NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

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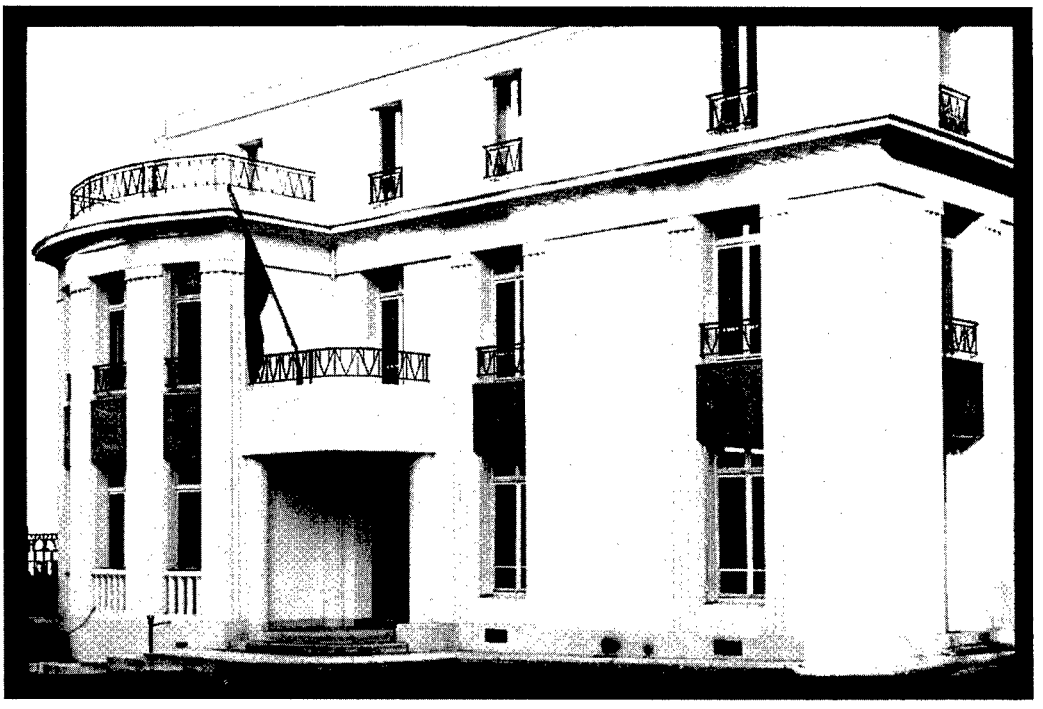
HIGHLIGHTS 1998



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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 6 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

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.

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Highlights 1998

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, and it has been decided to continue publication of a house magazine under RTO, twice a year. However, the editor apologises for the appearance of only one issue in 1998, and for its very late arrival, due to the work involved in the formation of RTO. He hopes that the content, particularly the technical presentations made to the Research and Technology Board meeting in Norway in 1997, will still be of interest, in spite of the delay.

Contributions from members of the RTO Family - Board members, Panel members, level 3 members, and indeed anyone involved, however remotely, with RTO - would be welcomed. They may relate to matters of specific interest to the RTO family or to the defence R&T community in general, and should be sent to the editor:

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The RTO headquarters building in Neuilly-sur-Seine, about 2 km west of the Arc de Triomphe in Paris.

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Highlights 1998

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A Note from the Director . . .
On our way . . .

The RTO is up and running. I have said this a number of times on various occasions. It is a statement that reflects a seemingly simple reality, but behind those simple words many things are hidden.

The NATO Research & Technology Organization had its Charter approved in December 1997 and started officially operating on the first of January this year. The year 1997 was largely a year of transition, with the AGARD conference in Palaiseau in April and the merging and redistribution of the old Panels into the new ones. Wrestling with the question of how to accommodate 17 Panels with all their activities into 6 new Panels and how to keep their heritage, how to broaden the scope and to keep people enthusiastic certainly was a major task. It was a task performed by Transition Team chairmen from the nations, staff in Brussels and Neuilly, and many others who supported this. Now, with the first two business meetings concluded, it is safe to confess that many of us had doubts about the outcome. It is thanks to a group of dedicated persons, 'old' representatives as well as newcomers, that the transition has been successful up to now. Their support, their belief that the new RTO is meaningful, their conviction that there is a bright future, has made it happen. We are now finalising the work on procedures, adapting the internal organisation of the RTA, and straightening out relations with NATO Headquarters. All this is not very fancy, and involves lots of details, but it is at the same time necessary, to keep the organisation also on the right track in the long run.

A very important event is the beginning of the participation of the invited members: the Czech Republic, Hungary and Poland have all now been present twice at meetings of the Research & Technology Board, and also in Panel meetings. Their enthusiasm to participate will certainly reflect on other people and bring a new dynamism to the Panels.

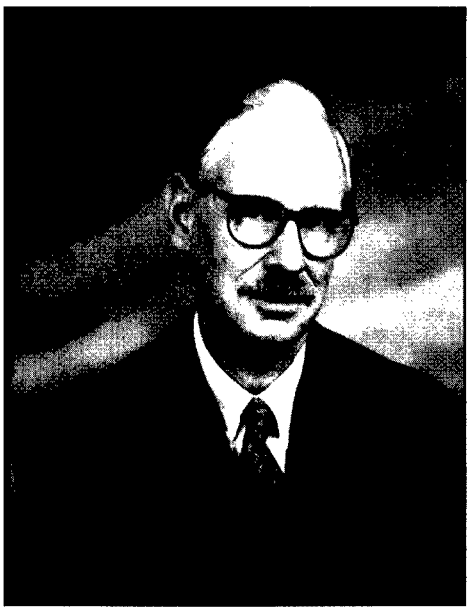
Further, a very important task for the new RTO is to "generate and maintain a NATO wide strategy for defence technology". This task is specifically mentioned in our Charter and should be a strategy which will be approved at the highest level in NATO, that is, by the NATO Council. To make such a strategy was never going to be an easy task. It has demanded creativity; it still demands hard and detailed work, discussions and drafting of texts. It is certainly, however, a task which will shape our own future. A strategy like this is also of great importance to NATO, because all of the predecessors of the RTO could only give fragmented pictures. It is now up to the RTO to prove its single focus role and to be more than just the sum of AGARD and DRG. Again, the enthusiasm with which the Strategy Group Task team, which has been leading this effort, has carried out its work has been heart-warming, it has been contagious to see these people at work and the desire to join them in their deliberations was strong. So even if the work ahead of us is scaring in one way, it is exciting in another, and as the RTO we should be proud that these opportunities have been given to us. It is with full confidence that we continue the final stages of the build-up of the RTO. Yes, we are well on our way....., and the future seems promising indeed!

Ernst A. van Hoek
1 October 1998

The von Kármán Medals for 1998

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) with which AGARD has now been merged to form the RTO. Since the merger, the terms of reference of the Medal have been changed to reflect the broader scope of the RTO, and it is now 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".

Two von Kármán Medals were awarded in 1998, to Mr Nils Holme of Norway and Dr Peter Hamel of Germany.



CITATIONS

Mr Nils Holme's discerning method of analysis and his communicative enthusiasm played a significant role in the recent successful merging of the previous AGARD and DRG. He has been an active member of both organizations since 1993 and was able to clearly convey the views of one organization to the other.

In 1994 he was selected to direct the AGARD Aerospace 2020 Study. This involved an enormous amount of coordination, negotiation and long term vision in order to complete the task and present the results of the Study at the final AGARD Symposium in Palaiseau in Spring 1997. His foresight and diplomatic leadership cannot be too highly praised, and the work he performed in combining the numerous inputs from many varied sources into a viable and animated study was exemplary.

Mr Holme has been involved in international cooperation from early on in his career and continues to play a major role in the formulation of Norwegian Defence R&T strategy.

In recognition of Mr Holme's outstanding contributions to the Research and Technology community, he is awarded the von Kármán Medal for 1998.

Dr Peter Hamel distinguished himself through outstanding technical and managerial contributions to AGARD/RTO with 25 years of dedicated service. In particular, he played a significant role as a member of the Flight Mechanics/Flight Vehicle Integration Panel since 1972; and served as the Panel Chairman from 1984 to 1986.

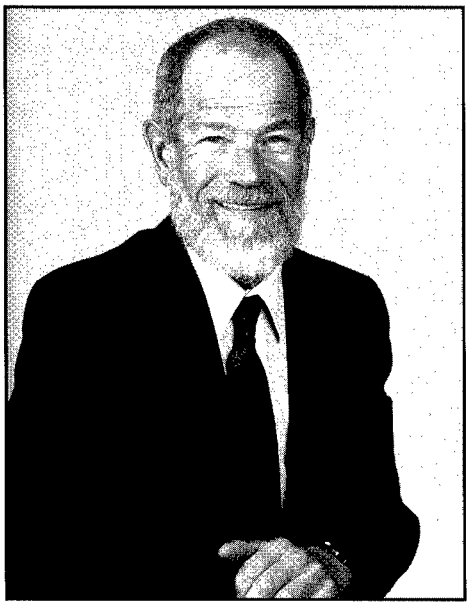
Dr Hamel's Institute for Flight Mechanics is recognized internationally for the development and use of new rotary-wing test rigs for the German-Dutch Windtunnel. He is particularly recognized for his leadership in the development and utilization by the Institute of fixed-wing and rotary-wing in-flight simulators. Under Dr Hamel's leadership, a new fly-by-light helicopter research facility is under development at DLR. This new facility will be used for collaborative research with Eurocopter.

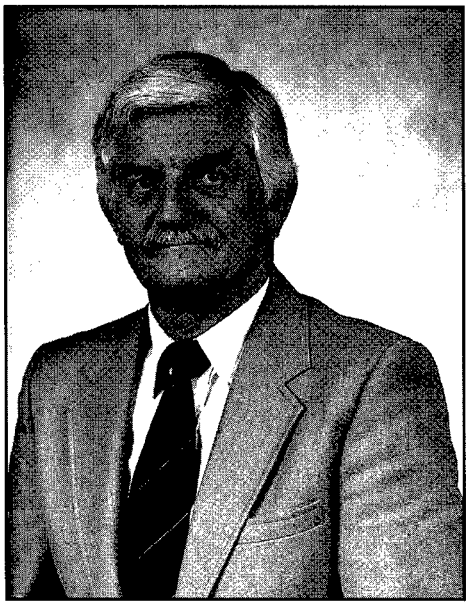
Dr Hamel's exceptional service for NATO's Research and Technology Organization, combined with his personal efforts to initiate and establish multilateral collaborative research, symbolizes the von Kármán spirit of wide international cooperation. It is for these reasons that he is awarded the von Kármán Medal for 1998.

Scientific Achievement Awards for 1998

The Scientific Achievement Award of AGARD was instituted in 1990. Since the merger of AGARD and RTO, its terms of reference have also been changed. It is now 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 1998, Dr Jürgen RichteR & Dr Russell Burton, both of the USA.





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The Scientific Achievement Award is presented to **Dr Jürgen Richter** who has made significant contributions to solving radio and electro-optical propagation problems, in particular to the development of remote sensing techniques, tactical decision aids, and propagation assessment systems. His development of ultra-high range resolution radars for sensing atmospheric refractivity has fundamentally changed the understanding of atmospheric microstructure. Under his direction, marine aerosol models have been developed and incorporated into universally used propagation codes. He proposed and directed a multi-year modelling and measurement effort to assess electro-optical propagation in coastal environments, involving several NATO nations. Previously he had directed a programme to quantify effects of evaporation ducting on microwave propagation, the results of which are now operationally implemented throughout the NATO Alliance.

Dr Richter has utilised very effectively the resources and opportunities provided by both the DRG and AGARD for over 25 years. He has facilitated and advanced scientific exchange and cooperation by proposing and chairing eight AGARD and RTO symposia between 1989 and 1998. He has also authored 15 publications for AGARD, 56 papers in other publications and 25 refereed journal articles.

The Scientific Achievement Award specifically honours **Dr Russell Burton** for his efforts as Chairman of RTO/AGARD/AMP Technology Watch on Spinal Injury to Repeated Exposures to High-Sustained Acceleration. He recommended, initiated and developed the Technology Watch as de facto Chairman of AMP Working Group 17, in lieu of a complex and costly cross-sectional or longitudinal study. From its conception in 1994, he has moulded the Technology Watch into a very active and effective organization and his activities have proved essential in the success of the Technology Watch.

As Chairman of the Technology Watch, Dr Burton has provided crucial guidance concerning the research in several countries on spinal injury from repeated exposures to high-sustained G. As editor as well as co-author, he has played a decisive role in producing the (forthcoming) RTO Report, which will be the definitive publication on this important topic. The Report establishes the precise relationship of G with acute and chronic spinal injury, addresses major occupational health concerns of pilots flying in high-performance aircraft, and provides recommendations for addressing related operational issues.

Norwegian National Day

As is customary at RTB meetings, one day of the meeting of the Board in Bergen in Fall 1997 was designated as 'Norwegian National Day' and was devoted to presentations by the host nation and a technical visit. The visit was to Kollsnes Gas Treatment Plant of the Statoil Company, where members were given a graphic description of the very impressive works associated with bringing natural gas from the middle of the North Sea to Norway, and were able to tour some of the installations.

Dr Yarymovych, the Chairman of the Board introduced the proceedings by saying that it had been a practice in AGARD for the Board meeting to include one day ('National Day') to allow the host nation to describe their industrial and scientific capabilities. As this had always been very rewarding for those who attended, and the new organization was adopting the best practices of its predecessors, it had been decided to continue to do so. He was delighted that Norway should be the first to present their defence industry in general and not just their aerospace activities as had been the case under AGARD. They had put together a very interesting, exciting and thought-provoking programme. Moreover, the afternoon's visit would expand the horizons beyond defence technology, and he was sure that it would be highly educational. He then thanked Mr Nils Holme, the Norwegian National Delegate, who had organised the whole meeting and put together the programme for National Day.

Mr Holme then introduced the day. He said that the focus of the programme was to be the research and industrial capabilities of Norway as they appear today, and added that anyone who had been present when the AGARD Board met in Norway in 1984 would find it a very different country now from what it was then. In both research and industry, the skills and technologies that are used are blending in a very detailed fashion between the military and the civilian sectors. In most cases, the basic technologies are equally applicable, and the skills at the highest system levels are in demand to the same extent in both areas. In preparing this programme their aim had been to highlight this situation and to give examples of what was happening.

The texts that follow are edited versions of the presentations.

Fig. 1: The speakers at the start of National Day

The photographs of equipment used throughout this section were kindly supplied by the Norwegian Defence Research Establishment (FFI). They are all described in the last article (by Mr Holme).

The Industrial Scene in Norway

by

Arve Thorvik

Mr Arve Thorvik's background is in political science and diplomacy. He was born in 1948 and educated at the University of Bergen and Drew University, where he obtained a Master's degree in Political Science. He also spent a year at the Georgetown School of Foreign Service. At the time of the meeting, he was Managing Director of the Federation of Norwegian Process Industries (PIL), a post he had held for 5 years, and he had been with the Norwegian Foreign Service before that, stationed in Lagos, Geneva and Washington DC. However, he had just been appointed Vice President for Health, Safety and the Environment with the Statoil Company. Mr Thorvik led one of the organisations campaigning for a 'Yes' vote during the EU referendum campaign, and he is Chairman of the Environment Northern Seas Executive Committee.

Process Industries

The meaning of this term might not be entirely clear. The Federation is a merger of a number of different associations for industry in Norway. We represent metal production, paper and pulp, chemical products, oil refineries, pharmaceuticals, plastics, packaging - about 650 companies with 60,000 employees, accounting for about 55% of Norwegian exports of goods. Statoil, which I am about to join and you will visit this afternoon, is the largest company in Norway, with some 17,000 employees. It is state-owned, but privately operated.

The economy

Norway is quite simply a rich country. Around the turn of the century it was one of the poorest countries in Europe, and industrialisation did not really start until the 1920s. The transformation from our parents' life to ours and our children's has been dramatic, as dramatic as in the countries in transition in Asia today, although over a slightly longer time span. Our GDP per capita (20% higher than the OECD average) is exceeded only by Luxembourg, US and Switzerland, and it is still rising faster than most others in the developed world. Why has this happened? Partly it is due to the growth of industry after the Second World War, but the current factor is oil. Without oil we would have a deficit in our current balance of trade, but with it there is a substantial surplus. We sell 80% of our exports to the EU (more than any EU member). In fact, in terms of trade we are more members of the EU than any EU member - we just don't have any influence; that's the only difference!

We have had very high growth in labour costs in the past, but recently wage settlements have been very moderate, with good cooperation between employers and employees. Inflation was a big problem at the end of the 1980s, about 8 or 9%, considerably higher than our trading partners, but it has since gone down substantially, and at about 1.5% it is now lower than their average.

How do we make our money?

Private services now make up the major portion, 42% of GDP in 1995. We are almost de-industrialising as a country, as indeed most of Europe and the US are. Traditional industry (manufact-uring) is now only about 13% of GDP, but the oil sector is up to 11% which compensates very much for that. Electricity at 4% is also an important sector. There is an impression internationally that Norway is a country of fishermen and farmers, but in fact agriculture and fisheries together account for only 2.5% of GDP.

Within the manufacturing sector, the main areas are machinery, ships and oil rigs (32% of the total), paper, printing and publishing (17%), chemicals and food products (both 15%), and metal products (11%). Traditionally we were a ship-building country; now many ships are built in Korea, Taiwan, etc, but we are coming back, particularly in the oil sector. Textiles used to be a large activity, but have dropped to just about nothing. We have the biggest fertiliser company in the world, half the computers in the world have silicon from Norway, and we are a very large producer of aluminium because of our large amount of hydro-electric power. Metal products have

been rising, because aluminium has had a very strong growth, not least because a lot of car production is now switching from steel to aluminium to decrease the weight and thereby reduce pollution. Manufacture of car parts is very important - we produce about 15% of the Volvo, and lots of parts for Mercedes, Audi, and even the American companies. As for exports, goods, which in most countries account for nearly 100% of exports, are down to 40% of our export earnings, and oil has risen to 35%.

Oil and gas

When will the oil finish? This is continually being revised, with the peak continually in front of us as we find new fields - moving further north mostly. This creates new challenges environmentally and because of the Arctic climate. The oil will eventually peak out and start slowly being reduced, although when or how much is uncertain. For the national economy, however, this is largely offset by the fact that we also have pretty gigantic gas fields, and the gas exports to Europe are very important. We currently supply western Europe with 15% of its natural gas consumption through pipe lines - to Emden, Zeebrugge, Northern England, and Scotland. Indeed, we have more gas pipe lines to Europe than roads!

The challenges to Norway

What will happen to Norway? The largest challenge to our economy is a potential fall in the worldwide price of oil. This would clearly affect government income very rapidly, because there is a taxation level of between 70 and 80% on the oil exploration in the North Sea. So that's challenge number one.

Challenge number two is that at present we have to import labour, from Sweden, Poland, and other neighbouring countries, particularly for construction work. Our challenge is to train our own people for these tasks.

The third challenge comes from the developing countries. I was in Shanghai recently and I was shocked by the speed of growth in China, about 9% a year. India is now the most important growth area in Asia, and eastern Europe will be coming up. Latin America (Venezuela and others) will pose a challenge, and even Africa is growing faster than we are in the western world.

The last challenge is that we are not really part of the European Union. We have a very good agreement for trade - the European Economic Area - but it doesn't give us much political influence.

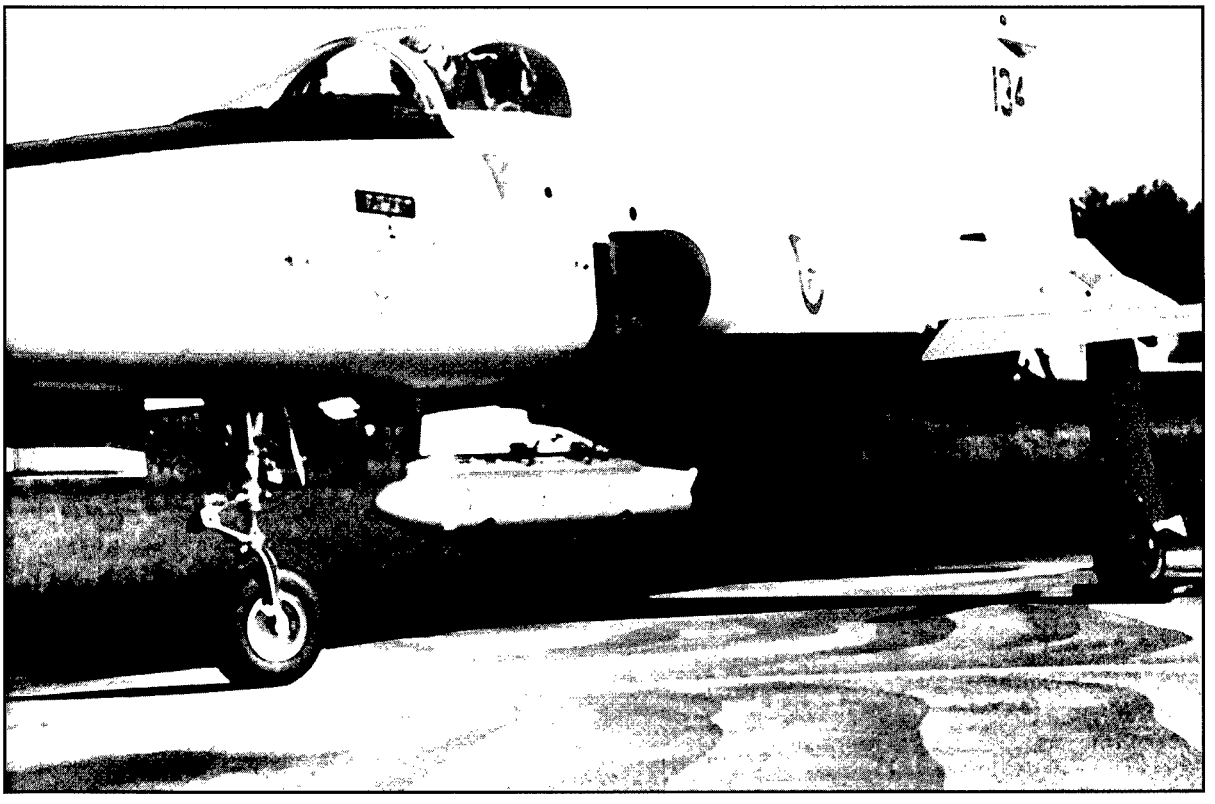


Fig. 2: The programmable EW pod

The Norwegian Defence Industry

by

Colonel Knut Nilsen

Colonel Nilsen is Director General of the Norwegian Defence Industry Group (NFL). He was born in 1938 and has spent most of his career in the Army. He has had a long and thorough military education and has a Master's degree in Mechanical Engineering from the Technical University of Norway. His Army career has been mainly with the Ordnance Corps in the ordnance and logistics areas. He has served with the United Nations forces in Lebanon. He retired from active service in 1996, after 41 years, and took up his present post in November.

Do we need a defence industry in Norway?

Many people in Norway and foreign countries have asked me this question. The answer is clearly "Yes", because we have to produce equipment and services for the armed forces based on specific national requirements and operational doctrines.

Norway is of course a very mountainous country, much of it covered with snow for many months in the year, with quite low temperatures for most of the year, and a very long coastline with all these beautiful fjords and thousands of islands. Obviously there will be some very specific requirements for the equipment we need to operate defence forces in this environment, and equipment meeting such requirements is not readily available in the world market. So we need our own industry to enable us to obtain suitable equipment. Moreover, our armed forces do not want to buy equipment 'off the shelf' or through catalogues but to work with industry as a partner. I call it logistics support to our armed forces in peace time, and the need is becoming more and more important as the complexity of military systems increases. The armed forces need specialists whom they can get only through industry support. They can't have all those specialists actually in the forces. So we do need to have a national defence industry, however small.

The structure of the industry

Reliable statistics on the size of the Norwegian defence industry are lacking, so the figures I will give are very much estimates, mostly made indirectly from budgets. There are less than 100 companies directly involved with contracts for the armed forces. The Norwegian Defence Industries Group currently has 63 members, and we believe we account for 80 - 90% of the companies involved in defence business. We have about 6000 - 7000 employees, and average annual turnover for 1992-1996 was about $670 million, divided into national contracts ($280 million), exports ($175 million), and dual use or spin-offs from defence activities ($215 million). So it's quite a small industry - indeed it was not even mentioned in Mr Thorvik's overview! - but it is important from a national point of view.

There are two major companies in the industry - the Kongsberg Group and Raufoss Technology. Both are quoted on the stock exchange but the majority shareholder is the government. The rest of the defence industry is privately owned. Some of the large multinationals do have subsidiaries in Norway, for example Alcatel, Siemens, Ericsson, etc. Most of the companies also have civilian production. Even the two major ones do; in fact defence work accounts for only about 40% of their turnover, the rest is civilian. Because of its small size, our industry is not capable of producing large and complex systems. Mostly it is involved at the sub-system and component level. It can't work with the whole spectrum of technology, either. It is concentrated in specific priority areas, priorities that are assigned by the Minister of Defence. So we are working in niches, in areas where we are capable.

As Mr Thorvik said, we are a relatively high cost country, so to be competitive it is necessary to produce products with a high technology content. Exports are crucially important to the industry, because we have a limited home market. So to maintain an adequate defence industry, we are heavily reliant on exports. As you can imagine, it is not easy for a small nation to gain access to markets, but we have succeeded and I can assure you that the Norwegian defence industry is competitive, both in quality and price, in the areas in which we are working. And this remark is not subjective; it is based on my experience in the Army

Materiel Command where I was responsible for the Army's procurement programmes and could compare bids from foreign industry and from the Norwegian industry. The Minister of Defence claims 100% offset when it comes to foreign contracts, and this is a major reason why we are able to get access to the markets in other countries, at least in the NATO nations.

Nowadays, of course, the defence industry is being restructured everywhere, in Europe and North America, and the Norwegian defence industry is closely monitoring that process in order not to be left behind. We now have many alliances between our industry and the defence industry in other countries, such as UK, France, Germany, Sweden and US. In this way we are trying to be a member of the 'family' of defence industries, even though they are all fighting nowadays to keep up their activities.

For many years now, the industry has operated under a quite stable defence budget. The overall average for the period 1992-1997 was $3.1 billion, with quite small variations and a slight increase compensating for inflation. The investment and procurement part has also been stable - on average about $800 million. None of the parties in the forthcoming parliamentary election has mentioned defence matters at all during the campaign, and that underlines the fact that there is general agreement about defence policy in this country and the budget that can be expected in future years. So we are in a much more favourable situation, I believe, than most of the other countries represented here, with no major cuts and a virtually stable budget situation. However, we are very much exposed to competition, unlike the position in many other countries. There is no political tradition in Norway to shield the defence industry from foreign competition. Indeed, the defence authorities demand the best value for money, no matter the country of the supplier, and they really do exercise that principle.

A few examples of products

Communications, Command and Control. We built up a fixed line Strategic Military Network in the 1950s and 1960s, and this was digitised during the early 1980s. Now it is capable of handling military messages and is also operating with the NATO Strategic Network. As regards mobile communications, in the 1980s we developed digitised radio transmissions, and now we are putting emphasis on gateways to other NATO nations' message handling systems. So we were relatively early when it comes to modern communications and the digitisation of communications. An example is the brigade and division level communications network. The concept of this network dates from the mid and late 1970s. Development started then, based on a major trunk system with several trunk nodes and access nodes capable of handling both voice data and radio connections, and with gateways to the public network, to the military strategic network, and also to other tactical networks, and using Eurocom protocols which makes it interoperable with other NATO nations' networks. Some of the components in this system were developed by Norwegian industry, such as a very compact tactical digital switch which was a development contract with the Army and is the heart of this tactical digitised network.

Another major part that is still being developed - it is under user-test at present - is an integrated data and voice radio system. You may wonder why Norway finds it necessary to develop its own military radio system, when so many are available in the world today. We made a thorough market survey at the beginning of the 1990s, and found that no military radios available in the market could meet our specific requirements for data transmission as well as voice. So we developed our own, which can be used as a normal combat radio and also as a mobile terminal in the network. It operates on a narrow-band spread spectrum principle, with frequency-hopping. It is available in both portable and vehicle configuration, and with a clip-on amplifier the output can be increased from 5 to 50 watt. We have a large number of radio relay link stations in our network, because of our mountainous terrain. A SHF piece of equipment has recently been developed by a Norwegian company, who have also started to market a satellite telephone which weighs only 2.4 kg and has the antenna integrated into the box. Through the Immarstat satellite system, you can transmit almost anywhere in the world with it. They are now developing a pocket-format satellite telephone.

Missiles. The Penguin missile system of the Kongsberg Group was started in the 1960s, and has been sold to a number of countries. They are now developing a new generation of anti-ship missiles in cooperation with Aérospatiale in France. And in conjunction with Hughes Aircraft they are producing a surface-air missile system using the AMRAAM missile. Kongsberg are responsible for the complete C3I system of this missile. The Kongsberg Group are also contractors for the new motor being used in the upgrading of the Sea Sparrow system.

Ship technology. An MCM vessel has been developed by one of our ship-building companies using surface-effect ship technology. This uses the catamaran principle with the bow and stern closed with curtains or seals and a centrifugal fan to increase the pressure under the ship by about .05 bar, thus lifting it about 1.5 m. so that the wet surface of the ship is reduced by about 65%. The company claims that it is the largest vessel of this kind in the world. It is made entirely of composite materials and has very good shock resistance because of the construction principle being used. The manoeuvrability and speed of this ship are essential for our shallow and heavily indented coastline. The same company has also received a development contract for the next generation of fast missile torpedo boats. The prototype is due to be finished early next year, and a number of the principles used in the MCM vessel will be used here also.

Ammunition. The Raufoss Technology Company is basically a medium-calibre ammunition producer, and has sold multi-purpose ammunition or licenses for production to a number of countries. Currently the company is developing APFSDS 30 mm ammunition for the chain gun of our new armoured infantry fighting vehicle. Such ammunition was not available in the market.

Applied Research in Norway

by

Bjørn Grandal

Dr Grandal was born in 1948 and educated in the US where he completed a Ph.D. in Theoretical Physics at the University of California, Santa Barbara in 1974. He then joined the Norwegian Defence Research Establishment where he rose to be Deputy Director General. Then he moved into industry as the Director of what is now Christian Michelsen Research, an applied research organisation in Bergen. However, he was speaking in another capacity, as Chairman of the Association of Industrial Research and Development Institutes, a post he has held since 1989. Dr Grandal has been a member of several Government task forces, notably on the evaluation of the Strategic Defense Initiative and on nuclear reactor studies.

Christian Michelsens Research dates back to 1930; it is the oldest research institute in Scandinavia. In 1992, the University of Bergen became the owner of the Institute, and it operates now as a contract research institute with a focus on the development of new products. We like to take projects all the way from an idea to the prototype, because then there is no problem over implementation. Our turnover is just short of 8 million dollars and we have 90 employees. We are active in oil and gas instrumentation, gas and dust explosions, and visualisation (from maps to the medical industry).

The Association of Industrial R & D Institutes has 14 member institutes with an annual turnover of about 300 million dollars, with 3,300 employees, and we carry out 14% of the total R & D in Norway.

Funding for R & D. The total volume of R & D in Norway is just above 2.1 billion dollars per annum, 1.7% of the GDP. Since the average in the OECD countries is 2.2%, this has been the subject of much discussion in Norway. One of the explanations advanced is that our industry works in branches with low R & D intensity. We don't have very heavy defence or computer and electronics industries. Of course, some of us think that it should definitely be higher. Industry carries out 46% of the R & D, the universities 26%, and the institutes 28%, the last being a very high figure compared to most other countries. The institutes were mostly initiated by the government after the Second World War as part of the effort to use technology to develop the country.

Half of the R & D funds come from industry, 43% from government, and 5% from abroad, and 2% come from other sources. Total public R & D expenditure is just above 900 million dollars. Of this, 45% goes directly into higher education, 27% to the institutes, and 5% to industry. The remaining 23% goes into the Research Council of Norway. This is a gigantic experiment in which we have merged five independent research councils into one body. Some people say we shouldn't put all our eggs into one basket, and we are very anxious to see how this will work out in the long run.

The institute sector. This is the major factor in applied research. The role of the contract research institutes is to provide R & D services to industry and government. There is of course a government-owned and funded institute sector, and the Norwegian Defence Research Establishment (NDRE) is one of the largest. We provide research and development, technology development, and customisation of technology imports. Contracts represent 88% of our turnover. The other 12% comprises work that the institutes themselves initiate and basic grants from the government. The market provides the majority of the funding. Oil and gas industry exports are of the order of 15 billion dollars a year. This industry has grown from nothing in the last 25 years, and there have of course been a number of technology issues to address in that time.

Examples of work

High strength concrete. Sintef have addressed this issue. The problem is that Norway has specific rules on the design of constructions in concrete, but for offshore platforms these rules mean that you would spend a tremendous amount of money on concrete and the weight would be far too great. So they developed procedures for the production of high-strength concrete and today we have a number of large offshore platforms, such as the Gullfaks, Draugen and Troll platforms, all made of high-strength concrete. The Troll Field platform is the largest man-made structure and is the source of the gas that comes in through Kollsnes Terminal.

Safer processing facilities for gas. This is an example from Christian Michelsen Research. The design rules used until at least the 1970s were very inadequate for designing an offshore platform that could withstand gas explosions. The Piper Alpha platform is of course the prime example of this, where there was a small leakage of gas, which resulted later in a terrible explosion with the loss of 166 lives. So we have carried out 15 years work that has resulted in an experimentally verified simulation code for gas explosions in complex geometries, based on a combination of experiments (both at reduced-scale and full-size) and computer simulations. All the major companies (Norwegian and foreign) now use this code to design their gas-processing facilities. The same tool can also be used to simulate what is happening in on-shore facilities.

Multi-phased transport of oil and gas. The question was whether we could develop other reservoirs in the vicinity of an existing one and send the unprocessed well streams in pipes to the existing facilities for processing rather than build a new facility for each reservoir. This would give a very large saving in cost. We have built a two-phase loop in Trondheim, and we can send gas and liquid up and down the loop and obtain real data on what is happening. Today we have a multi-phased transport simulation code, OLGA, based on extensive experiments and modelling, developed jointly by the Institute of Energy Technology and Sintef. The benefit of this code is that it is now possible to process gas from the Troll Field onshore. The cost is about 1.5 billion dollars for the offshore installation and about 3 billion for the onshore one, but this is much cheaper than doing the processing offshore.

Recovering more oil. 10 years ago, only 30% of the oil could be recovered from the reservoirs. Normally, the natural pressure in the reservoir drives the oil up, but it has been found that gas or water injection to increase the pressure is effective, and that laying pipes horizontally or using multi-branched ones is also helpful. The benefit is substantial. Today the recovery rate is 40% and this simple change has increased the recoverable reserves by some 40 - 60 billion dollars. And that is the main reason why the curve of recoverable reserves seems to be moving ahead all the time - it's not because we have found more oil. Combining this work with the previous item, we have multi-phased transport by pipe from the Troll Field to the Oseberg field, about 50 km away, where the gas is used for injection into the reservoir to increase the pressure and enhance the oil recovery.

Working in really deep water. Down to about 300 m. you can use platforms, but what do you do to get down to 1500 or even 3000 m.? You clearly have to use a vessel, you have to anchor it, you to have the risers (the pipes) to get the oil out, but you mustn't move, no matter how strong the sea. Extensive testing with deep water floating production storage and off-loading systems has been carried out at Marinetech's large ocean basin test facility. Not only do such systems allow the oil to be stored but they also let tankers come alongside to load it. They are in extensive use because they provide safe, simple and effective production systems. These systems are much more cost-effective than fixed installations, the life of which is limited to the life of the field, since they can be moved elsewhere when the field is exhausted.

Suction anchors. These have been developed by the Norwegian Geotechnical Institute. Traditional anchoring techniques, like piles and fluke anchors, are expensive due to time-consuming installations, especially in very deep seas, and are not easy to use in weak soil. The answer is inverted buckets, 5m. in diameter and 9 m. high, which are lowered to the bottom of the ocean and the water pumped out. The water column above then gives a pressure of 20-30 bars. This can be used both for fixed and anchored installations. The reduced costs allow the development of marginal fields and fields in deep sea, and the system provides better anchoring. These anchors can be driven 36 m. below the sea bed, and in weak soil they are an excellent solution.

Metering gas flow. Natural gas has traditionally been metered using orifice technology. By reducing the diameter of the pipe, and measuring the pressure drop, you determine the velocity and volume of the gas, but a number of different pipes are needed to give an accuracy of 1%, and this takes up the size of a tennis court, rather a waste of space on an offshore platform. We have developed a compact meter, only one metre across, in which three ultrasonic beams shoot through the gas, and measuring the time of flight of the beams gives a very accurate picture of the velocity profile of the gas. It gives almost double the accuracy and requires only one tenth of the space. At one platform, Statoil estimated the saving at 20 million dollars. This is now produced by part of the Kongsberg Group.

Crash sensors for car air bags. Not all the work relates to oil and gas. Very reliable sensors are needed to trigger release of air bags. Sintef has developed an economic solution using silicon sensor technology to make integrated piezo-electric sensors for measuring pressure and acceleration. They have been so successful that the largest supplier of such sensors in the world is now a Norwegian company. Its market share in Europe is over 70%.

Salmon farming. The Marine Institute in Bergen is not a contract research institute, because although fish farms are numerous, they are also very small, and thus are not easy to handle as clients for contract research. So the government has funded most of the research in this area. The Bergen area is the largest producer of salmon in Norway, and the issue here is how to maintain a high quality with large volume salmon farming. In the 1970s, total production in Norway was about 100 tonnes. Today, one person produces 130 tonnes in a year. They have taken wild salmon from 41 rivers, ranging from the north of Norway down to the fjords near Oslo, and have developed

their own breeding stock from these. Today they are using only the 6th generation, which is almost as close to wild fish as you can come in this type of farming. A dry feed system has been developed, which increases energy density but does not pollute the local environment around the fish cages with feed that has not been eaten. Vaccines have also been improved, but medicine is used very rarely today. The amount of medicine used in fish farming is about one tenth of that used in ordinary farming in Norway - which uses very little by comparison with other countries. However, mother nature provides us with solutions to some of the problems in a much more elegant way than we can. One such problem is salmon lice. But salmon lice is the natural feed of the wrasse. So we introduce this fish into the cages, and in a few days all the lice are eaten.

Conclusion. Our applied research scene is dominated by clients - the users - who drive the research by the volume of contracts they place. However, when there is extensive short-term applied research, the question of renewing the technology base arises, and I believe we need to strike a better balance between market-pull and technology-push. That is our prime challenge today.

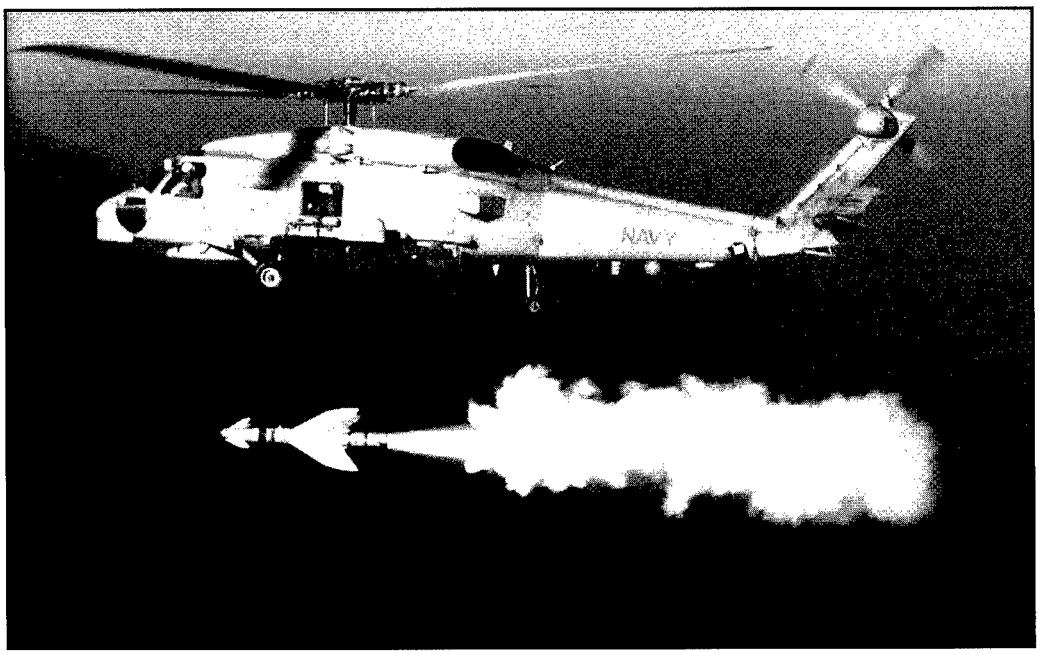


Fig. 3: A Penguin Mk 2 Mod 7 missile

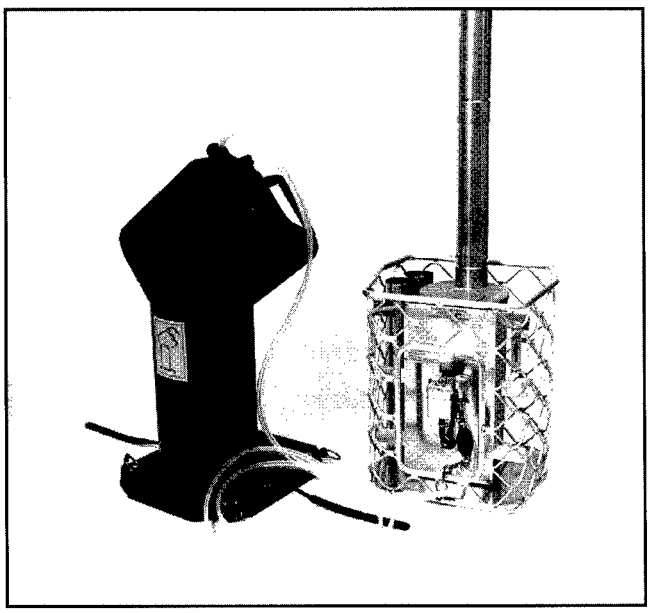


Fig. 4: 'Low-tech', but vitally important: a tent stove that burns all night without attention

Defence R & D in Norway

by

Nils Holme

Mr Holme is the Director General of the Norwegian Defence Research Establishment (NDRE - FFI) and a member of the RTB. He was born in 1936 and obtained an M.Sc. in Applied Physics at the Norwegian Institute of Technology in Trondheim. He has also taken the Total Defence Course at the National Defence College. He joined NDRE after leaving university and had several spells in the Systems Analysis Group, before becoming Chief Scientist, Division for Electronics, 1977 - 1988, and Chief of Staff, 1990 - 1993. He was appointed Director General in 1993. Mr Holme has also spent several periods away from NDRE, at SHAPE Technical Centre, twice in industry, including a year in Saudi Arabia, and as a Special Adviser to the Ministry of Foreign Affairs. He is a member of the Norwegian Defence Council and the Norwegian Academy of Technical Sciences, and was Director of the AGARD Aerospace 2020 Study (published in three volumes as AR-360).

Background

Norway spans almost 30 degrees of latitude. We have established a Resource Protection Zone around Spitzbergen to try to control the exploitation of the economic resources in the area. This area is of great importance because it is the breeding ground for the large schools of fish that form the economic basis for the fisheries of the north Atlantic. We are a small country located in an area rich in resources and of strategic interest to some very large countries. As a result of the end of the Cold War, some tensions and immediate threats have been removed, but some concerns remain, one of them being climatic change. I am not referring to long-term climatic change, but, because we are at the margin, even small changes could have an impact on the situation in the north, where we are very thinly populated. Overall, we have jurisdiction over about 2 million square km., and a further 2 million are of strategic interest to us.

In military terms, there are new international commitments. There is a great political readiness to accept responsibilities in NATO and UN operations. In Cold War days, we used to send hospitals and do guard duties in international operations. Nowadays, we send out people who are prepared to shoot, electronic warfare units, logistically trained people, etc, a very big change in respect of requirements and planning.

Funding

As you have already heard, the defence budget is being maintained at an almost constant level - about 3 billion dollars. Cost savings from a reduced alert state and operational readiness are directed towards modernisation, including major materiel programmes. Defence R & D is kept constant at about 3% of the defence budget. This is not the luxury of an oil-rich country, but rather it is deeply rooted in the Norwegian population in a perception of uncertainty and the historical lessons of the past, coupled with nearly 100% conscription for military service, which has led to a very high level of understanding of military issues by the population.

The total budget for Defence R & D is about 100 million dollars, about 50% of which is contracts for industry, mainly for product development but also for contributions to the Euclid Programme. The other 50% goes mainly to the Norwegian Defence Research Establishment (FFI). There are a few other organisations, some as small as 10 employees, in defence research, the largest being one devoted to aero-medicine.

FFI's Mission - summarised

- Inform the political and military leadership about the potential implications of scientific and technical developments for security policy and defence
- Advise on the best use of technology for defence purposes
- Undertake development of weapons and equipment as a basis for internationally competitive defence production
- Investigate geophysical areas of importance

Organisation of FFI

We have been through the same processes as the research organisations in all countries in NATO. They have examined why they exist, and whether they should be market-oriented, customer-driven, or even reduced. We were well on the way to becoming more customer-oriented in financing and management, but then the Chief of Defence, and the Minister decided to maintain the defence research activity as a government service available to themselves, and as advisers, without dependence on customers. So the basic foundations were reinforced - to maintain the independence and integrity of a government organisation. This is completely contrary to the currents of the times, but the decision was taken very consciously.

We have a Board of Directors, which reports to the MOD, but there is also the Defence Research Policy Board which advises MOD, and the Minister personally, on the long-term efforts, relevance and quality of the work and budget allocations. This body is chaired by the Chief of Defence personally, and includes the Inspectors General of the services, some civilian scientists not associated with defence work, the Chief of Intelligence, and the Chief of Operations in the General Staff. They meet for two days (including the evenings) twice a year, totally without staffers, so that everything that goes on is on the basis of preparation. This means that these very senior people spend at least one week twice a year considering the long-term issues of defence research and its implications to their responsibilities.

At the project level, there is a Project Review Group, which reviews all project proposals after headquarters staffing, and which is co-chaired by the Director of FFI and the Chief of the General Staff.

FFI activities

50% of our budget is for long term studies and some tasks that we undertake for MOD, and 50% is from customer tasking, mainly military. We may take contracts from anyone, but for policy reasons we keep a constant volume of activity, and so, because the military have more problems than we can respond to, we do civilian work only when there is an obvious dual use aspect, so that it will also serve a military purpose.

Of our work, 10-12% is basic research (curiosity-driven) and 14% represents tasks and functions for the MOD and other ministries. We are sometimes called upon by the Customs and the Police for immediate scientific advice, for example when they have captured something and want to know exactly what it is. And we give professional advice to the Foreign Ministry on such matters as chemical warfare treaties and strategic export controls. Studies for defence planning, mainly for the Chief of Defence, amount to some 11%.

One third of our activity is development of materiel-related concepts. This is perhaps our most important activity. It is not the development of materials in themselves, but studies to determine how new or existing technologies can be employed to solve fundamental needs in a new way, giving the basis for the specification of new products. When you look at our defence exports, you will see that it is not that we manufacture more cheaply than other countries but rather that we usually have a different product from the competition, one with a new 'twist' as to how an underlying problem can be solved. So the product is sold successfully, because the advantage is at the systems level. For example, we sell radios not because they are better, but because many fewer are needed since they carry out several tasks - and this is inherent in the concept. Development of materiel for production is now about 16%. It used to be higher, but has mostly gone to industry now.

10% is support of procurement and production - simulation, follow-up and bringing into service, etc - what we call 'the penalty of our success'. If you are successful in selling equipment, then you have to carry out follow-up tasks which are not really very research-oriented. Finally, 5% of our work is non-government.

Some few examples

Penguin infra-red seeking anti-ship missile (Fig. 3). We are very proud that we have been able to export this to the US, who have told us that this is only the second time that US forces have procured from abroad what is classified as a major weapons system, the previous one being licensed production of the Harrier aircraft. This missile was not licensed for production but was delivered. Incidentally, the weight of paper exceeded the weight of the missiles in the first batch! The reason we have been able to sell this missile was its countermeasures resistance properties. We did not have sufficient resources to be able to set up the test facilities and scenarios to establish the missile's characteristics to the extent that the US Navy could. The European nations should note that it is not sufficient to have the ideas and to be able to develop the specifications, you must also have the environment to verify the true characteristics of the systems.

Electronic component development related to infra-red detection. To support such systems into the future, we are already deeply engaged in this, the only research project I know of which has a ten-year perspective for delivery in Norway. It is because our admirals and generals have different views of the future than do the majority of industrialists. The aim is to have new ideas in the pipeline, to be produced every three years should successful countermeasures be developed against present equipments.

Programmable electronic warfare pod for the F-16 aircraft (Fig. 2). This is very highly classified, but unlike the seeker, where the secrecy relates to the hardware, here it concerns only the chip, which can be removed and the equipment sold as a Restricted-level item to people who have their own ideas for electronic warfare.

Combat-net radio. This is not dependent on a central control station. You switch it on and it sends out a signal, saying "I am here; is anyone listening?" A second radio comes on and send outs a signal saying "There are two of us, and I can hear you". Then a third is switched on and they determine that there are three. But perhaps A can not be heard directly by C, so the radios take care of that by organising communications appropriately. It is a self-organising net, and the user is not aware of what is happening. It has voice and data facilities, and it also has a flash facility, which makes it usable for the distribution of high-speed data as in air defence functions. Such messages are not put in by the operator but come from instruments. And you can steal a few milliseconds from people's use, without their noticing, to set up routes through the network according to the 'least emitted energy' criterion, which of course is required to give margins for electronic warfare activities, so that we can increase the gains and still have the margins. This emphasises the importance of working at the system level, not the design level of the radio.

Submarine weapon control systems. We are unable to do the console competitively, but we have developed new concepts for attack using conventional submarines and embedded that into the console, and that is why Germany and Italy are interested.

Self-propelled mine counter-measures device. This is the best value for money. Its cost is about that of the charge normally used in more complex systems. It takes one fifth of the time to deploy that normal procedures do.

Battery technology. This is 150 years old. The idea is to take oxygen from the sea and oxidise metal, thus getting back the energy you put in when producing the metal. Our innovation is how to absorb enough oxygen from the water to make this practicable. We have solved this problem and patented our methods. So now we can go to great depths with autonomous vehicles and get rid of the cable. Other equipments need a cable to provide power, but the deeper you get, the thicker the cable needed, to provide the greater power required, and the greater the drag, so that at around 400 m., the velocity is zero, and you can only inspect vertically below the mother ship.

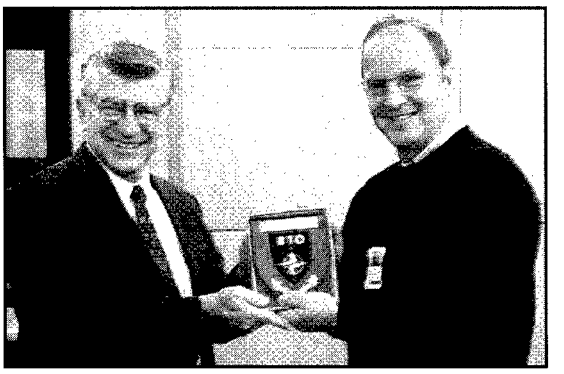
Autonomous under-water vehicle (Fig. 5). Under contract with Statoil we have designed a vehicle which is going to be marketed later this year, after a very speedy development programme. This will give cm. level mapping down to 2000 m. It works on an acoustic link to the mother ship, to monitor operations and to allow you to modify them if you wish, although it can be pre-programmed. The economy is such that you can map at around ten times the capacity, and the main cost is now not the underwater vehicle but the survey ship. You can deploy many of these at the same time, thus increasing the capacity. The next phase is to monitor the state of underwater pipe-lines, using the same device, and then we intend to follow up the systems studies we have already started for the navy to survey mine fields autonomously. In the first stage, the device will investigate a field and identify suspect objects and report back. This approach will be both cheaper than at present and considerably less hazardous to human life. In a later stage, we hope it will be able to destroy the mines also.

Stove for a tent (Fig. 4). We have even innovated in this area.. Needless to say, in our climate, stoves in tents are essential for much of the year. In the past, one person in a tent had to stay awake to feed the stove all through the night. Now this is no longer necessary, and all ten people can sleep through. It's an automatic device and has appropriate safety features.

Fig. 5: Autonomous under-water vehicle

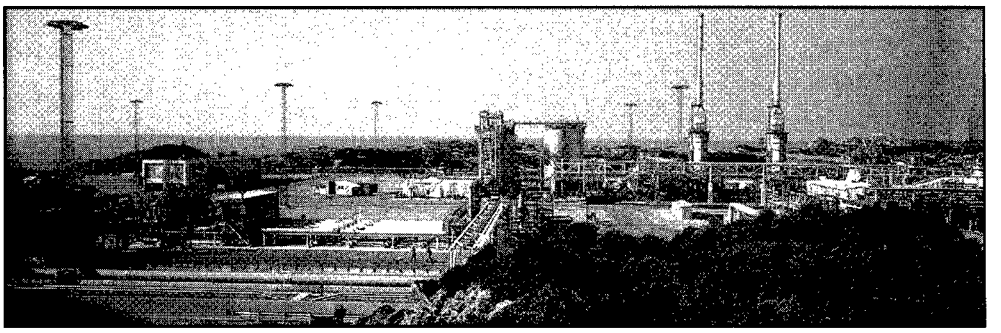
Visit to Kollsnes

The afternoon of Norwegian National Day was taken up with a visit to the Kollsnes terminal of the pipeline from the newly-operating Troll oil and gas field west of Bergen. The short note and illustrations that follow have been compiled from brochures provided by Statoil, the main partner in the operation. The photograph shows the Chairman presenting the Operations Manager, Mr Oeyvind Johnsen, with an RTO plaque.

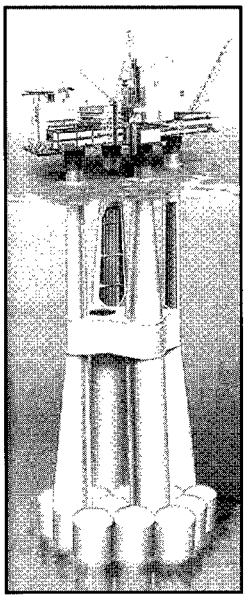


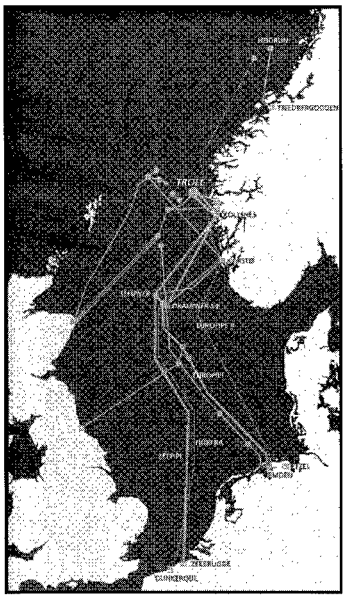
The Troll field was discovered in 1979. It is the largest offshore gas field in Europe, with a substantial volume of oil also. Development was approved in 1986. Oil production, piped to another terminal near Bergen, started in 1995, and gas came on stream in 1996. The top of the platform is over 100 m. above sea level, but like an iceberg, there is much more below than above. The sea bed is more than 300 m below sea level, and the supports of the platform are sunk deeply into it, making the whole structure 472 m. tall, half as tall again as the Eiffel Tower, and over a million tonnes in weight. It is the tallest structure ever moved by humans. Below the sea bed, there are 39 production wells, about a further 1400 m. deep.

To reduce costs and increase safety, it was decided not to process the gas on the platform but to pipe it ashore in a wet condition for processing at Kollsnes. Two 36 inch (~ 1 m.) pipelines are used, running most of the way on the sea bed, but with the final few km in a water-filled, larger than road-size, tunnel (8m. by 9m.) under the sea bed. There are some 80 employees at the platform, in three sets of crew, and about 200 at Kollsnes. At Kollsnes, the gas is dried and compressed before being exported to continental Europe, via the pipelines shown on the map. It takes about a week for the gas to travel from the field to its destination.



Kollsnes Terminal





The Board in Bergen

The Research and Technology Board met in Bergen, Norway in Fall 1997, from Wednesday 10 September to Friday 12 September, the final day being Norwegian National Day as reported elsewhere in this issue.

During the course of the meeting, the members were invited to two receptions. The first, held in the modern Bergen Aquarium, was hosted by the Norwegian Defence Research Establishment (NDRE - FFI in Norwegian), of which Mr Nils Holme, the senior Norwegian Member of the Board, is the Director General. The second reception was kindly offered by the Mayor of Bergen in Schøtstuene, one of the old Hanseatic League houses now preserved as a museum.

The hosts of the meeting were the two Norwegian National Delegates, Dr E. Alnaes of the Oslo Military Clinic, who had formerly been Chairman of the Aerospace Medical Panel of AGARD, and Mr Nils Holme, Director General of NDRE

This was the first meeting for Commodore Ir van Dord of the Netherlands Ministry of Defence

The three UK Board members are, from left to right: Mr J.C. Mabberley, Managing Director of DERAtec, Farnborough, Mr Martin Earwicker, also of DERA, Farnborough, who was attending his last meeting, and Mr W.I. McFarlane, Systems Engineering Director of British Aerospace, also from Farnborough

Mr A. Jara Albarran, Deputy Director of R&T in the Spanish Ministry of Defence, and Dr J. Simon Calero, Director of the Launchers Programme at INTA, near Madrid

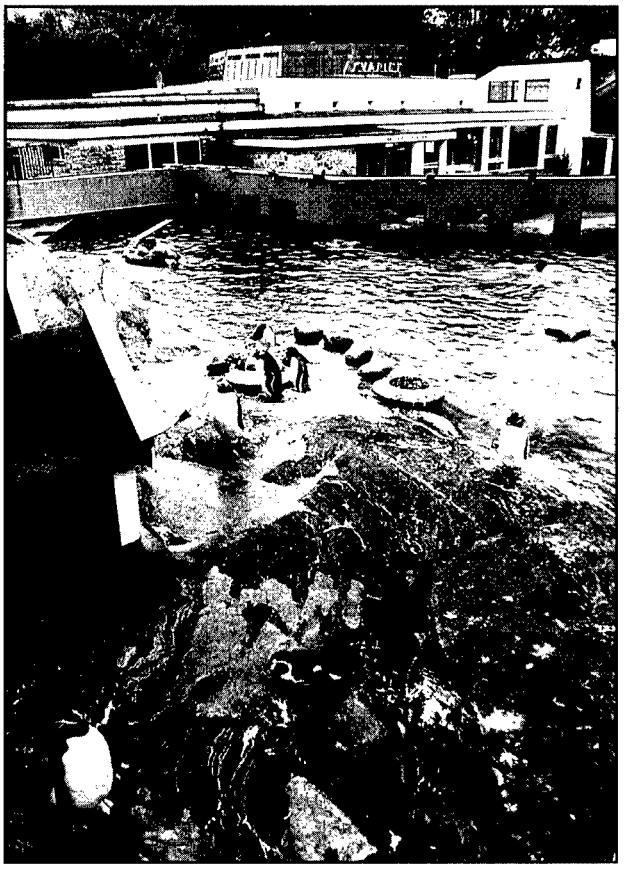
Three ex-officio members of the Board: Mr G. Vettori came in the place of Admiral Spoelstra, Director of SACLANTCEN, Commodore A.L. Vey was then the Deputy to SACLANTREPEUR at NATO Headquarters, and Mr L.D. Diedrichsen is the General Manager of NATO's C3 Agency (NC3A)

Rear Admiral V. Ascoli is Chief of Research for the Italian Ministry of Defence, and General A. Altori is Commander of DASRS, the Italian Air Force Research Studies and Experimentation Division (described in AGARD Highlights 94/1)

Colonel Gioldasis, Commander of the HAF R&T Centre (KETA), was attending his last meeting. Next to him are Dr E. Narlis of the Greek Ministry of Defence and Dr T. Spathopoulos, Director of Engineering R&D for Hellenic Aerospace Industry

The Canadian Board members present were Dr Tom Lefeuvre, Director General of the Institute for Aerospace Research and Mr Ken Peebles, then Chief of R&D for the Department of National Defence

Behind the National Delegates at every meeting sit their National Coordinators and other attendees such as Panel Chairmen and Executives. A few of them are shown here

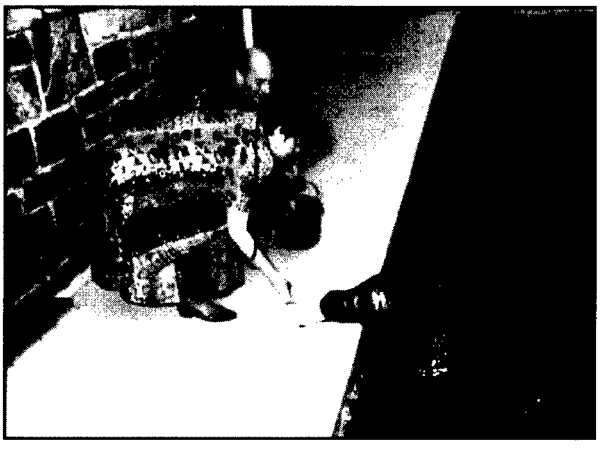


The Bergen Aquarium, where the NDRE reception was held

Mr and Mrs Holme and Dr and Mrs Alnaes greet Professor Dr P. Jeppesen and Mrs Jeppesen. Professor Jeppesen is from the Department of Electromagnetic Systems at the Technical University of Denmark and was attending his first RTB meeting

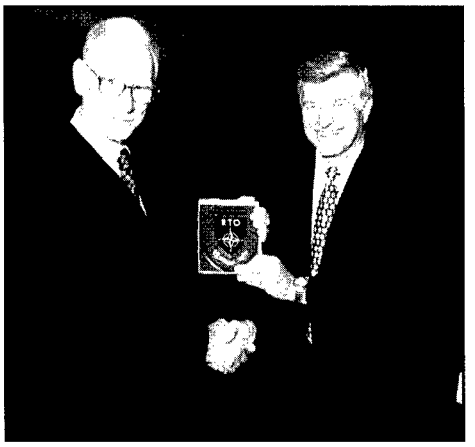
Mrs Yarymovych

Our guide to the Aquarium proved very adept at teaching visitors to feed the fish and other aquatic animals, as shown at the right

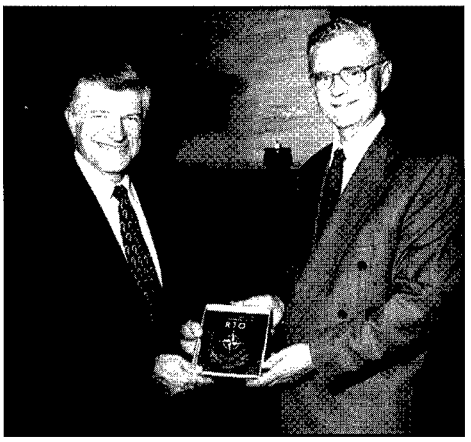


Mrs Holme

A US gathering: Dr D.C. Daniel, Executive Director of the US Air Force Research Laboratories at Wright Patterson AFB, General J.R. Dailey, Acting Deputy Administrator of NASA, Dr M. I. Yarymovych, Chairman of the Board, Mrs Yarymovych, Dr Ann Miller, representing IST, Mr L.J. Williams, representing AVT, Mr G.T. Singley III, then Principal US Board Member, and Mr Barry De Roze, US National Coordinator



The reception at the Aquarium was brought to a close by the presentation of the first RTO plaque to Mr Nils Holme, Principal Norwegian National Delegate, who had hosted it



The Deputy Mayor of Bergen, Mr Ole Jorgen Johannessen, hosted the reception at Schostuene and the Chairman presented him with the second RTO plaque

Mr Singley with Dr van Hoek, Mrs Jolly van Hoek and Dr Keith Gardner, the former Head of the Defence Research Section at NATO

An extra touch of grace was added by the appearance in national costume of Mrs Else Kuvland, a member of Mr Holme's staff, who was the local coordinator for the meeting. She is seen here with the Deputy Mayor

Although he is seen arriving at the Aquarium, it is fitting to put this photograph last, since BDir F. Günther of the German Ministry of defence was attending his last meeting, after many years of service both as a member of the Defence Research Group's governing body and as German National Coordinator for AGARD

Photos from Paris

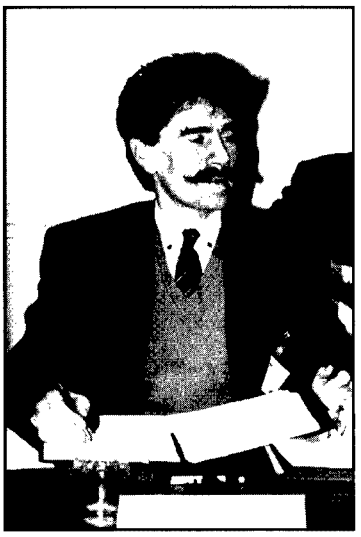
The Spring 1998 meeting of the Research and Technology Board was held in the Espace DCN (Direction des Constructions Navales) in Paris on 4 and 5 March. Members were invited to a reception, hosted jointly by the French National Delegates and the Director of RTA, at the Cercle Militaire, and to a dinner at the 'Maison des X', the club for former graduates of the Ecole Polytechnique. The following photographs were all taken at the Board meeting or the dinner.

Mr N. Ray, The Assistant Secretary General of NATO for Defence Support, Dr M.I. Yarymovych, Chairman of the Board, and Dr E. A. van Hoek, Director of the R&T Agency

Invited Nations

This meeting was truly historic, since it was the first to have representatives of the three 'invited' nations.

Ing. J. Janosek of the Department of Assets of the Ministry of Defence of the Czech Republic. Behind him are Mr B. Muranyi and Prof J. Bokor, both of Hungary



Colonel B. Rath of the Hungarian Ministry of Defence

Professor K. Santarek of the R&D Department of the Polish Ministry of Defence

Newcomers

Some of the members who were attending a Board meeting for the first time.

Brig Gen J. Brown represents SHAPE

Brig Gen A. Ergonen, Turkish General Staff

Mr G. Ferenczy represents the NATO HQ C3 Staff

Dr L. J. Leggat, Chief of Defence R&D, Canada

Dr M. S. J. Markin, Director General, Defence R&T, UK

Captain E. Theofilou, of the Greek Ministry of Defence

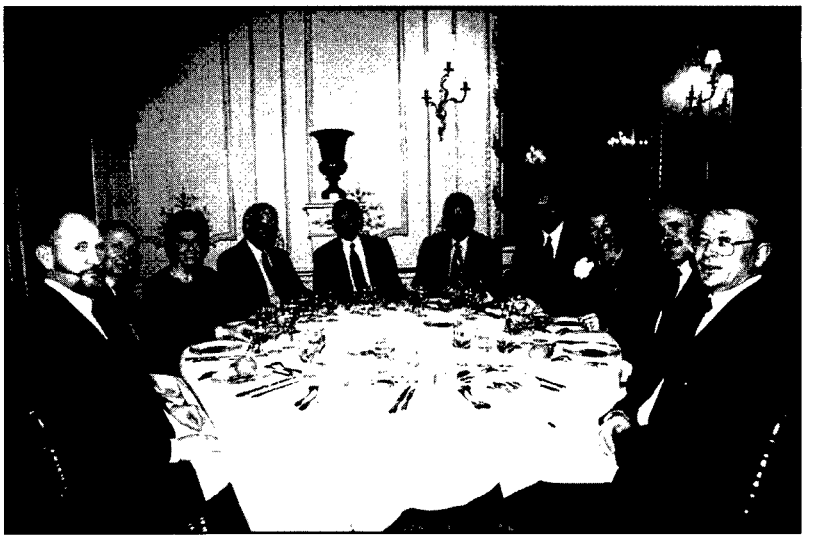
Prof V. von Tein, Member of the Executive Board of the German Aerospace Centre

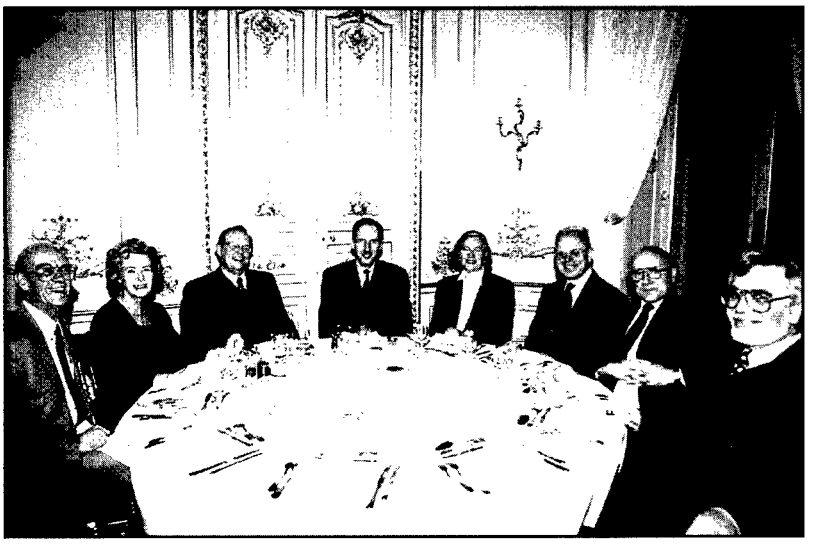
The Social Side

In these photographs of some of the dinner tables, all names are given from left to right.

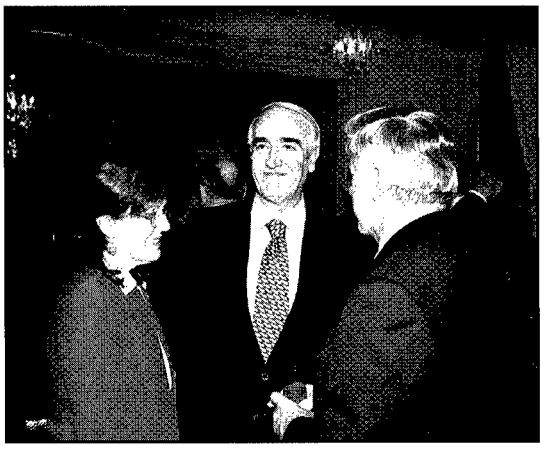
Mrs van Hoek, Mr G.T. Singley III (US), Dr E. van Hoek (RTA Director), Mrs Van Daele, Mr G. Leira, (Co-Vice Chairman of the Board, NATO Defence Support Division), Dr E. Narlis (Greece), Maj.Gen. A. Van Daele (Belgium), Professor A. Üçer (Turkey), IGA Dr J-P. Marec (France), Mr G. Ferenczy (NATO C3 Staff)

Maj. Gen. A. Gronheim (Co-Vice Chairman of the Board, NATO Military Staff), Maj. Gen. Pirou (Chief of Operations and Coordination, RTA HQ, who was also attending his first meeting), Mrs Diedrichsen, Mr L. D. Diedrichsen (General Manager, NATO C3 Agency), Gen J.R. Dailey (US), Radm J.L. Spoelstra (Director of Saclantcen), Brig Gen. J. Brown (SHAPE), Mrs Pirou, Dr L. J. Leggat (Canada), Dr E. Alnaes (Norway)





Mr W. I. McFarlane (UK), Mrs McFarlane, Dr Keith Gardner (Chief of Technology Studies and Cooperation, RTA, Brussels), Dr T. Lefeuvre (Canada), Mrs Van der Voorde, Prof M. H. Van der Voorde (Netherlands), Mr J. C. Mabberley (UK), Dr T. Stathopoulos (Greece)



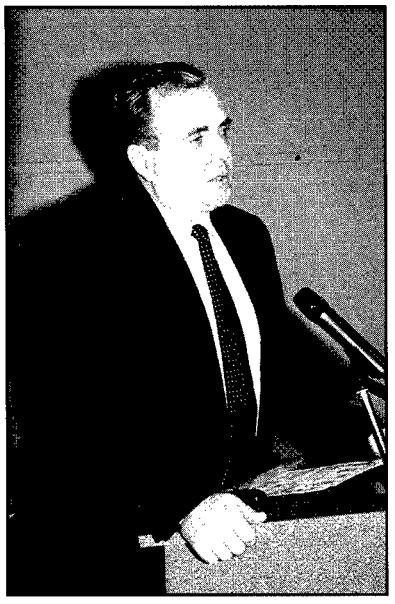
Admiral and Mrs V. Ascoli of Italy with the Chairman of the Board

Mrs Jeppesen, Professor P. Jeppesen of Denmark, and Mrs Stevins, wife of Col Stevins of Belgium

Mrs Jolly van Hoek with the Chairman

The Director with his Secretary, Mrs Heather Laget, who made most of the detailed arrangements for the meeting, and can relax now that it is nearly over

Farewells



Two people received certificates because they were leaving the Board: Mr G.T. Singley III, Principal Board Member from the US (shown making a short farewell speech) and Maj. Gen. K. Jessen, Surgeon General of Denmark, who had been an AGARD National Delegate for many years, having previously been the AMP Chairman. Col IMM G. Stevins of Belgium also received a certificate although he was not leaving. He had previously been the National Coordinator but had recently been appointed a Board Member.

Time Off

Some of the RTO Panels, and a Committee, at meetings in Fall 1997 or Spring 1998
(NB for reasons of space, one similar photograph has been included at the back in "This Really is the End")

The Applied Vehicle Technology Panel (AVT) at its '0th' meeting* in Koblenz, Germany, December 1997

The Information Systems Technology Panel (IST) at its '0th' meeting* in Malvern, UK, January 1998

*The '0th' meetings were preliminary meetings of the Panels prior to their first true meetings in Spring 1998.

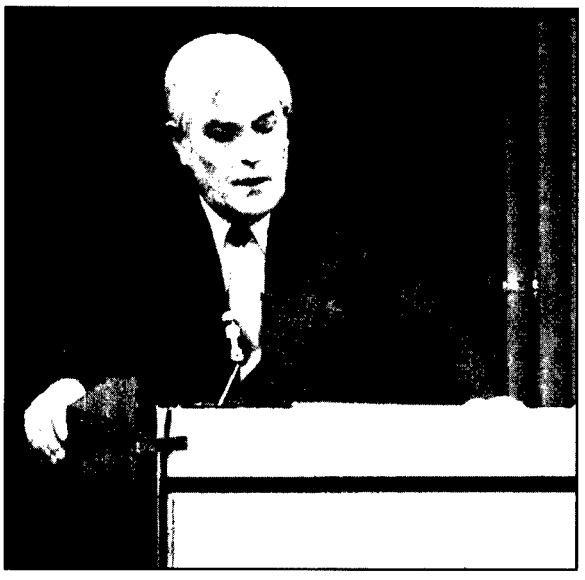
The Systems Concepts and Integration Panel (SCI), and participants in its symposium in Mannheim, Germany, Spring 1998

The Information Management Committee (IMC), formerly Technical Information Committee, in Trondheim, Norway, Spring 1998 (the cannon is aimed directly at the site where part of the meeting took place)

Twenty Years Ago

(Extracts from AGARD Highlights 78/1 and 78/2)

The 1977 AGARD Annual Meeting was held in Copenhagen, Denmark, and the participants were welcomed by the Danish Minister of National Defence, at that time, The Honourable Orla Møller, who pointed out that it was AGARD's Silver Jubilee - 25 years of existence. The main part of his address referred to the continuing great discrepancy between the Soviet Union, which spent an estimated 11-13% of its gross national product on defence, with an annual increase in real terms of about 5%, and the NATO countries which spent about one third as much, with little or no annual increase. He drew the conclusion that there was a need for greatly increased cooperation between the NATO nations, and challenged AGARD to determine how cooperation could be improved in the aerospace field. In his Foreword, the Director, Dr Robert Korkegi, referred to "today's 'belt-tightening' atmosphere", and stressed the importance of cost-effectiveness and life-cycle costs of systems. A short retrospective article described how AGARD had played a prominent role in the setting up of a Danish defence operations research function, both by organising a conference in NATO HQ in 1957 and then in Copenhagen in 1958, at the specific request of Denmark, and by supplying consultants through the Consultant and Exchange Programme. The Director, and the Chairman of the Military Committee, General Zeiner Gundersen, both referred to Project 2000 which had been requested by the Military Committee to assess potential advances in aerospace technology up to the end of the century and their possible military applications (a sort of forerunner to Aerospace 2020), which was then at the half-way stage. A report on the activities of the Flight Mechanics Panel was given by the Chairman, Dr Irving Statler, who later became Director of AGARD - from 1985 to 1988.



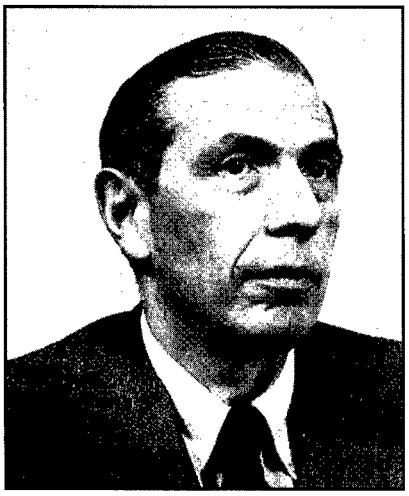
The Honourable Orla Møller

General Gundersen

Dr Korkegi

Dr Statler

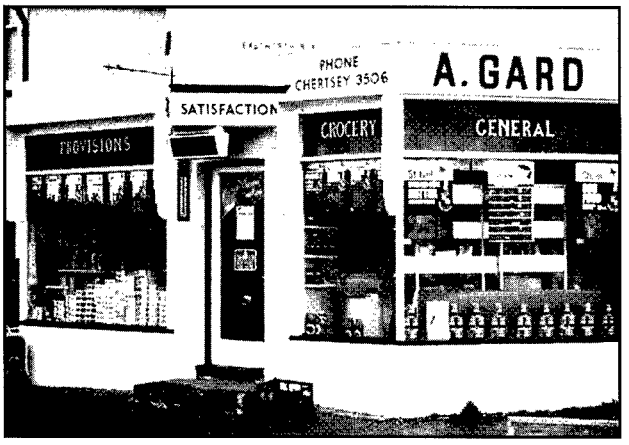
At the Spring 1978 meeting, von Kármán medals were awarded to Dr Alexander Flax of the US and Professor Teunis van Oosterom of The Netherlands; and Dr Hans J. Albrecht of Germany, Chairman of the Electromagnetic Wave Propagation Panel of AGARD, gave a description of that Panel's work.



Dr Flax

Professor van Oosterom

Dr Albrecht



Two 'branch offices' of AGARD photographed in 1978. The Danish one was apparently intended to give people better vision and the British one claimed to give satisfaction, both hoped-for attributes from AGARD, and indeed RTO.

The editor would welcome photographs, originals or photocopies of other uses of RTB, RTO, RTA or the abbreviations of Panel or Committee names (AVT, HFM, IMC, IST, SAS, SCI, SET), for use in a future issue of RTO Highlights.

Obituary - Frank Thurston

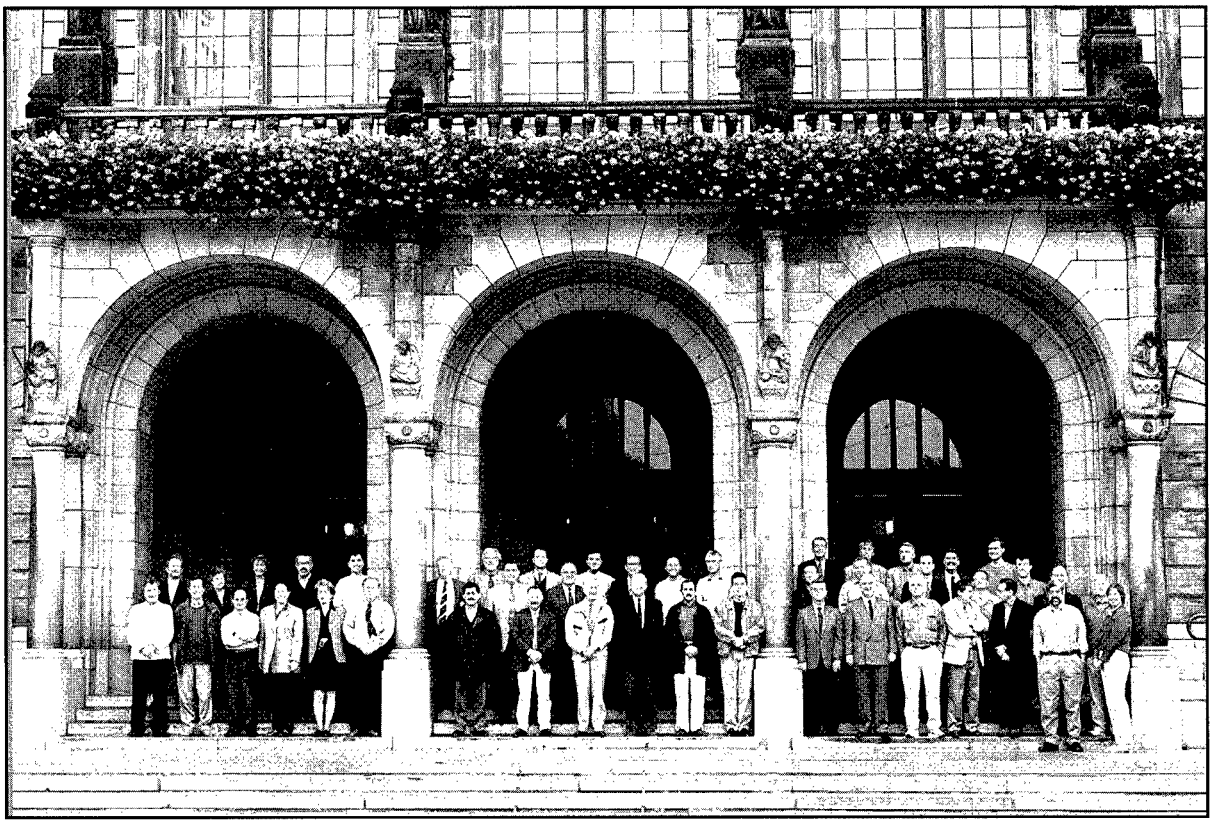
We are sorry to say that another link with the past was broken when Mr Thurston died on 9 April 1998. He was one of the founding members of AGARD and a National Delegate for Canada for 21 years, from 1960 to 1981, and Chairman of AGARD from 1976 to 1979.

Frank Russel Thurston was born in Chicago, Illinois and was educated at the University of London, where he took a Bachelor's degree in Physics in 1940. Until 1947 he was a scientist at the British National Physical Laboratory. He then joined the Division of Mechanical Engineering of the Canadian National Research Council, and was appointed Director of the National Aeronautical Establishment in 1959. He was the author of numerous publications on the theory of structures, fatigue of materials and structures, and aerodynamics, and was awarded the von Kármán Medal in 1980.

The citation for his von Kármán Medal was:

MR FRANK THURSTON (Canada) has been associated with AGARD since its early days both as a member of the Fluid Dynamics Panel and of the Structures and Materials Panel. Deputy Chairman in 1955 and Chairman of the Structures and Materials Panel from 1957 to 1960, he played a leading role in the rapid and efficient growth of the Panel. Thanks to his able guidance and diplomacy he established a unique method of working, using a number of sub-groups and sub-committees. This pattern has since been adopted by other Panels. As Canadian National Delegate from 1960, he contributed to the efficiency of the Board's achievements. Appointed AGARD Chairman in 1976, he conducted the work of the Board with great enthusiasm and perspicacity, and was instrumental in setting up the initial paths for Project 2000. Since 1976 Frank Thurston has shown great interest in directing AGARD efforts to assisting the smaller nations. Mr Thurston enjoys an international reputation in Canada as Director of the National Aeronautical Establishment, NRC, a post he held from 1959 to 1979, and as a Director of the Canadian National Research Council. He is the author of numerous publications on the theory of structures and on aerodynamics.

This Really is the End



Fall 1997 really was the end of AGARD Panel meetings. The only photograph we have of these last meetings is of the Aerospace Medical Panel in Rotterdam.

This photograph appeared on the front cover of the French weekly aerospace magazine, 'Air & Cosmos', issue No 1607, 4 April 1997. It shows the preparations for a test flight of a Mirage 2000 being undertaken by Lt Colonel Bruno Berthaud, of the French Air Force who later became Executive of the IST Panel of RTO. He has now left the Air Force, but hopes to continue flying in the civil sector.

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