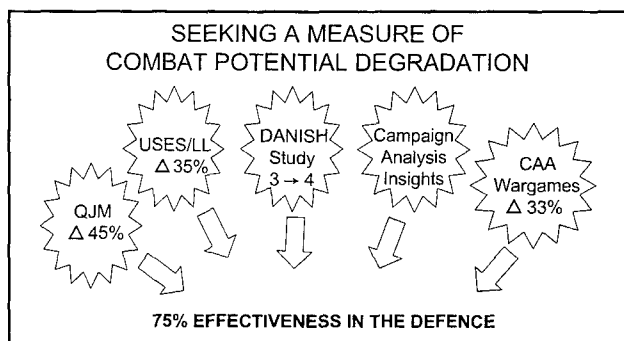


Fig. 4

Army Analysis which has run war games on Korean, Southeast Asian and Turkish scenarios.

All end up with a roughly similar result. A defender without APMs is defending at about 75% of his effectiveness. So you have to make up about 25% if you don't have an equivalent area denial system. That figure is not universally accepted, and it is obviously a place where operational research would give us a great advantage. NC3A has undertaken to carry out a study, independent of these, to attempt to identify the appropriate degradation figure.

### Possible alternatives

I should now like to explain briefly several non-technical solutions.

ADDITIONAL DIRECT FIRE ASSETS					
	3PLT/CO W.APM	3PLT/CO W/O APM	4PLT/CO W/O APM	5PLT/CO W/O APM	6PLT/CO W/O APM
BLUE STRENGTH	485	485	588	687	788
BLUE CASUALTIES	236	287	326	375	421
RED STRENGTH	1014	1014	1014	1014	1014
RED CASUALTIES	970	863	876	908	909

Fig. 5

One possibility is simply to put more forces forward. Fig. 5 shows an exercise in which we added platoons to the defending company in the expectation that if you are down to 75% all you have to do is to increase your forces appropriately to regain your effectiveness. The problem is that because you are exposing more people to the enemy your casualties rise also, so as you put more people into the battlefield area you produce more targets, and because you are less thin on the ground you take more casualties. So that doesn't seem to be a good answer.

A second idea is to use more artillery. Fig. 6 shows time delays with artillery according to the type of command and control applied to a target. In fact most targets are 'adjusted fire', because you don't have unlimited artillery.

ADDITIONAL INDIRECT FIRE WEAPONS	
PRIORITY TARGET/ FINAL PROTECTION FIRES	1 TIME UNIT
REGISTERED TARGET	5 TIME UNITS
ADJUSTED FIRE TARGETS	8 TIME UNITS
REINFORCING FIRES	9 TIME UNITS

Fig. 6

So they take about 5 minutes to bring in. This means that the target is usually not a target any longer. So you can not use artillery alone to replace mines with respect to the effect that they have in fixing or disrupting a target.

A third alternative is to find a different type of obstacle. Fig. 7 shows the effect of some of the possibilities. The first four lines are the mines we have discussed earlier, and you will see that the times for the dismounted breach are those given in Fig. 3. The anti-tank ditch and the anti-tank berm have no effect on infantry, which just walks through them, although they take 10 hours to emplace, and they have a limited effect on a mounted breach. A triple concertina takes 6 times as long to put in, but it doesn't take infantry long to get through. It takes about as long for a mechanised breach as do the ditch and the berm. So none of these possibilities will solve the problem.

## What can RTO do?

I have tried to outline all the non-technical solutions, and I think none of them have been found to be satisfactory to all nations of the Alliance. If we continue with this division between signatories and non-signatories, we are going to have some brutal and ugly bickering as we try to figure out how to defend ourselves on contemplated or actual Article 5 battlefields. If you could come up with a technical solution that solved the singular purpose of denying terrain, it would be wonderful for all of us because this would then be an academic and historical discussion rather than one dealing with contemporary means.

The following systems have been suggested:

### Prospective non-lethal area denial systems

- High power microwaves
- Anti-traction agents
- Super adhesives
- Irritating odours
- Soil destabilisation

### Prospective lethal area denial systems

- Explosive gas
- Predetermined cluster bombs
- Radio controlled weapons
- Remotely fired weapons
- Remotely piloted UAV

The non-lethal ones are all science fiction at present. Of the lethal ones, the only ones that seem reasonably promising are those controlled by an operator and so instead of being victim-actuated are actuated by someone making a decision, but then the operator is exposed and is likely to become a casualty. The other problem is to carry out surveillance of the target area to know that you have the kind of coverage you previously had with the unattended sentinel, the simple and cheap landmine lying on the ground. Remember that the aim is not to kill more people but to try to deny terrain in such a manner that we can fit into a larger and comprehensive and tactical whole on the land battlefield.

## Conclusion

My conclusion is that we are searching for a substitute for anti-personnel mines, which is either non-lethal or not actuated by the victim. The best result would be to have a technical means of doing this, but it would also be useful to have a comprehensive discussion of the prospects, even if you came to the conclusion that such a technical solution would not exist for 10, 15 or 20 years. Such a conclusion would be just as useful to the decision makers as the promise that a solution would be found at a particular point in time.

Finally, I should like to emphasise that SHAPE is actively involved in all the Panels, and that this is not the only problem to which we want solutions, although it is a very important one at present because of the Ottawa Convention.

---

## Brigadier General John S. Brown

General Brown is an armour officer who has commanded at every company and field grade level. He has served as a tank platoon leader and company executive officer in Germany, as a tank company commander in the Rapid Deployment Joint Task Force, and as a battalion operations officer and battalion executive officer, again in Germany. He commanded the 2-66 Armour Battalion, based in Garlstedt Germany, during the Gulf War, and later returned to Kuwait during a period of crisis in command of the 2<sup>nd</sup> Brigade, 1<sup>st</sup> Cavalry Division, out of Fort Hood Texas. His other assignments include service as a Brigade Equal Opportunity Staff Officer, Brigade Training Officer, Brigade Executive Officer, Division G3, Corps Operations Officer, and Executive Officer to the Deputy Chief of Staff for Operations of the United States Army.

General Brown is a 1971 graduate of the United States Military Academy. He holds a Masters Degree and a Doctorate in history from Indiana University, and a Master of Military Arts and Science from the Command and General Staff College in Fort Leavenworth, Kansas. He is a 1992 graduate of the United States Naval War College where he earned a Masters Degree in National Security and Strategy. He has served as an Assistant Professor at the United States Military Academy, and is the author of one book, 'Draftee Division', published by the University of Kentucky Press.

General Brown's awards include the Legion of Merit (three awards), Bronze Star, Meritorious Service Medal (two awards), Army Commendation Medal (two awards), and the service ribbons associated with participation in the Gulf War.

General Brown is a third generation soldier with ancestral roots in the Carolinas. He is married to the former Mary Elizabeth Hoisington, a third generation army wife with ancestral roots in Kansas and Michigan. His daughter Amy is married and attending Georgetown Law School in Washington D.C. His son Robert (a.k.a. Todd) is a Second Lieutenant in the 1-508<sup>th</sup> Airborne based in Vicenza, Italy.

General Brown is now Chief of Military History and Commander of the US Army Center of Military History at Fort McNair, Washington D.C.



<b>COUNTER-MOBILITY OPTIONS</b>				
	<u>DIMENSIONS</u>	<u>TIME TO EMBLACE</u>	<u>DISMOUNTED BREACH</u>	<u>MOUNTED BREACH</u>
VOLCANO (AT/AP)	278x120m	135 sec	94 min	2 min
VOLCANO (AT ONLY)	278x120m	135 sec	10 min	2 min
AT/AP BURIED	100x300m	24 hours	40 min	3.5 min
AT ONLY, BURIED	100x300m	24 hours	17 min	3.5 min
AT DITCH, 2m	3.5x300m	10 hours	0 min (N/A)	10 min
AT BERM, 25m	4.0x300m	10 hours	0 min (N/A)	10 min
TRIPLE CONCERTINA	10x300m	60 hours	15 min	10 min

Fig. 7

Another possibility is to change your doctrine - fight your battle differently. Instead of depending on a fixed position, delay, move back, use your superior technology, firepower resources and ability to accurately bring the enemy under fire and engage him in such a manner that by giving up space you produce the target opportunities over time that you would otherwise have developed on a fixed point. Fig. 8 shows opposed rates of advance from an operations research model. For example, a prepared defender who is outnumbered at 3 to 1 can hold a mechanised adversary to 7-8 km, but when he is committed to a hasty defence, the speed at which an adversary moves forward doubles. So when trading space for time, you have to remember that you are giving up space.

ODDS	PREPARED DEFENCE				HASTY DEFENCE / DELAY			
	GO TERRAIN		SLOW-GO TERRAIN		GO TERRAIN		SLOW-GO TERRAIN	
	ARM/MECH	INF	ARM/MECH	INF	ARM/MECH	INF	ARM/MECH	INF
1:1	2	2	1	1	4	4	2	2
2:1	5-6	4	2-3	2	10-12	8	5-6	4
3:1	7-8	5	3-4	2.5	13-16	10	8	5
4:1	8-10	6	4-5	3	16-20	12	10	6
5:1	16-20	10	8-10	5	30-40	18	20	9
6:1	24-30	12	12-15	6	48-60	24	30	12

Fig. 8

Fig. 9 shows a hypothetical rectangular country about 600 km long with the adversary coming from the right and having a 5 to 4 advantage against the defender. With APMs, you can stop him after about 12 days having lost a third of the country. Without APMs, and using the tactic just described, you bring your opponent to a halt only after 18 days and having lost about two thirds of the country. So the idea of giving up space for time works fine except for the nation that is giving up the space.

The idea exists of a national division of labour, Fig. 10. At present, we have signatories and non-signatories, and let us suggest that the Turks and the Americans, purely for example, would be the ones to put in and defend

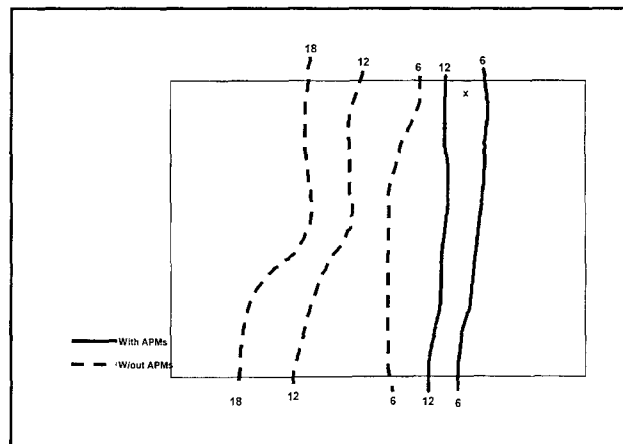


Fig. 9

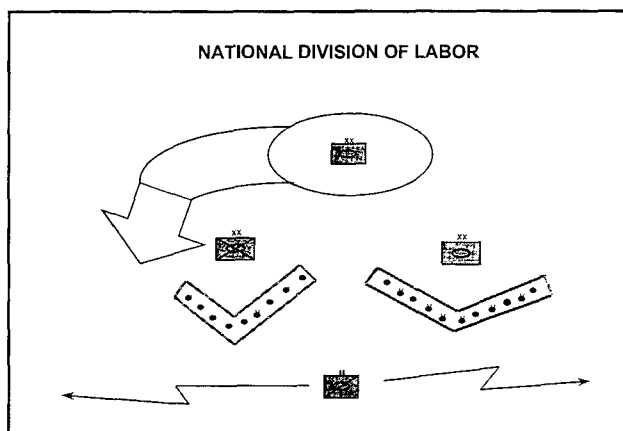


Fig. 10

minefields, and the signatories would fill other battlefield functions, for example the counter-attack reserve could be German or the screen to the front could be British. That is difficult for command and control, and it becomes a little bit prickly when you also find some national positions are that a country can not lay in minefields but if someone else does so, they can use them. This system would work, but only when the battle was being fought on the territory of a non-signatory. So this technique would work in Turkey but not in any country which was a signatory to the ban on APMs.

The prospect exists of beefing up your highly mobile assets, so that as the attacker penetrates you have enough mobility to get somebody in front of him quickly and you have an excess of mobile forces for the purpose of countering penetration. In particular, attack helicopters, high quality tanks and the MLRS produce this effect of always being able to get in front of a penetration before it can get very far. The disadvantage of this technique is that all such systems are very expensive. Although the system will work, by the time you have produced the force structure that is able to counter all these potential penetrations, you will have a force ratio that suggests you should no longer be defending but attacking, because you have such a technical and mobility advantage.



# One Man's Vision for the RTO

by

**John Maberley**

*The address below was given by Mr John Maberley, Managing Director of DERAtec Farnborough, UK, and RTO Board member, to the Systems Concepts and Integration Panel's symposium on "Aircraft / Weapon System Compatibility And Integration", held in the UK in September 1998. With his permission, we have reproduced it here because it gives a very clear and succinct summary of what the RTO is all about.*

Good morning. I'm John Maberley, Managing Director of DERAtec - the part of the Defence Evaluation & Research Agency which focuses on international and commercial business partnerships. I also have the privilege of being one of the UK's National Delegates to NATO's Research and Technology Organisation.

As a member of this Board, I would like to welcome you to the UK, to this historic city of Chester and to this symposium on "Aircraft/Weapon System Compatibility and Integration". This symposium has been organised by the Systems Concepts and Integration Panel, one of the six panels of the RTO.

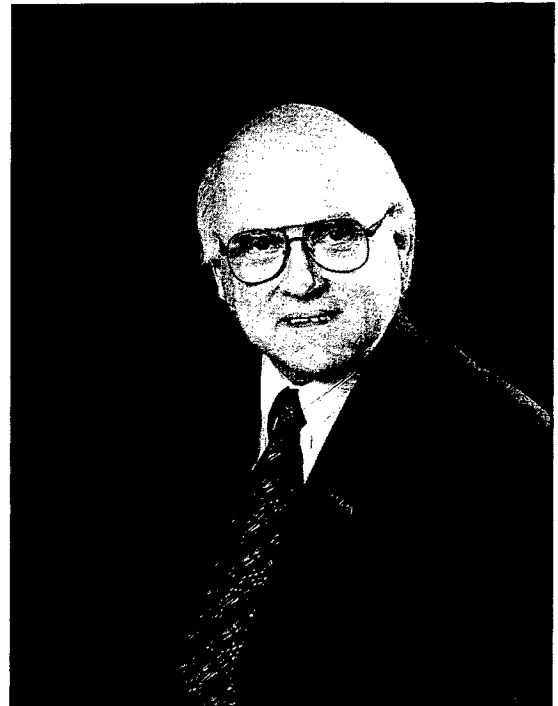
I am delighted we have more than 120 participants from the NATO nations here today. We particularly welcome participants from Poland, one of the Invited Nations\* at the RTO. I am also pleased we have representatives joining our symposium from Estonia and Lithuania, Partnership for Peace nations, and a guest participant from Australia (welcome to you all; welcome to our Summer!).

It also gives me great pleasure to welcome our Keynote Speakers, Admiral Chenevey, current head of the Weapons Division at the US Naval Air Warfare Centre and Dr Chris Pell, Director of Science (Air) from the MoD here in UK. I look forward to hearing your remarks in a few moments.

The RTO, formed as you know from the former AGARD and DRG, is a relatively new organisation within NATO, and is still evolving. All of those on the Board greatly appreciate the efforts made by you all in achieving such success in this transition. Such important events as this symposium are a valuable legacy from the former AGARD, but it is very much a model for the future of the new Panels.

The full SCI Panel will be meeting here later this week, to conceive and plan further new and worthwhile activities to foster research and technology within NATO and to take the Alliance into the new Century. I have a personal passion about this organisation and what it might achieve, but that potential can only be realised if you all help us think about this future. In your deliberations, consider how the RTO work can complement and draw benefit from your national programmes. Decide how it fits in with other collaborative initiatives and forums. NATO RTO must never be just another source of science and technology funding, nor is it adequate for it to be just another networking forum (however good it is as just that). It must be a science & technology community which focuses on the mission of NATO and is seen to support that role not only in terms of shared technology but also by ensuring common standards, interoperability, transparent communications, shared logistics and training in preparation for an increasingly diverse range of future operations.

I wish you all a very stimulating and successful symposium.



---

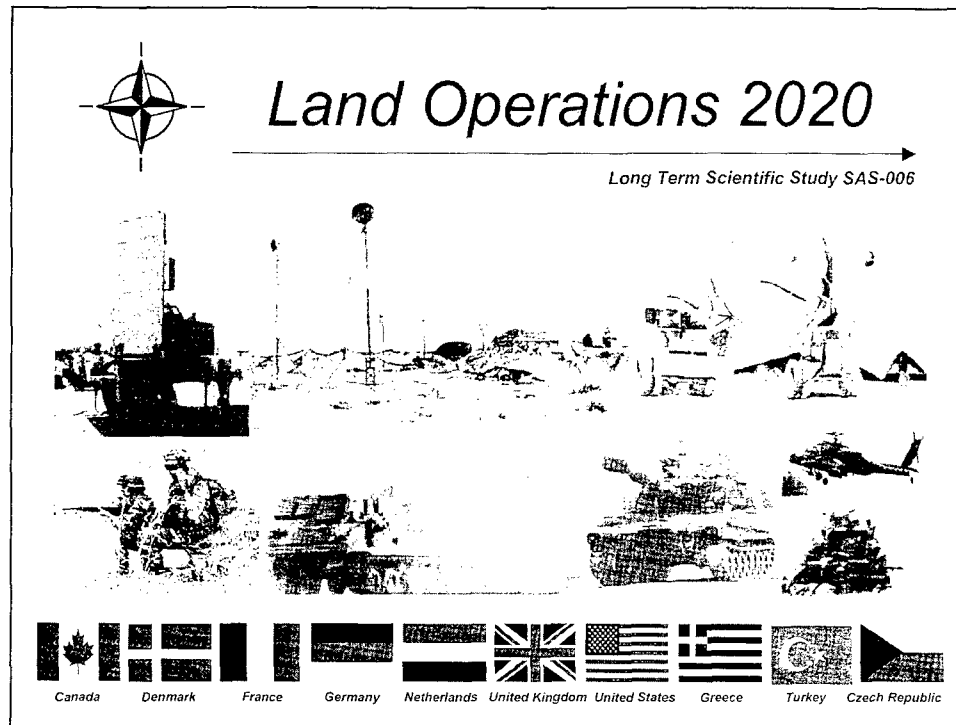
\* Poland has of course since become a full member of NATO

# Land Operations 2020

by

**Albert B. Garcia**

*This presentation on the results of the Land Operations 2020 study was given to the Spring 1999 meeting of the Board by the Study Director, Colonel Garcia. The report is RTO publication TR-8, "Land Operations in the Year 2020", published in March 1999.*



This briefing describes the NATO Long-Term Scientific Study titled Land Operations in the Year 2020, commonly called LO2020. This study was conducted under the guidance of the Studies, Analysis and Simulation Panel (the SAS Panel) of NATO's Research & Technology Organisation. It began with 7 nations participating -- Canada, Denmark, France, Germany, Netherlands, the United Kingdom, and the United States as the lead nation. Greece and Turkey joined the study in 1998, and the Czech Republic participated in the 1998 Multi-National Exercise.

I will begin by describing the purpose of the LO2020 study. I will then describe in sequence:

- the study schedule
- the process used to meet the study purpose
- the challenges of the Battlespace 2020, which are the military concept and doctrine findings of the study
- the impact of technology on land forces and weapon systems in the year 2020
- the major conclusions and recommendations of the study

## **The purpose of the study**

The purpose of LO2020 was to identify the most critical key and emerging technologies, and the impact on military land forces in the year 2020. This was accomplished by considering the availability and impact of new technologies that have the potential to appear in fielded weapon systems in the 2020 timeframe. The specific objectives of the study, as stated in the study Terms of Reference, were to:

- identify and describe the likely nature of the battlespace in 2020
- identify the types of land forces NATO needs in 2020
- identify the required capabilities and characteristics of future land forces
- assess the impact of technology on future battlespace, and the desired characteristics for NATO forces in 2020 that will arise from new technology

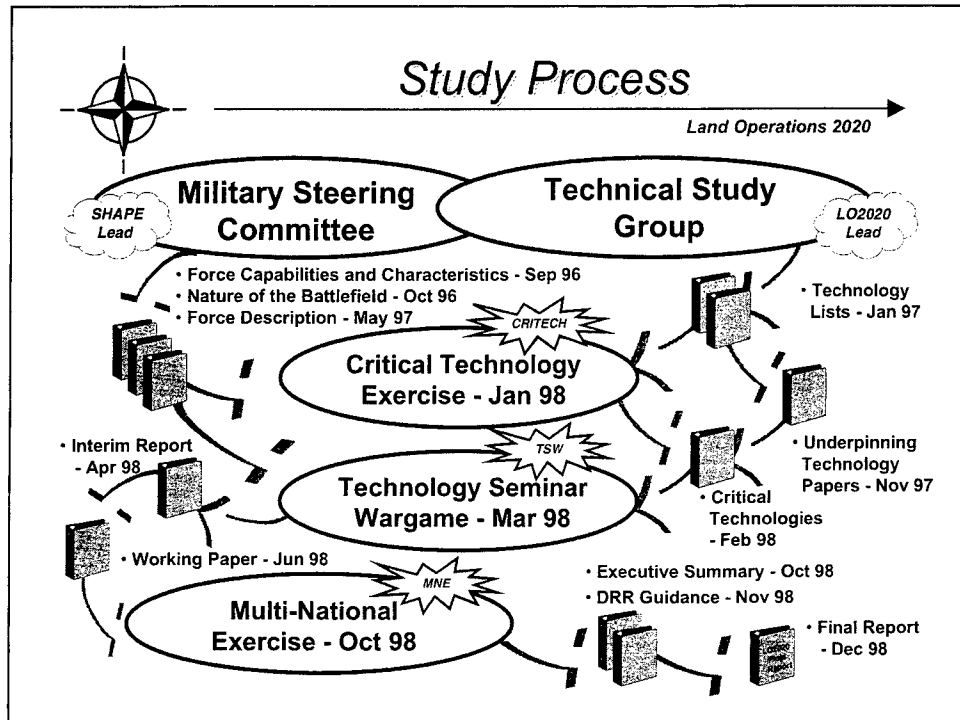


Fig. 2

## Study Process

Fig. 2 shows the work process used in LO2020, the products produced, the major events, the dates of the products and events, and how it was all interrelated.

In the early stages of the study two groups of experts worked independently -- the Military Steering Committee led by SHAPE, and the Technical Study Group led by the Study Director. The Military Steering Committee produced concept papers that set the requirements for land forces in 2020. The Technical Study Group identified the technology that will be available in 2020. Prior to the Critical Technology Exercise, the two groups of experts were combined into a single co-operative team.

The Military Steering Committee produced three major papers during the study:

- 1) a discussion of the battlefield in 2020
- 2) a list of the components and characteristics of land forces in 2020
- 3) a description of land forces in 2020.

These documents were used as part of the decision criteria in CRITECH, and they formed the basis for the scenarios and the friendly forces in the TSW.

The Technical Study Group produced several technology lists that were consolidated into a single list in preparation for CRITECH. Underpinning Technology papers describe the wide range of basic science and applications needed to support the development of advanced weapons for the year

2020. The Group used the Underpinning Technology papers and the critical technologies identified in CRITECH to propose the future weapon systems that were fought in the TSW.

Following the TSW, an Interim Report was provided to the SAS Panel and a Working Paper was written and staffed with all participating nations. The Final Report was delivered to the SAS Panel in December 1998 for printing and distribution.

## Challenges of the Battlespace 2020

These are shown graphically in Fig. 3 on the next page. In the 2020 battlespace, NATO must be prepared to conduct operations in a seamless spectrum involving conflict prevention, conflict, and post-conflict activities. There will be no neat classification of operation by type. Potential adversaries may range from one extreme of large, all-arms, similarly equipped regular forces, to the opposite extreme of irregular insurgents and terrorists who may not be identified with nation-states, and whose structure, sophistication, doctrine, training and ethos range from the similar to the radically dissimilar. In reality, conflict is likely to be a complex amalgam of forces and capabilities. To provide a structure to the 2020 battlespace in this study, two "views" of the battlespace were defined: View 1 is symmetrical conflict between two large, well equipped and well trained forces. View 2 is an asymmetrical conflict between one large, well equipped and well trained force, and a smaller terrorist-type opposing force that is less well equipped and trained.

- recommend directions for Allied and national research and development to support land operations, provide inputs to the Defence Requirements Review (DRR) and Force Goal Cycle

This information will provide the Supreme Headquarters Allied Powers Europe (SHAPE), and the major NATO commanders, with a basis for long-term requirements and defence planning.

The study accomplished its purpose by considering the availability and impact of new technologies that have the potential to appear in weapon systems in the year 2020.

### The Schedule

Fig. 1 shows the overall schedule. LO2020 was initiated in March 1995 by a request from SHAPE to conduct a study of Land Operations in the Year 2020 to parallel the on-going studies for maritime and air force operations -- Maritime Operations 2015 and Aerospace Operations 2020. During the year following this request, SHAPE established a Military Steering Committee, and the United States accepted the study lead and appointed a Study Director. Detailed planning for the study began, and by April 1996 the NATO Defence Research Group, a forerunner of the Research & Technology Organisation, approved the study Terms of Reference.

From September 1996 to May 1997, a series of workshop meetings and intense outside work produced a series of military and technology papers. These papers are included in the final report.

Three major exercises were conducted in LO2020:

- 1) a Critical Technology Exercise (CRITECH)
- 2) a Technology Seminar Wargame (TSW)
- 3) the capstone event, the Multi-National Exercise (MNE).

The one-week CRITECH exercise was held to identify the most important technologies out of a list of more than 140 candidates. Three teams composed of military officers, scientists and engineers evaluated the technologies using the criteria of technical feasibility, military effectiveness and relative cost. Using computer-assisted decision support systems, the technologies were prioritised and evaluated against the capabilities needed by land forces in 2020.

The two-week TSW was conducted to examine the military effectiveness of 12 conceptual weapon systems in the 2020 battlespace. Two friendly Blue teams fought against an opposing Red team in three scenarios covering high intensity combat between major forces and small-scale operations other than war. The battles were fought in a structured debate followed by questionnaires to identify the most effective weapon systems.

The two-week Multi-National Exercise was attended by 60 participants from 10 nations. During the MNE, the LO2020 Working Paper was discussed, revised and extended, to complete the Final Report. The major conclusions and recommendations were agreed to at the MNE.

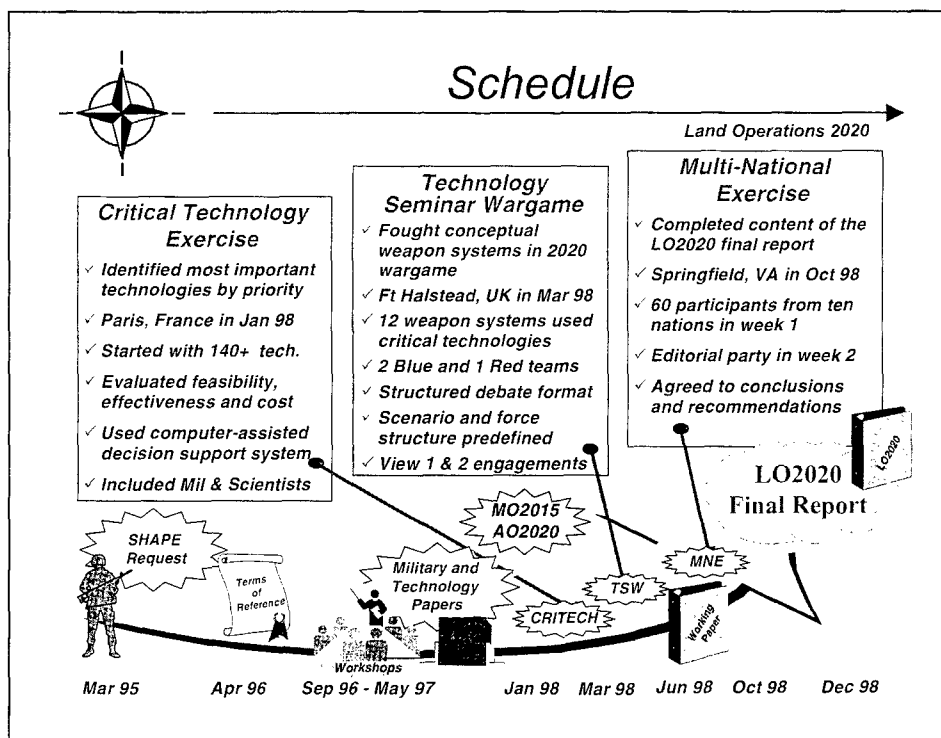


Fig. 1

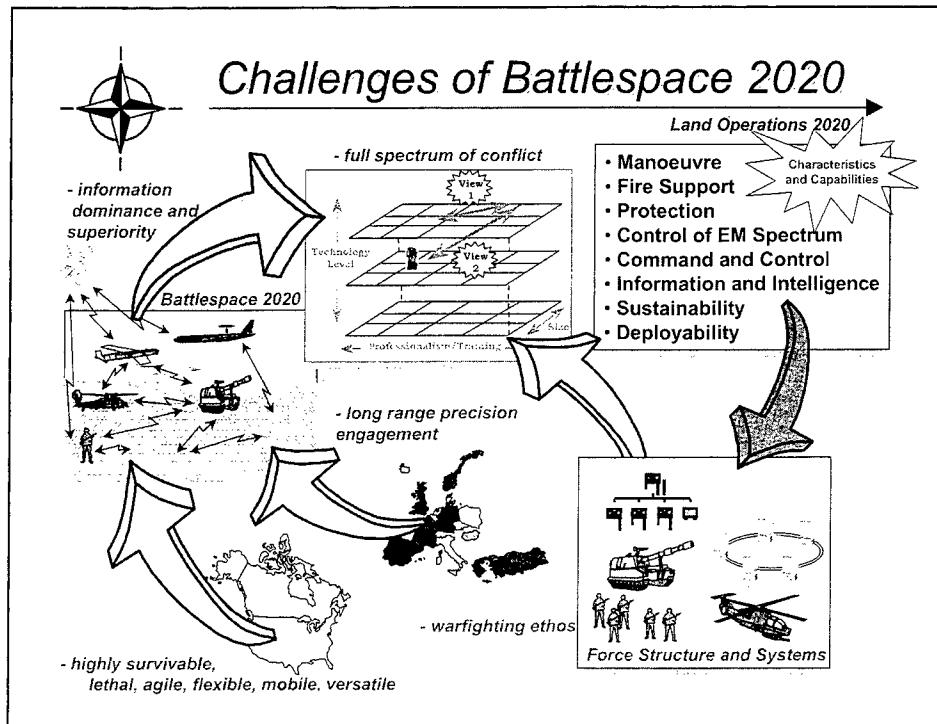


Fig. 3

## Characteristics and Capabilities

Potential adversaries will, to a large degree, have transformed from industrial-age to information-age forces by 2020. Formations are likely to be smaller, expeditionary and joint. The emphasis will be on deployable, versatile, flexible force, applied at high velocity and precision, at increasingly long-range, with, if necessary, intense and overwhelming violence. The military capabilities required in 2020 have been used throughout this study as a framework for analysis of the underpinning technologies.

The force characteristics and capabilities are the following:

- Manoeuvre
- Fire Support
- Protection
- Control of Electromagnetic Spectrum
- Command and Control
- Information and Intelligence
- Sustainability
- Deployability

The requirements defined by these characteristics and capabilities determine how force structure and systems should be built to meet the full spectrum of conflict likely to occur in 2020.

## Battlespace 2020

The battlespace in 2020 will be variable in density, non-linear and more dispersed. It will be cellular in nature, multi-directional and increasingly determined by what is above the battlefield in air and space. The 2020 battlespace is thus the whole of time, space and activity. Herein lie the challenges of the battlespace 2020.

A number of enduring factors will be present in 2020. The following are three of many factors discussed in the final report:

**The Soldier.** Conflict is, and will remain, essentially a human activity in which man's virtues of judgement, discipline and courage -- the moral component of fighting power -- will endure. To out-think, break, and if necessary, kill an opponent, whilst retaining the moral high ground, will be fundamental -- if not essential -- to success. It is difficult to imagine military operations that will not ultimately be determined through physical control of people, resources and terrain -- by people.

Thus NATO will continue to demand high standards of leadership, the core values of selflessness, self-reliance, moral and physical courage and integrity, and an ethos of fighting spirit in its soldiers. New technologies will, however, pose significant challenges to the art of soldiering; they will increase the soldier's influence in the battlespace over far greater ranges, and herald radical changes in the conduct, structures, capability and ways of command. Information and communication technologies will increase his tempo and velocity of operation by enhancing support to his decision-making cycle.

However, technology will not substitute human intent or the decision of the commander. There will be a need to harness information-age technologies, such that data does not overcome wisdom in the battlespace, and that real leadership -- that which makes men fight -- will be amplified by new technology.

**Warfighting Ethos.** The most effective means of protection -- every sense of the word from protecting member nations' vital interests to minimising the totality of casualties across the spectrum of conflict -- will, ultimately, continue to be the application of overwhelming force if, where, when and how NATO chooses. Fundamental, therefore, is the retention of a core ethos based on combat operations -- a requirement to focus on warfighting while being able to adapt for other operations. Technology must ultimately enhance combat operations.

**Balance of Investment.** A perpetual challenge is to ensure best possible value for money out of the processes of procuring combat power. To gain real operational advantage at maximum value for money, military scientific research will need to be prudent in its investment. Overall, the balance of investment in technologies will need to be in those that contribute to the broadest range of the components of capability, and in those that provide manifest qualitative step-changes in effect.

### **The Information Age**

A significant change in the conduct of operations is likely to come not from weapons alone, but from the all-pervasive application of information technology. There will be a synergistic combination of long-range precision weapons and networks of sensors and data processors, such as, digitised real-time sensor to shooter links, combat identification, decision-support, and UAV technologies. The effect will be to expand further the continuum of the battlespace, obfuscating the distinction between the strategic, operational and tactical levels of operation. The ability to see will also become conceptually and physically separate from the ability to shoot on a wide range of weapon systems, including direct-fire platforms. This will blur the distinction between direct and indirect fire and, possibly, render heavy and cumbersome combined sensor-shooter platforms less effective in the digitised battlespace. These factors will present NATO forces with major challenges to their doctrine, structures and training, and increase the imperative for standardisation, interoperability and cohesive command and control arrangements amongst the member nations.

### **Technology for 2020**

A number of separate, independent approaches were used to identify the Key Technologies of 2020, capitalising on the expertise of individual nations in certain technologies and methodologies.

In the first approach, the LO2020 Technology Study Group generated a "top down" Critical Technology List containing eleven broad technical areas. Within these key technology areas, numerous specific technologies were identified. In a second "bottom up" approach, ongoing government and civilian research formed the basis for identifying technologies. The result was the Key Technology Areas listed here.

Next, the CRITECH exercise examined in great detail, the feasibility, effectiveness, and cost of 142 very specific technologies. The outcome was a completely auditable shortlist of 63 technologies deemed to be the most relevant from the joint perspectives of feasibility and effectiveness. Further analysis led to a shorter list of 34 technologies, of which 67% were dual, and only 33% specifically military. All of the technology lists are contained in the LO2020 Final Report.

### **Key Emerging Technologies**

Identification of a number of Key Emerging Technologies, which offer step changes on the battlefield, has been one of the main outcomes of the Critical Technology Exercise, the Technology Seminar Wargame, and the Multi-National Exercise. These are:

**High Power Battlefield Electrical Systems**, for propulsion of land vehicles and UAVs, for direct fire weapon and armour systems, and in the form of radio frequency electro-magnetic radiation for non-lethal soft-kill weapons.

**Biotechnology** that will allow development of new sensors and agents that can accomplish mine detection and clearance. Biotechnology will also contribute in improving the strength, health, efficiency and endurance of the soldier.

**Micro Electrical Mechanical Systems (MEMS)**. As miniaturised sensors, these are expected to have multiple applications in different areas of military operations, ranging from wide-area monitoring to equipment and personnel monitoring.

**Novel Energetic Materials** will result in significantly increasing the range and lethality for all weapons using propellants and explosives. Additionally, reduced logistic burden will result from decreasing the size of munitions.

### **Key Technologies to Support Force Capabilities and Characteristics**

A large amount of technical data was collected and analysed. The most important information is included in the Final Report in a series of papers on the Underpinning Technologies. Rather than present a large volume of technology data at this time, I will show the key results for each of the military components of capability.

## **Manoeuvre**

During the next 20 years, there will be evolutionary changes in all aspects of land and air platforms leading to improved speed, range, and fuel consumption, as well as reduced signatures. Mostly these will be led by improvements in materials and the way materials are used in subsystems -- for example, the aero-elastic tailoring of rotorcraft blades and the adoption of active suspension systems for land vehicles. Lightweight vehicles, sensors and weapons will enhance air transportability, and crew reduction resulting from increased automation will further reduce size and weight.

A potentially revolutionary change can be expected from the introduction of Electric and Hybrid Electric drive technologies to land vehicles. Materials advances, in the form of new insulators, magnetic materials and semiconductor switches, coupled with microprocessor based control systems are the key enabling technologies for this.

Micro Electro-Mechanical Systems used in sensor arrays will permit commanders to identify corridors of approach that are open or lightly defended.

## **Fire Support**

Recently, molecular dynamics modelling techniques have shown that novel explosives may be realisable that have, for example, five times the energy density of TNT. If so, and if such materials are stable, they could re-invigorate conventional gunnery.

High power lasers could provide another radical alternative to conventional direct fire capability for the future, and some non-NATO nations have fielded such systems.

Radio Frequency Directed Energy Weapons could provide another revolutionary direct fire asset in 2020. Modulated RF signals have the ability to disrupt electronically controlled systems ranging from command and control computer systems to the engine management systems of modern vehicles. RF directed energy would be a valuable non-lethal weapon because it can readily provide soft kill of enemy electronic systems without harming personnel.

## **Protection**

The Air threat will grow in quantity and quality including both Guided and Long-Range Ballistic Missiles. This development puts a premium on early warning, identification and prioritising engagements of aerial vehicles. Radar, optics, lasers and acoustical technologies will have to be further developed and integrated into the battlespace information technology infrastructure.

Making equipment harder to detect is a key element of protection. In part, stealth can be achieved by design, but reduced signature coating or construction materials will also be essential. By 2020, it is possible that tuneable,

multi-spectral coatings will be available, which will allow the signature of key assets to be changed according to their particular environment, achieving a chameleon effect.

Increased use of interconnected computers, communications and other electronic systems will offer many new potential vulnerabilities. A robust integrated defensive capability will be required which will detect, identify, deter and react to hardware and software threats. There will be many rapid developments in COTS software and hardware in areas such as encryption, authentication, virus detection, network monitoring and artificial intelligence.

Advances in nanotechnology, MEMS, biotechnology and information processing technologies will yield progressively smaller NBC detectors, so that by 2020 it should be possible to have miniature replacements for the current truck-sized systems. Biological detectors interspersed in a MEMS security field could provide a dispersed detection system capable of providing early warning of biological attack.

## **Control of the Electro-Magnetic Spectrum**

There are a wide variety of systems which need to be managed, ranging from communications systems supporting battlespace digitisation, through active surveillance systems such as radar, to passive surveillance systems. The possible use of high-power microwaves and RF weapons, as well as conventional EW, will pose special problems, in particular bandwidth availability. Management of the spectrum will require an analysis system which links databases containing information on equipment characteristics, deployments, geographic data and international regulatory data.

Denying the enemy use of electromagnetic spectrum amounts to jamming. Technology will offer new platforms on which jammers can be deployed, such as highflying UAVs. Advances in RF power generation, digital signal processing, and photonics will continue to result in fielding of smaller, more capable coherent jammers.

## **Command and Control**

Digitisation of the Battlefield is an initiative currently being researched in many NATO nations. Digitisation is intended to link those battlefield systems which gather, store, process, transmit or use information, in particular sensors and weapons, via appropriate communications and command and control systems.

A variety of technologies will be required to deliver battlespace C2 systems including mm wave and optical communications links to satellites, spread spectrum and low probability of intercept waveforms, encryption and multi-level security protocols. The impact of this will be the capability to provide secure high bandwidth information at all parts of the battlefield, linking sensor to

shooter in a seamless manner, and providing tactical data and intelligence to all units that require it, even to the level of individual soldiers.

### Information and Intelligence

Dramatic increases in computing power and in miniaturisation will lead, by 2020, to an increasing tendency for co-located information gathering and processing so that high-level target information emerges from sensors. Many of the technologies supporting Information and Intelligence have already been discussed.

### Sustainability

Future operations will require soldiers to undertake longer periods without rest and to recover more quickly from combat. New drugs and food supplements offer opportunities to enhance performance and resistance of the soldier. Improved integrated clothing systems with personal heating and cooling, including miniaturised power supplies will permit operations in extreme environments.

Biotechnology offers the prospect for new diagnostic procedures and treatments against chemical and biological agents. In combination with MEMS health sensors on or possibly implanted within individual soldiers, these substances could be accurately and automatically delivered at the precise moment they are needed, thereby dramatically reducing the casualties that might otherwise occur.

The expanded spectrum of possible NATO operations poses new demands on logistics. This is a very complex problem and its solution will require a true systems approach, combining many of the key technologies.

For example, lightweight packing materials could be used to reduce the parasitic mass of stores, while the introduction of precision weapons and novel energetic materials should mean that fewer rounds of ammunition are actually required. Hybrid electric power systems could reduce the requirement for fossil fuels. Valuable as these advances would be, the key to an efficient, "Just In Time" logistics delivery service will be the digitised battlefield. This will provide a seamless information technology infrastructure that can receive input from stores monitoring and health monitoring sensors built into all platforms and link these to a re-supply centre in real time. Stock control systems developed already for industrial use will analyse the data and issue stores where and when needed. Robotics and automation techniques will further help this process and in some cases stores could actually be delivered to appropriate battlefield locations by means of autonomous robot platforms.

### Deployability

The joint Combined Task Force and national contingents will be tailored by use of enhanced analysis tools to support the planning process. The use of Operational Analysis and Simulation will lead, after reviewing a broad range of scenarios, to an optimised force composition.

Advanced information technology can be used for planning, directing, and monitoring transport assets. Technology can contribute in improving transport capabilities by reducing weight and size of containers and packaging materials, providing advanced navigation logistics.

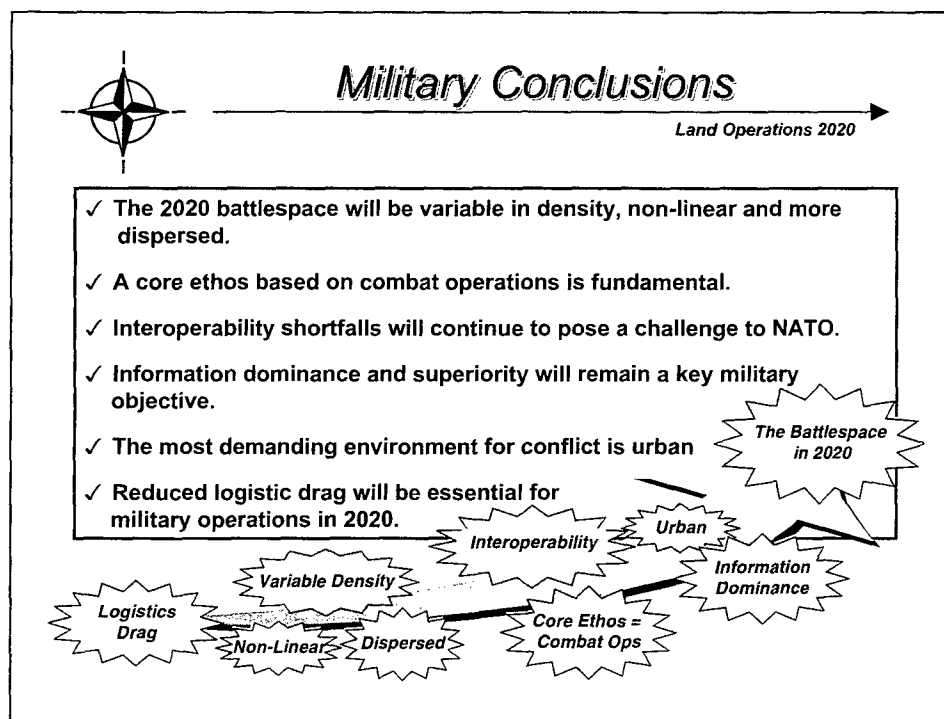


Fig. 4



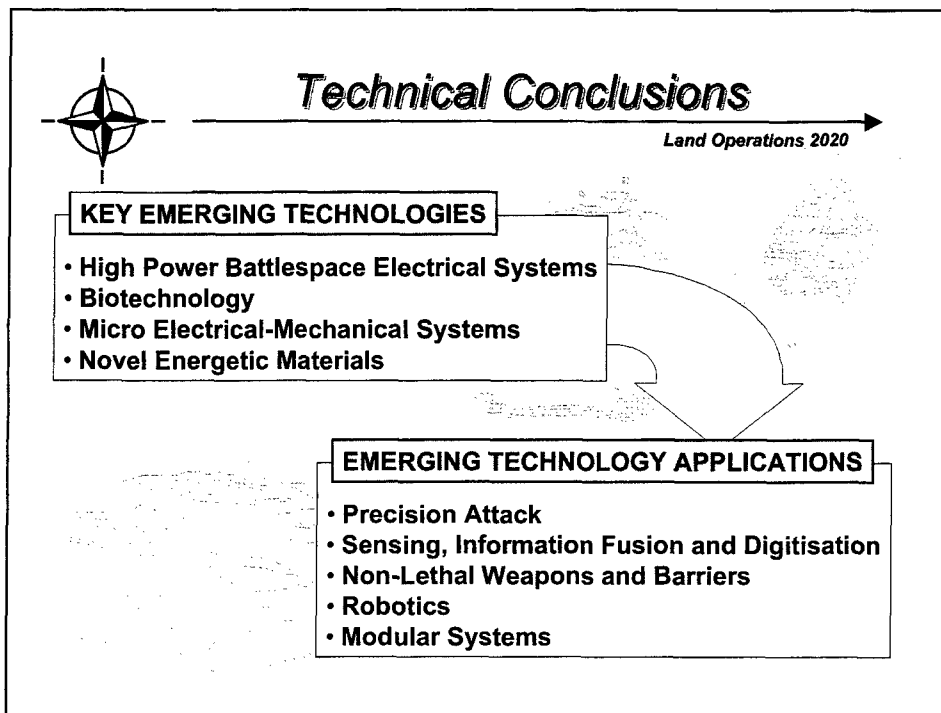


Fig. 5

## Military Conclusions

The most important Military Conclusions are shown in Fig. 4. Notes amplifying some of these conclusions follow:

- **interoperability** is perhaps the biggest challenge to NATO and as new nations are assessed, will present an even greater challenge.
- **information dominance** will continue to be a force multiplier (that is, knowledge is power), and will enable NATO to proactively apply combat power at the desired place and time to disrupt an adversary's planning cycle and unhinge his military operations and perhaps even his economic, social and political state.
- **logistics drag** is an area that requires significant emphasis in order to keep pace with envisioned military operations, systems, and weapons in the 2020 battlespace. Just-In-Time logistics does not reduce the volume, weight, and transport requirements. Smaller, lighter, more capable, and more efficient supporting logistics are essential.

## Technical Conclusions

Fig. 5 shows the four **Key Emerging Technologies** presented previously, which will support the development and fielding of the five **Emerging Technology Applications** also shown in the figure.

## Recommendations

The most important Recommendations from the LO2020 Study are:

- All NATO nations should emphasise standardisation and interoperability in all research and technology programs. Weapon system interoperability, as well as interoperability of military techniques and procedures, must continue to be a goal, especially in the development of the Key Technologies.
- The NATO Research and Technology Organisation should initiate studies and research on the Key Emerging Technologies.
- SHAPE should use the LO2020 study results in the Defence Planning Cycle 2000.
- NATO should establish military working groups to study the concepts and doctrine needed for 2020. These studies should focus their emphasis on the LO2020 View 2; that is, asymmetrical conflict between a NATO nation and terrorist forces that are smaller in size and less disciplined.
- SHAPE should request follow-on studies, like LO2020, to keep pace with emerging technology and changing military environments.

This concludes my briefing on the Land Operations 2020 long-term scientific study.

## **Colonel Albert B. Garcia, Ph.D.**

**Commander, U.S. Army Research,  
Development and Standardization Group  
Bonn, Germany**



Colonel Garcia assumed command of the Standardization Group on 1 August 1997. The Group's mission is to support U.S. Army research, development and acquisition objectives by fostering international cooperation with European governments. Colonel Garcia was born at Fort Devens, Massachusetts, USA in 1944, was commissioned in 1968 and entered active duty in 1970 from the state of West Virginia. He is a member of the U.S. Army Acquisition Corps.

In 29 years of active service, Colonel Garcia has held a variety of command and staff positions both in the United States and overseas. His previous assignments include Commander, U.S. Army Information Systems Software Development Center - Lee, Fort Lee, Virginia; Project Manager, Electronic Campus at the Defense Systems Management College, Fort Belvoir, Virginia; Product Manager, Communications Processor Interface, All Source Analysis System, McLean, Virginia; U.S. Army Detachment Commander, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio; Advisor to the Commander, Saudi Arabian Land Forces Signal Corps, Riyadh, Saudi Arabia; Assistant Program Manager for Logistics, Tactical Operations System, Fort Monmouth, New Jersey; Commander, A Company, 34th Signal Battalion, Ludwigsburg, Germany; and Aviator, 238th Aerial Weapons Company, Tuy Hoa, Vietnam.

Colonel Garcia holds a Doctor of Philosophy in Engineering degree from the University of Dayton, a Master of Business Administration degree from Fairleigh Dickinson University, and both Master and Bachelor of Electrical Engineering degrees from West Virginia University. He also completed the Program for Management Development at Harvard University. His military education includes a U.S. Army War College Fellowship to the Defense Systems Management College, the Armed Forces Staff College, the U.S. Army Command and General Staff College, the Signal Officer Advanced Course, and the Transportation Officer Basic Course.

His awards and decorations include the Legion of Merit Medal, the Bronze Star Medal, the Defense Meritorious Service Medal with one oak leaf cluster, the Meritorious Service Medal with three oak leaf clusters, the Air Medal with third award, the Army Commendation Medal, the Vietnam Gallantry Cross with Bronze Star, the Secretary of Defense Identification Badge, and the Army Aviator Badge.

Colonel Garcia has been married to the former Mary Katherine Myers from Moundsville, West Virginia for 31 years.

# Alternative Control Technologies

by

**Alain Léger and Don Jarrett**

*This was the title of an RTO publication prepared for the Human Factors and Medicine Panel: Technical Report TR-7, December 1998. It reported the results of a former AGARD Working Group which had been set up in 1996 with the aim of evaluating the state of the art of, and formulating a framework for, the integration, evaluation and application of a variety of emerging control technologies in aerospace systems. The Foreword to this publication was written by the Chairman of the Group, Dr Alain Léger of Sextant Avionique, France and one of the members, Dr Don Jarrett of DERA, UK. With their agreement, it is published here because of its philosophical as well as technical nature.*

Man inherited a superior ability to interact with the environment using his hands. The major evolutionary step taken when this capacity was extended to manufacture stone tools, to enhance the direct mechanical action of the hand on "dumb" mineral, vegetable and animal elements in the environment, perhaps qualified him as "habilis" long before he became "sapiens".

Through our social needs, which we had in common with all animals, we could also influence one another's behaviour without direct contact, using posture, sound, facial expression and, for instance like dominant wolves, cause submission by "gaze fighting". However, it was the human acquisition of articulated speech, with its rich mixture of semantic, prosodic and affective cues which introduced new dimensions to remote communication, albeit with the co-operation of a receptive "intelligent agent". We should note that this use of the voice has been vital for military purposes from antiquity to modern times to control the movement of troops in battle, and coordinate their actions.

In the aeronautical field, following the first powered lift-off of the "avion" at the end of the 19th century by Clement Ader, the first controlled flight manoeuvre, a stable turn, was performed in 1905 by the Wright brothers. Here the only intelligent agent was the pilot himself, and since all else was wood, metal, rubber and fabric, it required the pilot to exert mechanical control actions, largely through his hands. However nowadays most modern aircraft are controlled directly by complex computational systems, and such mediation theoretically overcomes the need to hold, push, pull or twist a lever in order to effect control. This transformation is worth emphasising; because a machine controlled by computers looks like a computer to its operator, the interface between the man and the machine can be as flexible as that between a man and a computer. We therefore have the opportunity to evolve the pilot from "habilis" status to "sapiens".

The computers have themselves evolved. Those from the 60's and 70's had very limited "intelligence" and memory, which greatly exercised both the programmer's skill in optimising the programmes and the operator's skill in

using intelligent strategies to compensate for his own and the machine's shortcomings. However, the situation on the machine side is now completely different and, although the machine still lacks "intelligence", it possesses a huge memory capacity and an ability to process data with extraordinary speed which is quite the opposite of human abilities, an imbalance which is most evident at their interface. Here work seems to be required in two areas: the direct interfacial mechanisms and the overall system design. The first is necessary to improve the physical modes of interaction. The latter is needed to make the machine more like a human so that it can accept high level instructions and, perhaps, eventually be capable of understanding the intentions and needs of the operator. There is a nice analogy here; the progress from programming a computer using machine-intelligible codes to the modern use of high-level languages is paralleled by the idea of the operator interacting with machines at present using numerous detailed machine-compliant actions and the future possibility of control via high level human-oriented intentions.

The challenge to engineers and cognitive scientists is obvious. As well as effort directed toward making information from the machine easier for the operator to perceive and understand, there is a need for "human-centred" control concepts. An excellent statement of the motivation was put forward by Rasmussen and Vicente as the "ecological interface" which, they suggested, should be constructed in such a way that it did not constrain the operator to work at a higher level of control than required by the situation. This concept may now have started with the adoption of novel head tracking and speech recognition systems in new generation aircraft like the Eurofighter, Rafale and the JSF, in which for instance, the pilot may give a short command to an "intelligent" speech recogniser rather than have to complete a lengthy sequence of alphanumeric key pressing actions.

It must however be borne in mind that the case for maintaining a progressive improvement to man-machine interaction, no matter how strong the theoretical argument, must be justified practically. The most evident case is that



An experimental large interactive display (viewed from behind the display - it has not been printed back to front)

manual controls and switches, particularly those mounted in the grip-tops and referred to as "hands-on-throttle-and-stick" (HOTAS), are already too numerous. There is an obvious chance of erroneous selection. One difficulty, which is quite likely to be a major problem, is somewhat paradoxical in that it stems from human adaptability, and here there are two issues. Firstly, the human ability to do without something which he has never had may make the provision of it unjustifiable to a hard-nosed accountant. Secondly, our intrinsic ability to devise a suitable strategy for overcoming equipment limitations makes it difficult to predict how something can be used most effectively, and therefore determine how best to set it up. Perhaps, to exploit novel technologies the system integrator should build-in the flexibility to allow the user to adopt a strategy which best enables him to fulfil his objectives. In any event, the rationale for providing alternative controls must be made primarily in terms of a reduction in the effort, both cognitive and sensorimotor, which the operator expends in performing his job. This, and a substantially reduced chance of error, would be apparent in war as improved mission effectiveness and in peace as enhanced safety. For the provider, the cost of equipment supply and maintenance are likely to be countered best by quantifying the benefits in terms of a reduction in training time, although the gain in confident proficiency and general well-being of the operators should not be neglected. If

built-in flexibility affects either the benefits to performance or the training needs, this must be included in the trade-off.

For two years Working Group 25 has tried to review comprehensively the issues associated with the implementation of Alternative Control Technology in the aerospace environment. Most of the information collected can be applied to other defence or civil applications, particularly the reviews of the states of the art in each of the technological areas. The issues which must be addressed in order to integrate these systems into the man-machine interface have been approached from both engineering and human factors viewpoints, and the need for further research has been identified, mainly as a set of challenges in the context of combat aircraft. It is recognised that a considerable amount of work remains, because very little will result from merely putting electronic boxes side by side and connecting them to the rest of the system.

Like the successful exploitation of automation, achieving meaningful and effectively integrated solutions will require the synergistic effort of a wide range of skilled individuals in research laboratories, equipment manufacturers and airframe manufacturers. We hope that our efforts will provide practical help in this endeavour.

# The Future of RTO's Publications

by

George Hart

*As the Director has said in his 'Note' on page 1, RTO is expanding into the new millennium with all kinds of new initiatives. One initiative he did not mention, which will affect all readers of Highlights and other members of the 'Family', is a major change in the way in which the results of RTO's work will be published. The Executive for Information Policy & Publications of RTA briefly describes here the background to this change and how it will be phased in over the next few years.*

## The past

DRG and AGARD, the constituent bodies of RTO, both had their own arrangements for printing and distributing the results of their work. NATO HQ printed everything for DRG and the resulting publications were mostly distributed through the national delegations to NATO. A few copies were also sent direct to the individuals who had contributed to the publication. Between 300 and 400 copies were generally printed, no matter whether they were classified or unclassified. On the other hand, AGARD's publications were printed and distributed commercially, with copies going direct to distribution centres in the nations as well as to Board members, relevant Panel members and authors (and the participants when it was the proceedings of a meeting). AGARD printed between 1000 and 1200 copies of those publications that were freely available (the large majority), and between 350 and 400 copies of NATO Unclassified and classified ones.

The last major change for AGARD was nearly 30 years ago when the present Chairman of RTO, Dr Yarymovych, was Director. They then ceased having everything type-set and started to use camera-ready copy supplied by the authors. DRG also used camera-ready copy for the proceedings of meetings, but for the reports of Research Study Groups they mostly asked for electronic files from the authors, which were edited by the staff of the Defence Research Section in NATO HQ. AGARD made less use of electronic files, mainly because their printers were able to edit the work when necessary.

## The present

With the birth of RTO, we had to make this into one common operation. We considered abandoning the old methods entirely and using only electronic input and output, but the Information Management Committee (IMC) of RTO advised that the time was not ripe for such a radical step, and so we continued to produce paper copies with the majority of publications printed commercially. We print about 1000 to 1200 copies of freely available publications and 300 to 400 copies of classified ones. Technical Memoranda, which have less stringent requirements, are generally printed in NATO HQ, with a print run of 300 to 400 copies. RTO places a greater emphasis on serving the military directly than did

AGARD. Consequently the number of NATO Unclassified publications has risen. We generally print about 800 to 1000 copies of these.

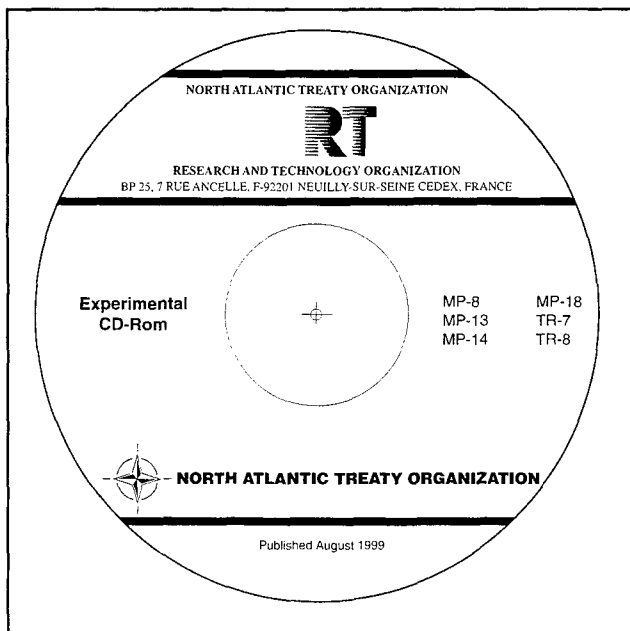
## The future

Since the start of RTO, the Research and Technology Board (RTB) has been saying that printing costs could be reduced by the use of electronic publishing. IMC have agreed that this is now feasible, but they advised us to proceed one step at a time, with careful experimentation, in order to ensure that the quality and usability of RTO results would not be not reduced. After all, one of the main purposes of RTO is to transfer information and it is important to ensure that this is not hindered.

We have carried out three experiments. In the first, the printers converted electronic files supplied by the authors of papers in a symposium organised by the Information Systems Technology Panel (IST) into PDF (Adobe's Portable Document Format - a *de facto* standard nowadays). In the second experiment, we mounted files supplied by the authors at another IST symposium directly onto the RTO Web site. In the third experiment, the printers scanned six publications of different sizes and types and converted them into PDF form, with hyperlinks from the entries in the contents lists to the corresponding pages, so that the user can click on the title of a paper and go straight to it. CD-ROMs with these files (see illustration on next page) were sent to the national Distribution Centres and to IMC members with a short questionnaire. The responses to this were very favourable and the RTB agreed at its Fall 1999 meeting that we should go ahead with electronic publishing for unclassified publications in three phases.

It should be noted that everything that follows relates to unclassified publications only. Classified ones will continue to be printed in paper form until electronic working has been completely established, because additional security precautions are required for handling classified documents on computers.

**Phase 1:** It seemed appropriate to start the new millennium with a new method of working and so we decided to begin the first phase with publications dated January 2000 onwards. As well as emphasising the importance of the new millennium, this has given our distribution centres 3 months to prepare for the changes.



In this phase, we will continue to print paper copies of each publication, but in smaller numbers than at present. These will be scanned to provide electronic files. We will still send copies of publications to individuals, so they will not notice any change. However, each National Distribution Centre will receive only two paper copies and two CD-ROMs for each publication. The files will also be mounted on the RTO File Transfer Protocol (FTP) server, where they will be available to registered users. We believe that this combination of paper copies and two sources for electronic files will ensure that no serious problems are experienced. The reduction in the number of copies we print should counterbalance the cost increase incurred by scanning the documents.

The RTO publications already printed and those that are currently in process will also be scanned into PDF form during this phase, so that we will have electronic versions of *all* RTO publications.

**Phase 2:** The current printing contract expires at the end of June 2000, and that is a convenient time to start phase 2. At that time, we plan to cease printing paper copies altogether. Electronic versions of all publications will be prepared in PDF form, either by scanning the printed version or by converting the electronic files submitted by the authors. The latter will be the preferred method when there are photographs or other grey-scale illustrations because the quality produced by scanning a printed image is not as good as that obtained directly from the original

electronic version. During this phase, the authors will still supply camera-ready copy with their electronic files in case there are problems handling the files. We will continue to distribute two CD-ROMs to each distribution centre, as well as mounting the files on the FTP server. In addition, we will notify the other potential individual recipients that they can view (and down-load if they wish) the files from the FTP server.

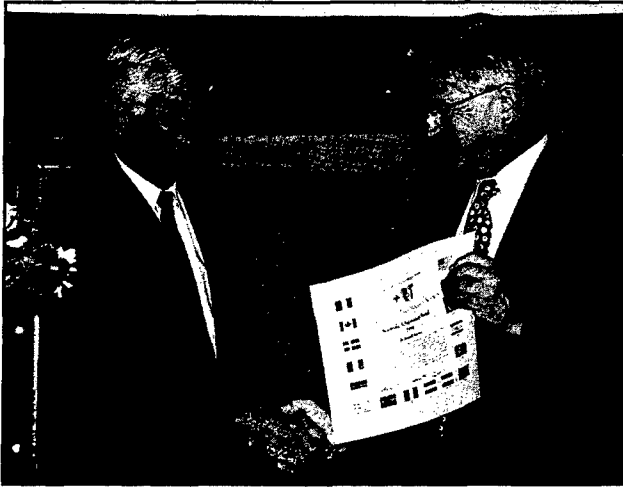
**Phase 3:** We do not yet know when this phase will start, but we intend to work solely with electronic files as soon as possible. When we do, we will no longer accept camera-ready copy from authors, and we will insist that only certain formats be supplied. These are likely to be PDF, Postscript, Word and WordPerfect, but others may also prove acceptable in the light of experience. The results of phase 2 will enable us to determine which formats should be avoided. As in Phase 2, we will continue to insist on having a printed version of every file, so that we can check that the electronic files are complete.

## AGARD publications

**Sets of CD-ROMs of all AGARD publications from 1952 to 1998** have been prepared by a Spanish contractor, and sets of 28 discs, including comprehensive search, retrieval and display software, are available for 170,000 pesetas each (about US\$ 1050 at present, but the Euro is falling as I write this). One set has been sent to every NATO nation. Sets will also be available without the software for about two thirds of the price.

**The Multilingual Aeronautical Dictionary (M.A.D.)** was published (in paper form, of course) in 1980. It has 900 pages and contains definitions in English of 7319 aeronautical and space terms, with their translations into 9 other languages: French, German, Greek, Dutch, Italian, Portuguese, Russian, Spanish and Turkish. It also lists about 4500 English acronyms and their expansions. It has been out of print for 16 years, but we continue to receive requests for it. It has now been scanned into PDF form, together with copious hyperlinks to enable it to be used easily, and put onto CD-ROM. One copy has been sent to each nation, and copies are also available for sale at 200 francs (about US\$ 32).

Please get in touch with me at RTA HQ if you are interested in buying either the complete set of AGARD publications or a copy of the Multilingual Aeronautical Dictionary.



Scientific Achievement Awards were presented to Dr Russell Burton (left) and Dr Jürgen Richter, both of the USA. The citations for these awards were also printed in the last issue of Highlights.



The French get together: IGA D. Estournet, Member of the Board (at right) and ICA P. Cunin, National Coordinator.



The Italians get together: Lt Col A. Pellicciotta, of the Ministry of Defence, and Colonel R. Vigiotta, National Coordinator, with their wives.



Dr D. Etter, senior Member of the Board from the US (centre) talks to the Dr Ernst van Hoek, Director of RTA, and his wife, Jolly.



Major General A. Grønheim, Co-Vice Chairman of the Board, who is Chief of the Logistics, Armaments and Resources Division of NATO, with Mr and Mrs E. Criel. Mr Criel is Financial Controller of the International Military Staff of NATO.

# Athenian Atmosphere

*The Fall 1998 meeting of the Research and Technology Board was held in Athens. As well as attending the meeting, the members had the privilege of being invited by the Hellenic Members of the Board to both a reception and a formal dinner. It is hoped that the photographs that follow will recapture some of the atmosphere of these occasions for those who were fortunate to take part. Members also made a technical visit to a Greek telecommunications company, Intracom, which is reported briefly in the article that follows this one.*



The Chairman of the Board, Dr Yarymovych, presented a plaque to the senior Greek Board Member, Captain E. Theofilou, as thanks for hosting the meeting.



Dr E. Narlis, another Greek member of the Board, who did much to ensure the success of the meeting, also welcomed members to Athens.



Three Board Members from different countries: Professor Ahmed Ücer of Turkey, Mr Ken Peebles of Canada, and Dr T. Spathopoulos, the third member from Greece.

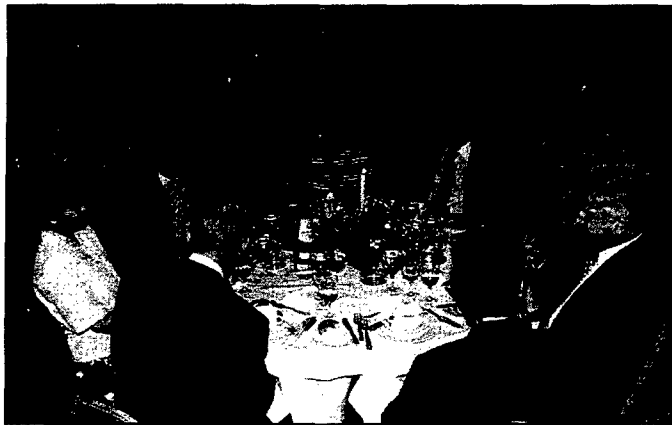


Mrs Lana Yarymovych (centre), wife of the Chairman, with Ir. Captain and Mrs Willie Sombroek. Ir. Sombroek was the National Coordinator for The Netherlands.

Mr Nils Holme of Norway received the von Kármán Medal and certificate from the Chairman. The citation for the award was published in the previous issue of Highlights. (A second von Kármán Medal was presented to Dr Peter Hamel of Germany. A photograph of the presentation to Dr Hamel is at the head of the article "Reflections on Theodore von Kármán", on page 3).



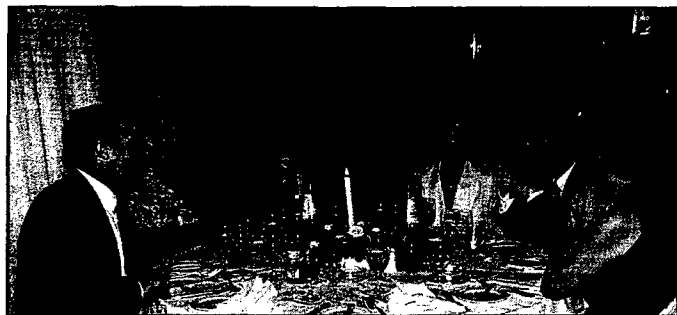




Dr Etter is nearest the camera. Going right from her are Dr Yarymovych, Mrs Holme, Dr Narlis, Mrs Yarymovych, Dr Spathopoulos, Mrs Narlis and Mr Holme.



Mrs Hamel is nearest the camera. Going right from her are Professor I. Drosos, General Director of the Defence Industry Research and Technology Directorate of the Greek Ministry of National Defence, Mrs M. Dali-Ziabaka, at that time Greek National Coordinator, Dr Hamel, Mrs van Hoek, Captain Theofilou, Mrs Spathopoulos, and Dr van Hoek.



From the left around this Dutch table are Dr Ir B.M. Spee, General Director of NLR, the National Aerospace Laboratory, Ms C. Heeremans, Ir and Mrs Sombroek, Commodore Ir D. van Dord of the Ministry of Defence and Mrs van Dord.

A nearly wholly American group: From left, they are Mrs Richter, Dr Richter, Lt Colonel Tom Roberts, Executive of SCI, Major General Grønheim (from Norway), Col A.R. Shaffer, Dr D.C. Daniel, Board Member, Mr Teddy Houston, RTA Assistant Director and Secretary to the Board, Dr Etter, Mr S. Stafford of the National Coordinator's office, Dr Yarymovych and Mr B. DeRoze, National Coordinator.



A German group: Dr Peter Tonn, Executive of AVT, with his Chairman, Professor H. Körner, and Mrs Körner.

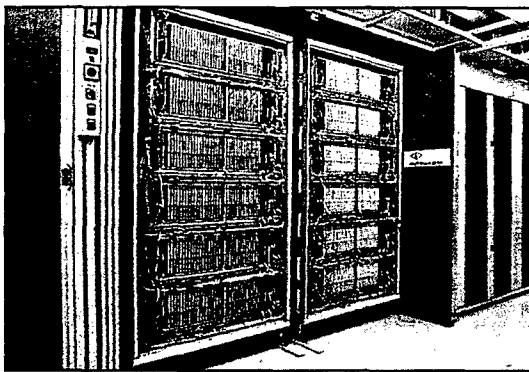


Mr and Mrs Ian McFarlane seem amazed to be photographed. He was a UK Member of the Board from British Aerospace at the time.

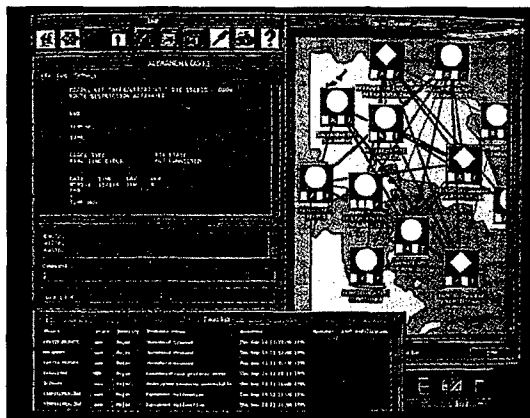
# Greek National Day

*During the Board meeting in Athens in Fall 1998, members were taken on a technical visit to Intracom, the largest Greek supplier of telecommunications equipment. The following notes and photographs are just a few excerpts from the English version of the company's Annual Report for 1997, copies of which were provided to Board members. The photographs are also taken from the Annual Report. They were not given captions there, so any errors are the editor's.*

At the end of 1997 Intracom signed a major, long-term, agreement with the Greek Telecommunications Organization (OTE) to provide digital exchange systems, synchronous digital hierarchy transmission systems, network management systems and digital network access systems. Included in this agreement are 1.5 million new digital lines, 160,000 ISDN channels, optical fibre and radio multiplex transmission systems and the digitilisation of 800,000 subscriber copper lines. The aim is to complete digitilisation of the Greek telephone network by 2000.

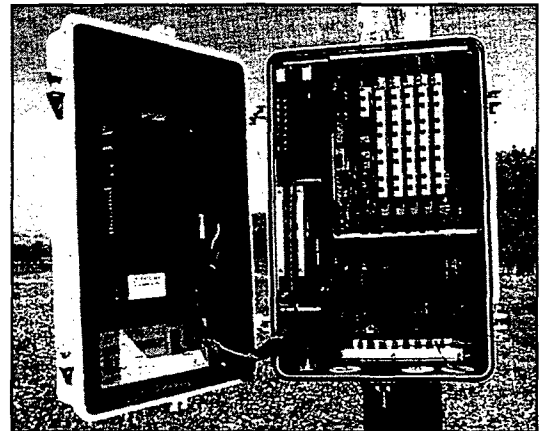


Digital exchange



Network management

Intracom also has other, smaller, contracts with OTE, for example for the supply of 170,000 digital exchange lines and 37,000 ISDN lines, point-to-multipoint radio links for OTE's services to remote rural areas, and with other Greek telecommunications companies. Intracom has also provided digital exchange support services for network design, installation, operation and project management to Spain, Sweden, Switzerland, Bulgaria, Brazil and Russia.



Rural telephone equipment

In the field of public telephony, Intracom is to supply 30,000 new card-phones to OTE and upgrade the 30,000 already installed. They have also undertaken projects in this area with 11 countries in eastern Europe, the Middle East and Asia. These projects jointly involve the supply and installation of cardphones and management software worth over \$13 million. Since some of them are pilot projects, the company expects to generate considerable additional sales later in some of these countries.

Special telephone booths have been designed for the Greek cardphone system, including secure data communication and secure crypto-key origination and transfer capabilities, allowing the use of phone cards from other systems.



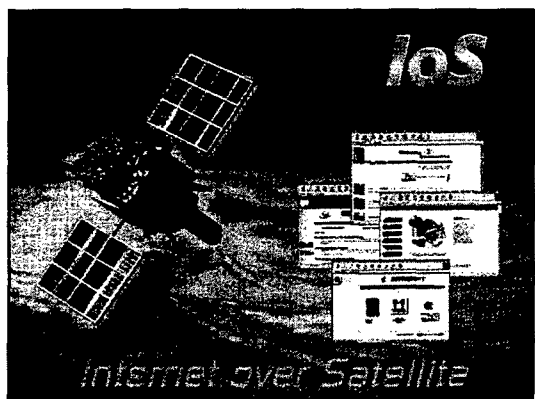
The upgrading of the OTE cardphone network is the first stage in the promotion of the Balkan Phonocard concept which aims to make phonecards from all Balkan nations mutually acceptable.

In 1997 also, the company completed a high performance network for the University of Patras and initiated a pioneering ATM network at the University of Athens. They also began to supply a new telecommunications network for the Ministry of Foreign Affairs. Intracom, in cooperation with Ericsson, will also design and implement the telecommunications network for the new Athens International Airport.

Intracom has activities in many other areas. These include defence systems, where Intracom is involved with major international consortia in, *inter alia*, the co-production of the Hawkeye Early Warning System for the Hellenic Air Force (HAF), in the up-grading of the Sea Sparrow missile and of the radar systems on the HAF's F-4 aircraft, the development of a new air-to-air IRIS-T missile, and the supply of digital telephone exchanges to the HAF.

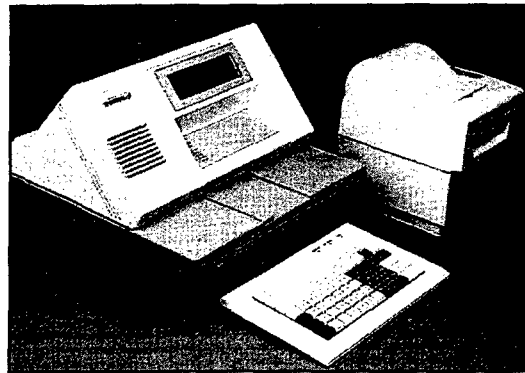


Intracom also developed the 'Internet over Satellite' software, which gives low cost, high speed, access to the Internet, and is now used by a subsidiary of News Corporation and Cyberstar, an American Internet provider.



Intracom is the largest Greek industrial participant in EU organised and financed programmes and is also undertaking work for NATO and CERN.

Other areas of interest include energy management systems for power transmission, European Union satellite communication and remote sensing projects, and networks for the Greek football pools and horse racing associations.



On-line betting terminal

Intracom carries out a large amount of R and D. In 1997, expenditure on this was a record and amounted to 11% of the income from sales. The work is organised into a number of laboratories for microwave applications, telecommunications software, subscriber applications, defence applications, VLSI microelectronics, digital signal processing, printed circuit boards, and system design certification and verification.

Intracom was the first Greek company to be certified under the ISO 9001 international quality assurance standard. Subsequently, it has also been certified under the NATO AQAP-110 and -150 standards for quality assurance in hardware and software development and production. Furthermore, the European Quality Model, which includes state-of-the-art process testing methods and quality metrics, is being used in the on-going effort to continuously improve quality.



Quality assurance testing



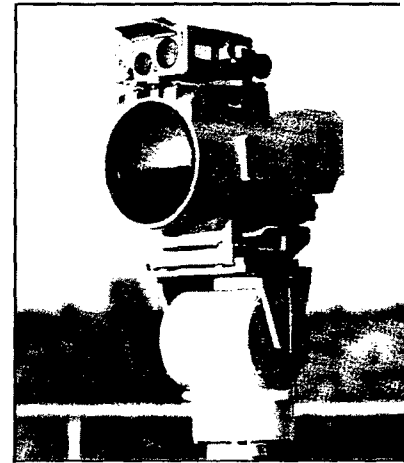
Intracom manufacturing plant

# Belgian National Day

*During the Board meeting in Brussels in Spring 1999, members were offered technical visits to two Belgian companies: Delf Sensor Systems and Techspace Aero. It is impossible in a small space to do justice to the companies' full range of work so only a few samples from each are shown here, taken from the hand-outs provided. Any errors are the editor's own.*

## Delft Sensor Systems

This company has locations in Oudenaarde, Belgium, which the members visited, and Delft, The Netherlands. It specialises in the development and manufacture of opto-electronic components and systems for defence, science, industry and space applications. It offers a comprehensive range of sophisticated night vision systems, head and helmet mounted displays, systems and components for the scientific and industrial market as well as the space industry. Defence applications include hand-held and tripod-mounted devices, aircraft and helicopter pilots' helmets, and equipment for tanks and other armoured vehicles.



MUNOS Multiple Use Night Observation System with 4 or 6x magnification as a weapon sight or 1x magnification as a hand-held observation device

STORE Stand-alone Thermal Observation and Ranging Equipment, with a detection range of 14 km and an integrated laser rangefinder



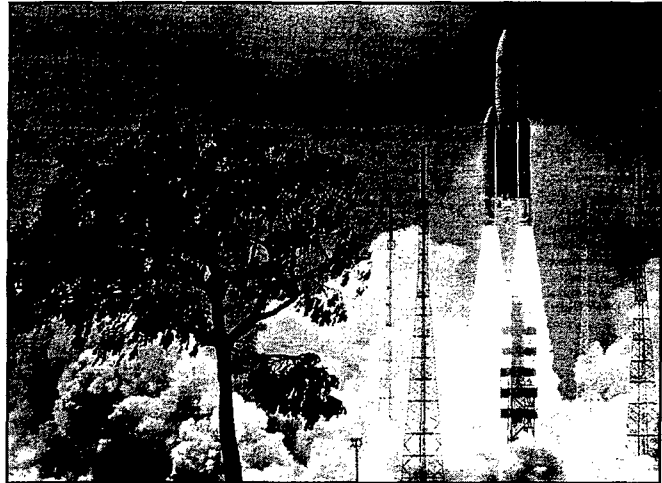
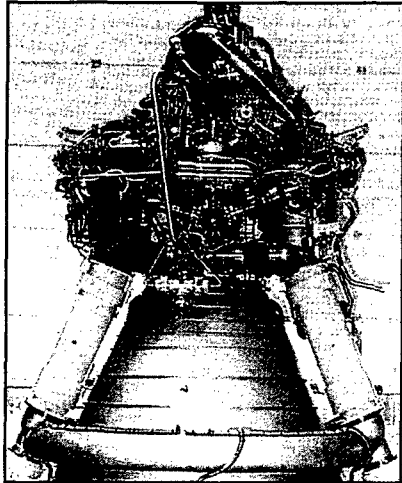
Night Viper Pilot's day and night helmet with image intensifier tubes and a binocular visor-projected helmet-mounted display

LION Lightweight Infrared Observation Night Sight - a lightweight, hand-held, uncooled, thermal imaging binocular viewer, inaudible from 2 m.

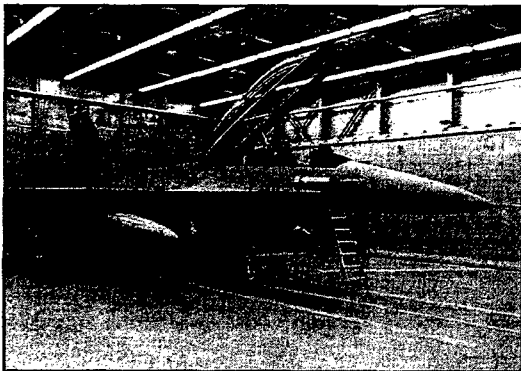
MLR 30 and 40 Handheld Laser Rangefinders, with ranges up to 20 km.

# Techspace Aero

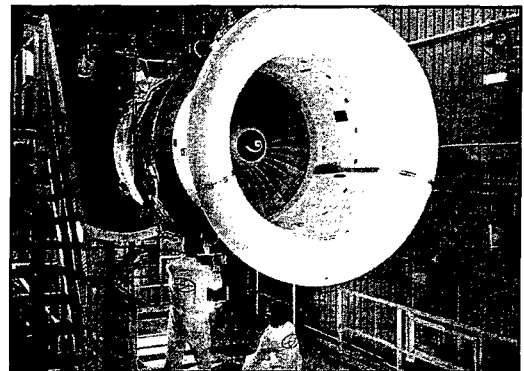
This company is located at Herstal near Liège. It is the only Belgian aircraft engine manufacturer, and one of only nine in Europe. It designs, develops, qualifies, produces and maintains its own products. It has developed three major strategic lines of products: in aircraft propulsion, low pressure compressors, bearing compartments and various major components for jet engines; equipment for aircraft lubrication systems and spacecraft propulsion systems or related subsystems; and aircraft engine maintenance, repair and testing services. The company also develops and provides turbojet engine test facility engineering (turn-key tailor-made projects) to airline and air force customers.



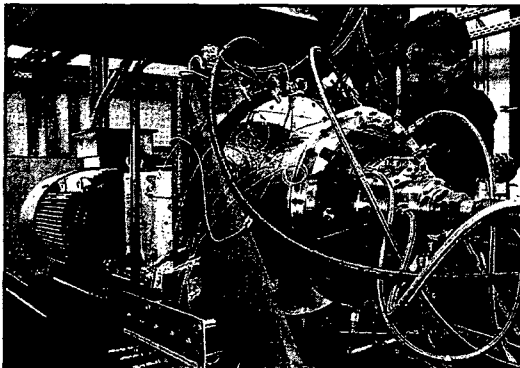
The company has contributed to the design of the Vulcan engine that powers the Ariane 5 launcher main stage, by developing a functional model of the complete propulsion system



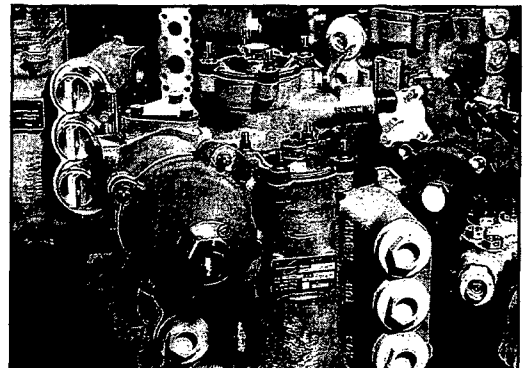
The Hush House facility allows testing without dismantling the engine from the aircraft cell



Transport aircraft engine installed in a Techspace Aero test cell



Techspace designed and installed a specific development test bench for bearing compartments of turbojet engines



Techspace's lubrication units equip more than 50% of the commercial transport aircraft engines delivered over the last ten years

# The Board in Brussels

*The Spring 1999 meeting of the Research and Technology Board was held in Brussels. As well as attending the meeting, the members had the privilege of being invited by the Belgian Members of the Board to a reception in the ornate Wedding Room of the famous Town Hall in the Grand Place and a formal dinner at the Club Prince Albert (the Belgian Officers' Club in Brussels). Members also made a technical visit to one of two Belgian defence companies. These visits are reported briefly in the article that precedes this one.*



The reception line at the Town Hall comprised Major General A. and Mrs van Daele, Colonel G. Stevins, Mrs Stevins, and Professor F. Breugelmans of the von Kármán Institute (mostly obscured by the edge of the photograph). Arriving are (from right): Dr L.J. Leggat, Board member from Canada, Colonel K. Konwin (US), Chairman of the newly-formed Modelling and Simulation Group, and Dr E. Alnaes, Board member from Norway.



Members and guests listening intently to a description of the Town Hall.



Dr P. Lawaetz, Board member from Denmark (left), Mrs Lawaetz, and Major General E. Margherita, Board member from The Netherlands.



Mr Teddy Houston (US), Assistant Director of RTA, Dr R. Bartram of Germany, and ICA P. Cunin, National Coordinator of France make up this truly international group.



General van Daele welcomed participants to the Club Prince Albert.



Dr. M. Yarymovych, Chairman of the Board, Mrs Jolly van Hoek, wife of the Director of RTA, and Col Stevins.



This photograph of the same table, taken from behind Col. Stevins, shows Major General A. Grønheim, Co-Vice Chairman, Mrs Lana Yarymovych, General van Daele, Mrs Stevins, and Professor Breugelmanns. On the right, the faces of the first three people have been seen in the previous photograph. Beyond them, Mrs van Daele and Dr van Hoek are just visible.



Clockwise around the table from the left are Professor P. Jeppesen, Danish Board Member, General J. Dailey and Dr D.C. Daniel, both US Board Members, Mrs Wendt and Dr J.F. Wendt, Director of the von Kármán Institute.



Seen during the Board Meeting are Dr Jacques Vermorel, Head of the RTA Brussels office, Mr G. Leira, Co-Vice Chairman of the Board and Director of the Armaments Planning, Programmes and Policy Directorate of NATO, and Mr Houston. Just visible in the background are Mr Ken Peebles, Board Member from Canada, and the Chairman.



Dr Daniel is talking to Major General M. Pirou, Deputy Director of RTA. Behind them are Mr S. Stafford of the US National Coordinator's Office and Mr Johan Balster, Chief of Finance at RTA, whose last meeting it was.



General Grønheim with Commander E.A. Lofquist of SACLANTREPEUR (NATO HQ) and Rear Admiral L. Baucom of SACLANT.



An American table: from the right, they are Colonel and Mrs P. Nutz, Lt Col R. Vantine, Assistant to the Deputy Director of RTA, and Major T.B. McIntire. Col. Nutz is the IMS Liaison officer for RTO and works closely with General Grønheim.



Three Greeks: Mr K. Zarpas and Captain E. Theofilou, both Board Members, and Mr A. Loupos, National Coordinator. In the background is Adjutant H. de Luyck of the Belgian Air Force, who made many of the detailed arrangements for the meeting.



Three Britons: Mr M. Markin, Board Member is in the centre; the others are Dr J. Grimshaw (left) of MOD and Dr K. Chaplain of DERA.



# RTO Family

*In this section, we feature news of members of the RTO 'Family', including former members of DRG or AGARD, and we will warmly welcome items for future issues – see also the note on the title page.*

## **Dr Henning E. von Gierke**

At the Fall 1998 meeting of the Human Factors and Medicine Panel (HFM), held at Wright-Patterson Air Force Base, US, a dinner reception was held to honour the career and lifetime achievements of Dr von Gierke from the Base. Although never a member of the former Aerospace Medical Panel of AGARD, Dr von Gierke nonetheless had a long-standing association with it, having been a 'Non Panel Member Expert' and participated actively in many of its meetings, lecture series and working groups, both as a speaker and as an organizer. The address was given by James W. Brinkley, Director of the Human Effectiveness Directorate Air Force Research Laboratory (AFRL) at the Base, and can be read in full in RTO publication, MP-20. The photograph shows from left to right Dr. Jack Landolt, DCIEM CA; Dr. Russell Burton (Chairman), AFRL US; Mr. William Fraser, DCIEM CA; Dr. Ints Kaleps (Chairman), AFRL US; Dr. Henning von Gierke, AFRL US; Dr. Jac Wismans, TNO NE; Mr. James Brinkley (Keynote Speaker), AFRL US; Dr. Cornelis Wientjes (Panel Executive), NE; and Dr. Louise Obergefell, AFRL US.



## **RTO Liaison with other NATO bodies**

As part of the outward-looking nature of RTO so strongly urged by Mr John Maberley in his 'Vision' on page 13, the Applied Vehicle Technology Panel (AVT) has nominated Professor Roland Decuypere of Belgium as the point of contact to Air Group 7 of the NAFAG (the NATO Air Force Armaments Group). This Group coordinates the unmanned vehicle activities of the Main Armament Group of which Professor Decuypere is a member. He is also Chairman of the Programme Committee for AVT's Fall 2000 symposium on Unmanned Vehicles for Aerial, Ground and Naval Military Operations to be held in Turkey.





The Systems Concepts and Integration Panel (SCI) met in Ankara in Spring 1999



The Information Systems Technology Panel (IST) met in Aalborg, Denmark, in Fall 1998

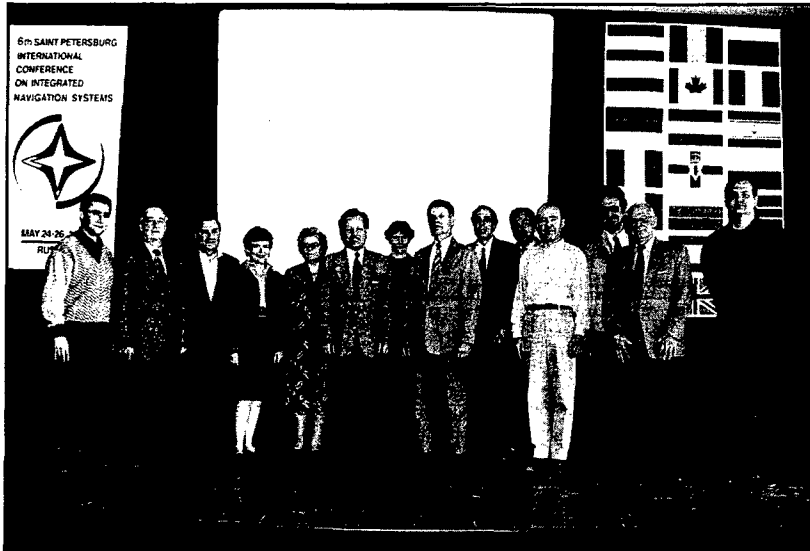
The Information Management Committee (IMC) met in Winchester, UK, in Spring 1999



The Systems Concepts and Integration Panel (SCI) organised a symposium (the 6th Saint Petersburg International Conference on Integrated Navigation Systems) jointly with the Russian Central Scientific and Research Institute, 'Elektroprigor', in St Petersburg, in May 1999. The publication resulting from this symposium is MP-43.



CENTRAL SCIENTIFIC AND RESEARCH INSTITUTE "ELEKTROPRIBOR"



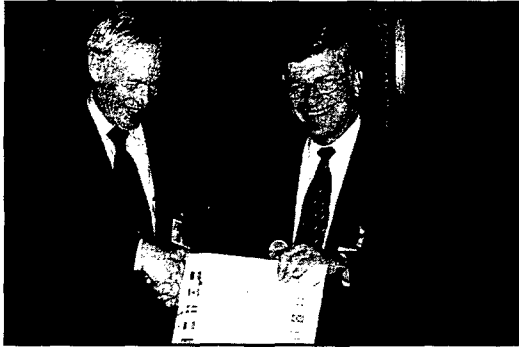
In the upper photograph, the Programme Committee and meeting organisers are seen on the stage at the start of the meeting. The Co-Chairmen of the Committee were (just left of centre) Professor Vladimir Peshekhonov, President of the Academy of Navigation and Motion Control of Elektroprigor, and (just right of centre) Dr John Niemela, Director of the Modelling and Simulation Division of the Army Command and Control Directorate at Fort Monmouth, US. The meeting organisers, all ladies, were (between the Co-Chairmen) Mrs Yelena Zvereva and (next to Prof. Peshekhonov) Mrs Margarita Grishina, both of Elektroprigor, and Mrs Arlette Person of RTA.



The Information Systems Technology Panel (IST) met in Lillehammer, Norway, in June 1999

# Farewells

*At most of its meetings, the Board says 'Farewell' to many members, and the meetings in Athens and Brussels were no exception. Those recorded by the photographer are shown here.*



Professor Gero Madelung of Germany, an AGARD Board Member from 1978, its Chairman from 1985 to 1988, and von Kármán Medal winner in 1996.



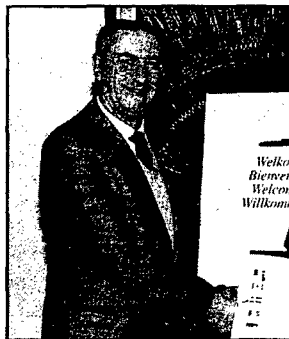
Professor M. van de Voorde of Belgium, a Board Member from the beginning of RTO.



Brigadier General Brown who had been an Ex-Officio Delegate from SHAPE since July 1997.



Captain (retd.) Ir L. Sombroek, who had been National Coordinator for the Netherlands for AGARD and RTO from 1988.



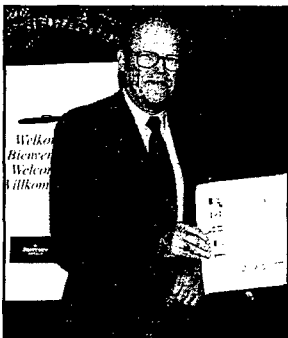
Col. R. Viglietta, National Coordinator of Italy from the beginning of RTO.



Col. G. Schneider, USAF, IMS Liaison Officer with RTO from 1996.



Dr Keith Gardner, US, a member of the executive staff for the Defence Research Group from 1985 and first Head of the Brussels office of RTA and Secretary to the Board.



Mr Johan Balster, from the Netherlands, Head of Finance at AGARD and RTA from 1985.



Mr Jack Molloy, US, Executive of the AGARD Fluid Dynamics Panel and then of the Applied Vehicle Technology Panel of RTO since 1993.



Lt Col. H. Montfort, France, of the Operations Coordination Division of RTA and its AGARD predecessor since 1995, and organiser of the AGARD all-Panel Symposium in Spring 1997.



Lt Col. Tom Roberts, US, Executive of the Systems Concepts and Integration Panel from July 1997.

# In Memoriam

*It is with great sadness that we record the death of a number of distinguished former members of the RTO 'Family' or of one of its predecessors.*

## **Major General Médecin E.E.O. Evrard, MD**

*General Edgard Evrard of Belgium died on 1 July 1999. He had been a member of the Board of AGARD for 30 years (1967 - 1997), the recipient of the von Kármán Medal in 1987, and twice Chairman of the Aerospace Medical Panel (AMP) of AGARD - believed to be a unique distinction.*

The following obituary note has been contributed by Med. Col. (ret.) Paul Vandenbosch, also of Belgium and a former Chairman of AMP.

Major General Médecin Edgard EVRARD M.D. was born in Obaix (BE) in 1911 and died on 1 July 1999 in Brussels. He studied medicine at the Catholic University of Louvain, receiving his M.D. in 1935. He was awarded further degrees in hygiene and preventive medicine, by the University of Brussels in 1937 and in tropical medicine by the Institute of Tropical Medicine of Antwerp in 1949. He joined the Medical Services of the Belgian Air Force in 1936 and during the next four years he flew more than 600 hours in several types of military aircraft as an observer and as a medical researcher, studying the effects of hypoxia and the use of early prototypes of oxygen equipment for aircrews.

He fought during the invasion of Belgium and managed to escape, in June 1942, through France to Spain, crossing the Pyrenées near Andorra. After being held in a number of Spanish prisons and an internment camp he was deported to Portugal in May 1943. From there he flew to Britain and spent the rest of the war in the Medical Branch of the Royal Air Force (UK).

He was the innovative brain and the active force behind the creation of the Medical Service of the newly created Belgian Air Force (1946). He devoted his total career to the Belgian Air Force Medical Services where he was appointed Director from the beginning until 1964. During this period he created the "Centre de Médecin Aéronautique" (Institute of Aviation Medicine). He was awarded the Prix de Bruxelles Médical in 1949 for the first study undertaken by the Laboratory of this Institute - into the effects of decompression sickness during very rapid ascent to 33,000 ft (c. 10,000 m.).

In October 1951 General Evrard attended the USAF School of Aviation Medicine at Randolph Air Force Base in Texas, graduating from there as a Flight Surgeon and Aviation Medical Examiner.

He was a member of the Aerospace Medical Panel (AMP) from AGARDs' inception in 1952 until 1986. He was Chairman of the Panel from 1956 to 1959, and again from 1962 to 1964. He was appointed a National Delegate for Belgium in 1967 and continued in that position until AGARD was disbanded.

General Evrard is recognized by his peers in the international aerospace medical community as an expert in the fields of air crew selection and behavioral and clinical aerospace medicine. He has published nearly 100 papers in this area, including 9 AGARDographs - one of which was the second AGARDograph ever to be published by AGARD. He was the author of two books: « Hygiène de l'Aviateur - Physiologie du Vol », 1956 and « Précis de Médecine Aéronautique et Spatial », 1975. The latter is now one of the classical textbooks used in the teaching of aviation medicine.

As an active member of the Aerospace Medical Panel, and as its Chairman, General Evrard continuously used the weight of his influence to bolster and stimulate research and its immediate application to flying safety and improvement of the human factor in the air forces of the Atlantic Community.

General Evrard was a member and Fellow of the Aerospace Medical Association (USA) where he received in 1981 the Theodore C. Lyster Award. He was also a Member of the International Academy of Astronautics and of the International Academy of Aerospace Medicine.

One of General Evrard's outside interests was the History of Medicine, particularly Military Medicine and he was author of several papers on the medical services and military surgeons at the battle of Waterloo, and on the medical service in the Spanish Army in the Low Countries in the 17th Century.



## Professor C. Casci, MSc, PhD

*Professor Corrado Casci of Italy died on 8 January 1999. He was the recipient of the von Kármán medal in 1985 and had been Chairman of the Propulsion and Energetics Panel (PEP), 1965-1967. The following notes are taken from the nomination for his von Kármán Medal.*

Professor Casci was born in 1917 and held MSc degrees *cum laude* in Mechanical Engineering and Aeronautical Engineering, and PhD degrees in Machinery and Aircraft Engines. He was Professor of Machinery at the Polytechnic of Milan, Italy. As a member of the Board of the von Kármán Institute (VKI) Scientific Council he used his influence and expertise to bolster VKI both financially and scientifically in order to ensure its survival and prosperity.

During his time with AGARD, Professor Casci promoted and directed over 20 seminars and other meetings. Moreover, he presented and/or published over 100 scientific papers, 9 scientific books and 6 teaching publications, and he held at least three industrial patents. Despite all this scientific activity he found time to write further publications on Arts and Philosophy.

Perhaps his best asset was his gift for building and organising. He obtained funds and built from scratch in 1961 the Institute for Propulsion and Energy Research (CNPM) of the Italian National Research Council (NRC). As Director, he built it up so well that by 1985 there were 150 staff and six times as many scientists as originally, and the laboratories, which occupied 150 m<sup>2</sup> in 1961, occupied twenty times as much space. In 1967, Professor Casci founded and became Director of the Institute of Machinery of the Polytechnic of Milan, and in 1981 he amalgamated this Institute with the Institute of Technical Physics to form the Department of Energetics, of which he was appointed Director. Both the Department and CNPM had research contracts with the US Army and Air Force, several US universities, EURATOM, a number of Italian companies and Government organisations and even the USSR Academy of Sciences.

Among his other appointments, Professor Casci was Head of the Fluid Machinery Task Force in the Italian NRC "Energy Project" in which Italy's largest and most important industries, research laboratories and universities worked together to improve or develop efficient ways for energy conversion.



## Dr Leonard Roberts

*Dr Leonard Roberts of the US died on 6 March 1999. He had been a member of the Fluid Dynamics Panel of AGARD from 1980 to 1985 and its Chairman, 1983-1985. We are indebted to David Salisbury of the Stanford University News Service for permission to use extracts from an article written by him. The complete text can be found at: <http://www.stanford.edu/dept/news/report/news/march10/roberts310.html>*

A busy airport is a safer place because of the research of Leonard Roberts. The aerodynamicist, who retired from Stanford in 1993, died on Saturday, March 6, at the age of 69. Roberts, who worked for NASA Ames Research Center for 15 years before joining the Aeronautics and Astronautics Department at Stanford, was an expert on vortices, the violent swirls of air that large aircraft leave behind that can be dangerous to smaller aircraft flying in their wake. His theoretical studies of these hazardous phenomena provided a basis for the rules that air traffic controllers now use to space aircraft of different sizes at safe distances during landing and take off.

"He was very competent, both as an aerodynamicist and as a manager of the entire aerodynamics program at Ames," says longtime friend and associate Richard Shevell, professor emeritus of aeronautics and astronautics. "In the 20 years that I knew him, I never heard him say a nasty word about someone else. That's not something I can say about many people, certainly not about myself." Fellow aeronautics and astronautics Professor emeritus Arthur Bryson concurs with this assessment, adding, "He was a man of small stature, physically, but of large stature, intellectually."

Born in Wales in 1929, Roberts attended Manchester University in the United Kingdom and received his doctorate in 1955. He came to the United States as a mathematics instructor at the Massachusetts Institute of Technology, and two years later, joined NASA's Langley Research Center as an aeronautical research engineer. He rose to head of mathematical physics at Langley before transferring to the Ames Research Center, where he rose to the position of director of aeronautics and flight systems.

In 1981, Roberts retired from NASA and came to Stanford as a research professor. Here he developed methods for controlling delta wing aircraft without mechanical moving parts by blowing air across the wing's leading edge. This approach proved so successful that the military is incorporating it into the design of new, highly agile fighters.

Roberts received a NASA Distinguished Service Medal for his contributions in 1976, and was elected a Stanford-Sloan Fellow and a Fellow of the American Institute of Aeronautics and Astronautics. He served on several advisory boards for the U.S. Navy, U.S. Air Force, NASA and NATO. He is survived by his wife, two sons and five grandchildren.

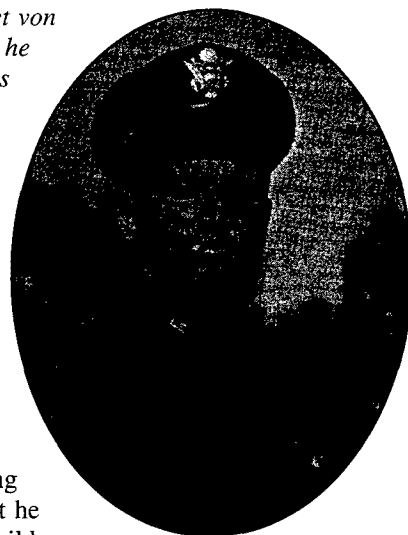


## Tom Weldon

*Colonel Thomas-Franklin Weldon of the US died on 31 January 1999. He first met von Kármán in 1946, and then was his liaison officer from the American Embassy when he first came to Paris to set up AGARD in 1951. Tom Weldon contributed three articles to AGARD Highlights, starting with reminiscences of von Kármán's time in Paris from 1951 onwards and followed by an interesting piece on pilot-induced crashes and another on Glen Edwards. They are in Highlights 93/2, 94/2 and 95/2.*

Tom Weldon was born in 1918 in New York and spent the first part of his active career as a pilot in the US Air Force. He flew B-29s in the China/India/Burma theatre, and took part in rocket-assisted take-off tests on B-29s at Eglin Field in 1945.

He received MS degrees in Jet Propulsion and Aerodynamics from the California Institute of Technology, where he first met von Kármán. He became Director of Research Procurement, Air Material Command, at Wright Field (now Wright-Patterson Air Force Base) in 1948. From 1950 to 1953 he was Director of the Air Technical Liaison Office at the US Embassy in Paris. He followed that by becoming a civilian industrial consultant in France, where he lived until his death. Posts that he held included Managing Director of the Paris offices of Boeing and WIPAC. His children were all born in the American Hospital in Paris, about a kilometre from the RTA Headquarters. He was buried in Arlington Military Cemetery.



# Twenty Years Ago

*(Extracts from AGARD Highlights 79/1 and 79/2 - unfortunately, no similar photographs are available from DRG)*



Dr Alan Lovelace of the US became Chairman of AGARD in 1979. He is seen here in the centre talking to the Turkish National Delegate, Brig. General Bentürk and his wife. On the left is the then Turkish National Coordinator, Colonel Doğan Kaya, who later also became a National Delegate.



Mr Jack Burnham, UK, who became Director in 1979.



Professor Haus of Belgium, senior National Delegate, who was later appointed Honorary Dean of the Board, presented a silver salver to the retiring Chairman, Frank Thurston, "in recognition of outstanding leadership" during his term of office.



Netherlanders and Norwegians. From left to right, they are Jan van der Blik of The Netherlands, who later became Director of AGARD, Mrs Corry van der Blik, Mrs Jager, wife of the then Dutch National Coordinator, Mr and Mrs H.K. Johansen, Norwegian National Delegate, and Mr P. Kant, Dutch Chairman of the Guidance and Control Panel.





Belgian members. They are Mr J. Ceulemans, NATO Financial Controller (left) and his wife, Major General Victor George and General Major Evrard, two Belgian National Delegates. We report elsewhere in this issue the recent sad loss of General Evrard who remained a member of the Board until the end of AGARD.



Dr Al Flax, former AGARD Chairman and later Honorary Vice-President, is clearly delighted to receive the von Kármán Medal for 1978.



The von Kármán Medal for 1979 was awarded to Professor Young of the United Kingdom, a leading aerodynamicist and Chairman, after the death of von Kármán, of the Board of the von Kármán Institute which he had helped to set up.

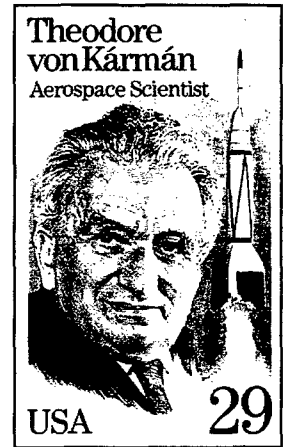
Project 2000 was a study carried out in the late 1970s which was not unlike the Aerospace 2020 study carried out by AGARD 20 years later. Three of the team working on it are shown here. On the right is John Scott-Wilson, UK, who chaired the Review Board and later became Chairman of AGARD. The others are Jürgen Wild of Germany, who later became Director of AGARD, and Colonel Gilbert Bron of the French Air Force, both of whom were working in the Military Committee Studies Division of AGARD at the time.



# This Really is the End

## Theodore von Kármán

This postage stamp was issued by the US Post Office in memory of the founder of both the constituent bodies of RTO - DRG and AGARD.



## Do you like mathematical problems?

If so, please help me (the editor)!

Having chosen a number of photographs of the 'Social Scene' for an issue of Highlights, I sometimes number them to enable me (with the help of colleagues, for which I am eternally grateful) to prepare a list of names of the people on them. Having done so, I then put them into what seems to me an appropriate order - and of course they then have to be renumbered.

On one occasion, I chose 20 photographs and found after putting them in order that I had to renumber all of them except one. This seemed a somewhat surprising result, and I wondered what its probability was. I have made some investigation, developing a simple algorithm to find the result for all possible numbers of matches for all numbers of photographs and (with the help of a colleague in Canada) a simple formula for the cases when there are no matches or exactly one. The formula, the algorithm and a computer simulation have all shown that the probabilities of exactly none or exactly one photograph having the same number after renumbering both tend to  $1/e$  (where  $e$  is  $2.7181828 \dots$ , the base of natural logarithms) as the number of photographs increases towards infinity - a horrifying concept! Interestingly, when we calculate the exact number of orderings with no matches or with one match in all possible orderings of  $N$  photographs, we find that the numbers differ exactly by one. In fact, they are the whole numbers either side of  $N!/e$ . Moreover, if  $N$  is even, the number with zero matches is 1 greater than the number with one match. And the reverse is true if  $N$  is odd.

For instance, there are  $2,432,902,008,176,640,000$  ( $20!$ ) possible orderings with 20 photographs (the number I started with). Of these,  $895,014,631,192,902,120$  (the integral part of  $20!/e$ ) have one match, and exactly one more have no match.

What I would like is an explanation as to why this should be so.

And can anyone give me a simple formula which is both non-iterative and non-recursive to give the probability for  $I$  matches when there are  $N$  photographs for values of  $I$  greater than 1?

I will award a bottle of good French wine to the sender of the clearest solution. My decision is of course final.

Replies may be faxed to +33 1 55 61 22 99 or e-mailed to [hartg@rta.nato.int](mailto:hartg@rta.nato.int)

Many thanks.

NORTH ATLANTIC TREATY ORGANIZATION



RESEARCH AND TECHNOLOGY ORGANIZATION

BP 25 • 7 RUE ANCELLE

F-92201 NEUILLY-SUR-SEINE CEDEX • FRANCE

Télécopie 0(1)55.61.22.99 • E-mail mailbox@rta.nato.int

DIFFUSION DES PUBLICATIONS

RTO NON CLASSIFIEES

L'Organisation pour la recherche et la technologie de l'OTAN (RTO), détient un stock limité de certaines de ses publications récentes, ainsi que de celles de l'ancien AGARD (Groupe consultatif pour la recherche et les réalisations aérospatiales de l'OTAN). Celles-ci pourront éventuellement être obtenues sous forme de copie papier. Pour de plus amples renseignements concernant l'achat de ces ouvrages, adressez-vous par lettre ou par télécopie à l'adresse indiquée ci-dessus. Veuillez ne pas téléphoner.

Des exemplaires supplémentaires peuvent parfois être obtenus auprès des centres nationaux de distribution indiqués ci-dessous. Si vous souhaitez recevoir toutes les publications de la RTO, ou simplement celles qui concernent certains Panels, vous pouvez demander d'être inclus sur la liste d'envoi de l'un de ces centres.

Les publications de la RTO et de l'AGARD sont en vente auprès des agences de vente indiquées ci-dessous, sous forme de photocopie ou de microfiche. Certains originaux peuvent également être obtenus auprès de CASI.

CENTRES DE DIFFUSION NATIONAUX

**ALLEMAGNE**

Fachinformationszentrum Karlsruhe  
D-76344 Eggenstein-Leopoldshafen 2

**BELGIQUE**

Coordinateur RTO - VSL/RTO  
Etat-Major de la Force Aérienne  
Quartier Reine Elisabeth  
Rue d'Evère, B-1140 Bruxelles

**CANADA**

Directeur - Recherche et développement -  
Communications et gestion de  
l'information - DRDCGI 3  
Ministère de la Défense nationale  
Ottawa, Ontario K1A 0K2

**DANEMARK**

Danish Defence Research Establishment  
Ryvangs Allé 1, P.O. Box 2715  
DK-2100 Copenhagen Ø

**ESPAGNE**

INTA (RTO/AGARD Publications)  
Carretera de Torrejón a Ajalvir, Pk.4  
28850 Torrejón de Ardoz - Madrid

**ETATS-UNIS**

NASA Center for AeroSpace  
Information (CASI)  
Parkway Center  
7121 Standard Drive  
Hanover, MD 21076-1320

**FRANCE**

O.N.E.R.A. (ISP)  
29, Avenue de la Division Leclerc  
BP 72, 92322 Châtillon Cedex

**GRECE**

Hellenic Air Force  
Air War College  
Scientific and Technical Library  
Dekelia Air Force Base  
Dekelia, Athens TGA 1010

**HONGRIE**

Department for Scientific Analysis  
Institute of Military Technology  
Ministry of Defence  
H-1525 Budapest P O Box 26

**ISLANDE**

Director of Aviation  
c/o Flugrad  
Reykjavik

**ITALIE**

Centro documentazione  
tecnico-scientifica della Difesa  
Via Marsala 104  
00185 Roma

**LUXEMBOURG**

Voir Belgique

**NORVEGE**

Norwegian Defence Research  
Establishment  
Attn: Biblioteket  
P.O. Box 25  
NO-2007 Kjeller

**PAYS-BAS**

NDRCC  
DGM/DWOO  
P.O. Box 20701  
2500 ES Den Haag

**POLOGNE**

Chief of International Cooperation  
Division  
Research & Development Department  
218 Niepodleglosci Av.  
00-911 Warsaw

**PORTUGAL**

Estado Maior da Força Aérea  
SDFA - Centro de Documentação  
Alfragide  
P-2720 Amadora

**REPUBLIQUE TCHEQUE**

VTÚL a PVO Praha /  
Air Force Research Institute Prague  
Národní informační středisko  
obránného výzkumu (NISCR)  
Mladoboleslavská ul., 197 06 Praha 9

**ROYAUME-UNI**

Defence Research Information Centre  
Kentigern House  
65 Brown Street  
Glasgow G2 8EX

**TURQUIE**

Millî Savunma Başkanlığı (MSB)  
ARGE Dairesi Başkanlığı (MSB)  
06650 Bakanlıklar - Ankara

AGENCES DE VENTE

**NASA Center for AeroSpace**

**Information (CASI)**  
Parkway Center  
7121 Standard Drive  
Hanover, MD 21076-1320  
Etats-Unis

**The British Library Document**

**Supply Centre**  
Boston Spa, Wetherby  
West Yorkshire LS23 7BQ  
Royaume-Uni

**Canada Institute for Scientific and**

**Technical Information (CISTI)**  
National Research Council  
Document Delivery  
Montreal Road, Building M-55  
Ottawa K1A 0S2  
Canada

Les demandes de documents RTO ou AGARD doivent comporter la dénomination "RTO" ou "AGARD" selon le cas, suivie du numéro de série (par exemple AGARD-AG-315). Des informations analogues, telles que le titre et la date de publication sont souhaitables. Des références bibliographiques complètes ainsi que des résumés des publications RTO et AGARD figurent dans les journaux suivants:

**Scientific and Technical Aerospace Reports (STAR)**

STAR peut être consulté en ligne au localisateur de ressources uniformes (URL) suivant:  
<http://www.sti.nasa.gov/Pubs/star/Star.html>  
STAR est édité par CASI dans le cadre du programme NASA d'information scientifique et technique (STI)  
STI Program Office, MS 157A  
NASA Langley Research Center  
Hampton, Virginia 23681-0001  
Etats-Unis

**Government Reports Announcements & Index (GRA&I)**

publié par le National Technical Information Service  
Springfield  
Virginia 2216  
Etats-Unis  
(accessible également en mode interactif dans la base de données bibliographiques en ligne du NTIS, et sur CD-ROM)



NORTH ATLANTIC TREATY ORGANIZATION



RESEARCH AND TECHNOLOGY ORGANIZATION

BP 25 • 7 RUE ANCELLE

F-92201 NEUILLY-SUR-SEINE CEDEX • FRANCE

Telefax 0(1)55.61.22.99 • E-mail mailbox@rta.nato.int

DISTRIBUTION OF UNCLASSIFIED

RTO PUBLICATIONS

NATO's Research and Technology Organization (RTO) holds limited quantities of some of its recent publications and those of the former AGARD (Advisory Group for Aerospace Research & Development of NATO), and these may be available for purchase in hard copy form. For more information, write or send a telefax to the address given above. **Please do not telephone.**

Further copies are sometimes available from the National Distribution Centres listed below. If you wish to receive all RTO publications, or just those relating to one or more specific RTO Panels, they may be willing to include you (or your organisation) in their distribution.

RTO and AGARD publications may be purchased from the Sales Agencies listed below, in photocopy or microfiche form. Original copies of some publications may be available from CASI.

NATIONAL DISTRIBUTION CENTRES

**BELGIUM**

Coordinateur RTO - VSL/RTO  
Etat-Major de la Force Aérienne  
Quartier Reine Elisabeth  
Rue d'Evère, B-1140 Bruxelles

**CANADA**

Director Research & Development  
Communications & Information  
Management - DRDCIM 3  
Dept of National Defence  
Ottawa, Ontario K1A 0K2

**CZECH REPUBLIC**

VTÚL a PVO Praha /  
Air Force Research Institute Prague  
Národní informační středisko  
obrněného výzkumu (NISČR)  
Mladoboleslavská ul., 197 06 Praha 9

**DENMARK**

Danish Defence Research  
Establishment  
Ryvangs Allé 1, P.O. Box 2715  
DK-2100 Copenhagen Ø

**FRANCE**

O.N.E.R.A. (ISP)  
29 Avenue de la Division Leclerc  
BP 72, 92322 Châtillon Cedex

**GERMANY**

Fachinformationszentrum Karlsruhe  
D-76344 Eggenstein-Leopoldshafen 2

**GREECE**

Hellenic Air Force  
Air War College  
Scientific and Technical Library  
Dekelia Air Force Base  
Dekelia, Athens TGA 1010

**HUNGARY**

Department for Scientific Analysis  
Institute of Military Technology  
Ministry of Defence  
H-1525 Budapest P O Box 26

**ICELAND**

Director of Aviation  
c/o Flugrad  
Reykjavik

**ITALY**

Centro documentazione  
tecnico-scientifica della Difesa  
Via Marsala 104  
00185 Roma

**LUXEMBOURG**

See Belgium

**NETHERLANDS**

NDRCC  
DGM/DWOO  
P.O. Box 20701  
2500 ES Den Haag

**NORWAY**

Norwegian Defence Research  
Establishment  
Attn: Biblioteket  
P.O. Box 25  
NO-2007 Kjeller

**POLAND**

Chief of International Cooperation  
Division  
Research & Development  
Department  
218 Niepodleglosci Av.  
00-911 Warsaw

**PORTUGAL**

Estado Maior da Força Aérea  
SDFA - Centro de Documentação  
Alfragide  
P-2720 Amadora

**SPAIN**

INTA (RTO/AGARD Publications)  
Carretera de Torrejón a Ajalvir, Pk.4  
28850 Torrejón de Ardoz - Madrid

**TURKEY**

Millî Savunma Başkanlığı (MSB)  
ARGE Dairesi Başkanlığı (MSB)  
06650 Bakanlıklar - Ankara

**UNITED KINGDOM**

Defence Research Information  
Centre  
Kentigern House  
65 Brown Street  
Glasgow G2 8EX

**UNITED STATES**

NASA Center for AeroSpace  
Information (CASI)  
Parkway Center  
7121 Standard Drive  
Hanover, MD 21076-1320

SALES AGENCIES

**NASA Center for AeroSpace  
Information (CASI)**

Parkway Center  
7121 Standard Drive  
Hanover, MD 21076-1320  
United States

**The British Library Document  
Supply Centre**

Boston Spa, Wetherby  
West Yorkshire LS23 7BQ  
United Kingdom

**Canada Institute for Scientific and  
Technical Information (CISTI)**

National Research Council  
Document Delivery  
Montreal Road, Building M-55  
Ottawa K1A 0S2  
Canada

Requests for RTO or AGARD documents should include the word 'RTO' or 'AGARD', as appropriate, followed by the serial number (for example AGARD-AG-315). Collateral information such as title and publication date is desirable. Full bibliographical references and abstracts of RTO and AGARD publications are given in the following journals:

**Scientific and Technical Aerospace Reports (STAR)**

STAR is available on-line at the following uniform resource locator:

<http://www.sti.nasa.gov/Pubs/star/Star.html>

STAR is published by CASI for the NASA Scientific and Technical Information (STI) Program  
STI Program Office, MS 157A  
NASA Langley Research Center  
Hampton, Virginia 23681-0001  
United States

**Government Reports Announcements & Index (GRA&I)**

published by the National Technical Information Service  
Springfield  
Virginia 22161  
United States  
(also available online in the NTIS Bibliographic Database or on CD-ROM)

