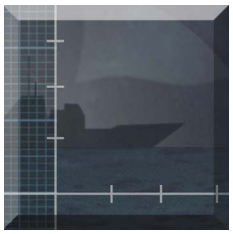

Sea Test Planning and Execution

William L. Harris and Gary S. Keys

The National Security Technology Department has conducted at-sea testing for U.S. Navy programs for the past 25 years. The planning and execution of at-sea tests is complex and usually begins at least 1 year before the actual test period. These tests have involved measurements of surface and subsurface parameters of the ocean in support of acoustic and nonacoustic projects as well as the development of acoustic and nonacoustic sensor systems. This article discusses how a test is designed and conducted, beginning with a description of an ocean acoustics test as an example.

RECENT SEA TEST

The National Security Technology Department (NSTD) conducted a sea test in February 2002 in support of Acoustic Research, Development, Test, and Evaluation (RDT&E) programs sponsored by the U.S. Navy and the Defense Advanced Research Projects Agency (DARPA). NSTD was the lead technical agent for the test, which included participation from Navy laboratories, university laboratories, commercial contractors, and multiple Navy commands. The test had two phases, with Phase I supporting the Navy program and Phase II the DARPA program. It was conducted over a 30-day period in operations areas in the Gulf of Mexico and the Straits of Florida.

The test configuration, as shown in Fig. 1, consisted of two research vessels (R/Vs), a Navy SSN submarine, a Navy P-3C military patrol aircraft, and data processing support in NSTD facilities at APL. R/V *Knorr* was outfitted with an advanced acoustic array being developed by NSTD for the Navy. Also on *Knorr* were data acquisition systems as well as real-time processing and modeling systems to support the acoustic array operations. In addition to the acoustic array support, environmental measurements were made to support the analysis of the acoustic data. Conductivity, temperature, and subsurface current measurements were taken of the water column using conductivity, temperature, and depth sensors and acoustic Doppler current profilers. Wind speed and direction, along with sea state and wave direction, were continuously recorded throughout the test.

Knorr was the command and control platform for conduct of the test. In support of this task, navigation and communications systems were installed along with the data acquisition systems to continuously record the radar contacts held by the ship's radar. The second R/V, *Acoustic Pioneer*, deployed a towed acoustic source system that was capable of transmitting multiple acoustic waveforms to support the performance evaluation of the acoustic array on *Knorr*. In addition, *Acoustic Pioneer* had environmental measurement capabilities similar to those of *Knorr* and navigation and communication systems to support test conduct.

The main purpose of the Navy submarine was to act as a controlled target to support data collection by the acoustic array on *Knorr*. The submarine had instrumentation to transmit known acoustic waveforms, record ownship's parameters, and record acoustic data from ownship's sonar systems. The P-3C served two functions in the test: (1) providing a large area survey of the water column in the operations area using airborne expendable bathythermograph (AXBT) probes, and (2) monitoring the surface ship traffic in the vicinity of the test operations area using airborne radar. The NSTD facilities provided weather forecasts and predictions of surface and subsurface currents in the operations area to support test conduct and data analysis.

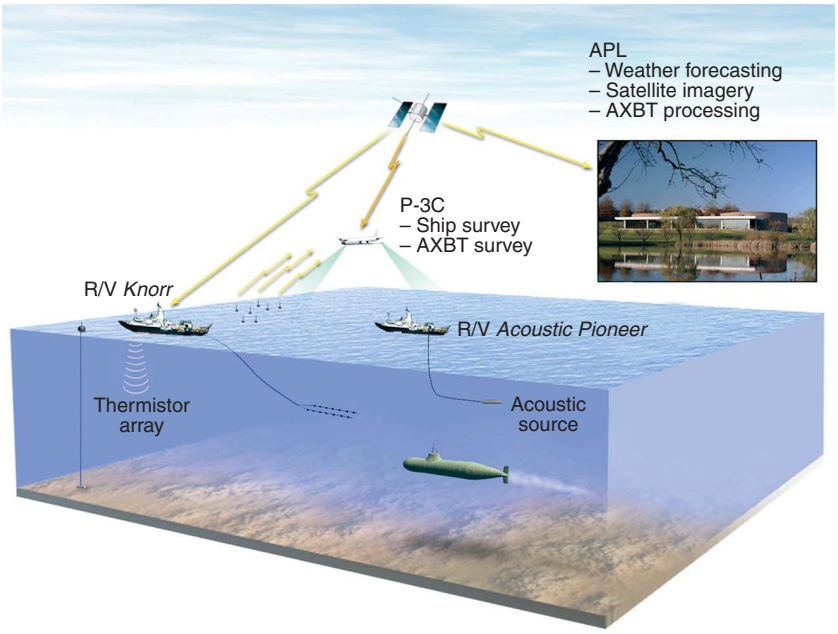

Figure 1. The configuration of a recent NSTD-led sea test.

During conduct of the test, engineering problems developed with the acoustic array on *Knorr,* making real-time reconfiguring of test scenarios by the science and operations teams necessary. On-site NSTD engineers were able to resolve the majority of problems, ensuring successful test measurements and data collection to support most test objectives.

The test described above is typical of most at-sea tests planned and conducted by NSTD. A test of this magnitude uses all the resources of the department and is executed by implementing organizational and planning procedures developed over the past 25 years. The following sections of this article describe these procedures.

PLANNING AND EXECUTION COMPONENTS

Overview

NSTD provides expertise to support the planning, coordination, and execution of experimental investigations. Three basic organizational elements are involved in this process:

- Test planning and coordination
- At-sea operations personnel
- Operational support

The sea test planning and execution element entails interfacing with sponsors and Navy commands, documentation development, and marine support. The degree of interface among sponsors, other government agencies, and/or Navy laboratories occurs relative to program/project requirements and goals. Navy command negotiations involve the translation of the established project requirements into a Fleet Request for Services that reflects the military platforms needed, the test location, and the desired time frame in which the test must occur. Documentation requirements often vary according to the level of complexity of the test. However, nominal requirements include an operations plan, a data management plan, an analysis plan, and an environmental measurements plan. Additional documents are briefing materials and a quick-look report.

The operations plan generally comprises a test description, which identifies the phenomenology involved, the test equipment to be used, and the rationale for time and location. Also included are operational procedures that identify how the test is to be conducted. The data management plan identifies data items that are to be collected on each platform. Generally, the listing is provided in order of highest to lowest priority, again relative to the project objectives. The analysis plan documents procedures, time frame, and various analysis approaches associated with each organization involved (if appropriate), and lists the assumptions and biases associated with any particular model that may be used. The environmental measurements plan details several environmental components. A review of historical data in the location of interest is produced that defines the pre- and post-test surveys so that oceanographic and meteorological characterization of the operations area can be determined. In addition, it defines the measurements that will be used during the actual test and during post-test analysis. Planning also involves the identification of vessels appropriate for purposes of the test.

Operations personnel and operational support are also elements in test planning and coordination. Operations personnel are responsible for the conduct of the test and test-related activities onboard each platform. The operational support element covers the development of test geometries for submarine or other platforms, track reconstruction, all navigation and communication activities between platforms and test facilities, and any special instrumentation requirements.

The following sections discuss the three basic elements of sea-test planning and execution in more detail.

Test Planning and Coordination

The test planning and coordination element includes details such as requirements, Fleet assets and R/Vs, and test documentation.

Test Requirements

Defining the test requirements, as depicted in Fig. 2, is an iterative process requiring multiple inputs that then define the test design. The process commences with the goals and objectives of the project that are translated into test objectives. It may not be feasible to design one test to meet all project test objectives, so they are prioritized and matched to the test budget. Once the test objectives are derived, the test measurements required to meet those objectives can be defined. The required test measurements are then iterated by considering the funding available and the existence of systems that can make the measurements versus the necessity to develop new systems.

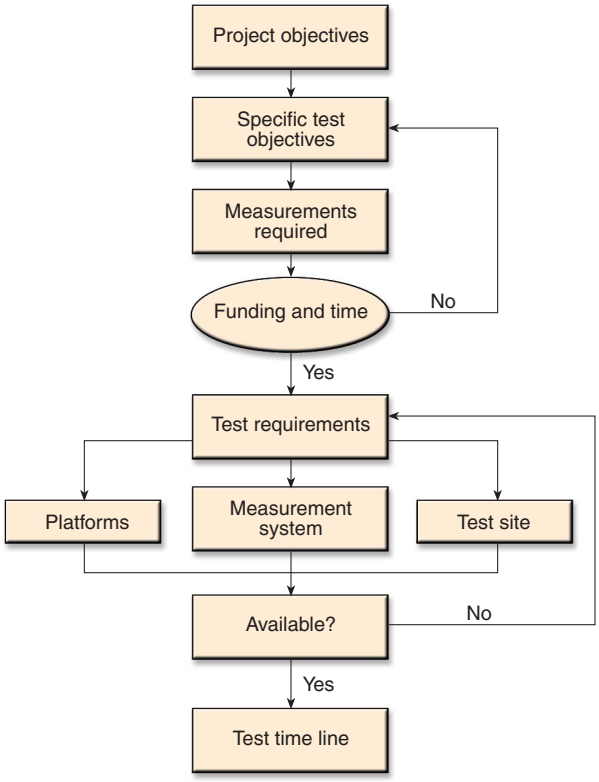

Figure 2. Test requirements flowchart.

The initial results of this process are folded into the prioritized list of test objectives to achieve a final list of measurements that can be supported in the test scenario. From the aforementioned inputs to this process, a list of the measurement systems required to support the test objectives is compiled. Again, cost is factored in with these objectives to define the measurement systems for the test. The required measurement systems and the test objectives then define the test platforms needed for the test. Cost, availability, and suitability of test platforms are then considered before the final selection is made.

Identifying the test site is usually driven by the test objectives and measurements. Factors that define test sites include oceanographic and atmospheric conditions and the logistics of getting test platforms to the site. Several sites may be selected initially based on suitability to support the test measurements, after which the final site is selected based on funding and logistics.

The final requirement to be defined is the test time line, which is driven by two factors: time of year and test duration. The time of year a test is conducted is based on the environmental conditions required and the time required to prepare for the test after funding is secured. Duration is determined by the amount of on-station time needed to make the measurements to meet the test objectives. The duration is a compromise between the funding available and meeting the test objectives. If a specific time of year is required to support measurements, then the planning may encompass multiple years, with initial planning in the first year and conduct of the test in the second year.

This process may take several months before the test requirements are defined and the detailed test planning can commence.

Fleet Assets and Research Vessels

Typically, test platforms supporting NSTD sea tests are a combination of Navy assets and commercial ships. Navy assets are scheduled by initiating a request to the Chief of Naval Operations (CNO) program office funding the test project to establish an RDT&E Test Identification Number (TEIN). If the test project is on a critical path, along with the request for the TEIN, the request and justification to have the project assigned a Priority One status is included. Priority One indicates to the Fleet the importance of the measurement project.

Once the TEIN has been assigned, the request for Navy assets to participate in the test is accomplished by submitting the requirements to the Commander, Atlantic and/or Pacific Fleet. This is a formalized process that

starts with NSTD defining the support requirements and producing a formal document that is sent to the program sponsor's office, usually 9 to 12 months prior to the test, for endorsement and forwarding to the CNO office that compiles the requests. The request is then sent to the appropriate Fleet for inclusion in a quarterly scheduling conference for the requested time period.

After assets have been assigned by the Fleet, NSTD is authorized to begin test coordination with the Type Commander (TYCOM) or appropriate naval command. For example, with an Atlantic Coast–based submarine, NSTD coordinates test planning with the Commander Submarine Force Atlantic, Submarine Group, and Squadron controlling the submarine.

If the submarine supporting the test requires installation of special equipment supplied by the project, a Temporary Alteration (TEMPALT) Request must be submitted to the Navy. This process consists of the project producing an engineering package describing the electrical and mechanical characteristics of the system to be installed and subsequent review by Navy commands (i.e., Naval Sea System Command, TYCOM, Submarine Group and Squadron). The procedure should be initiated 6 to 7 months prior to the test period. Similar procedures and time lines apply to installation of equipment on Navy surface ships and aircraft.

For commercial assets (usually ships), NSTD personnel compile the test requirements for the vessel and do a survey of ships available in the vicinity of the designated test site. Once the list is completed, the specifications of each ship are compared to the test requirements and several candidate ships are selected. For the final selection, on-site checks are conducted to determine the suitability of the ship to meet the test requirements. After the ship has been selected, coordination with the organization controlling the ship begins and a contract for services is initiated. NSTD maintains coordination with the vendor throughout the duration of the charter.

Test Documentation

Two documents are produced during the test planning process: the Test Description Document and the Test Operations Plan. The intent of the Test Description Document is to provide an overview of the planned test and give participating organizations the information necessary to plan the test in detail. Information contained in this document includes project description, test objectives, technical issues, proposed measurements, test instrumentation, test platforms, schedules, and proposed test scenarios. The Test Description Document is produced 3 to 6 months before the Test Operations Plan.

The Test Operations Plan contains all the details necessary to describe and conduct the test. The areas addressed in the Test Description Document are expanded and included in this document. In addition, there are detailed test ship track geometries, instructions, and time lines for all test platforms; security guidelines; and data analysis, data management, and environmental pre-assessment plans. All operational requirements for Navy assets are described in the Test Operations Plan and must be approved by the Fleet commanders prior to the conduct of the exercise.

The writing of the Test Description Document and Test Operations Plan is coordinated by the test director and test scientist. Members of the NSTD test team, together with test participants from outside organizations, contribute information to both documents. The department produces them in two stages, draft and final. Internal reviews are conducted by the test team, and the documents are then submitted to the sponsor for review and approval prior to distribution to all organizations involved in the test. The draft Test Operations Plan is normally distributed 60 days before the test so that all participants can review it and submit comments to be included in the final document. The final Test Operations Plan, as required by Navy commands, must be submitted for approval 30 days before commencing the test.

Start to Finish

A time line summary of the various generic components that are usually considered when setting up a typical field test is provided in Table 1.

At-Sea Operations Personnel

The configuration of the at-sea operations test team is shown in Fig. 3. It comprises four areas of responsibility: test operations (white), science planning (tan), environmental characterization (blue), and engineering (green). The lead in each group is appointed by the NSTD Department Head upon recommendation of the program and project leaders responsible for conducting the test, with the concurrence of the respective group supervisors. The lead person in each group works with the project manager to establish the test program.

Test Operations

This area is the responsibility of the test director, who staffs the following positions:

- Test administrator
- Data manager
- Marine coordinator
- Navigation/communication coordinator
- Test platform coordinators

The test director and staff are responsible for test planning and test conduct. Tasks involved in planning include coordination of test requirements from the science planning, environmental characterization, engineering, and other organizations (both commercial

Table 1. Test planning time line.

Month	Outside agency event	In-house event
12	Fleet Request for Services draft submitted to sponsor (including all Fleet assets)	Test team established Test requirements defined
11	Fleet Request for Services submitted to sponsor for approval Priority assigned	Test Description Document begun
8	Fleet Request for Services received by Navy (6 months prior to beginning of quarterly scheduling conference)	PDR begun
7	Candidate submarine checks conducted TEMPALT Request initiated	Test Operations Plan initiated
5	TEMPALT submitted to NAVSEA	
4	TEMPALT approved (received 60 days prior to install)	CDR/TAT Review done
3		Test Operations Plan draft reviewed (in-house and by sponsor)
2	Test Operations Plan draft to TYCOM (60 days prior to commencement of exercise) Submarine installation performed	Test Operations Plan revised
1	Test Operations Plan approved by TYCOM Pre-sail brief given on all vessels (approved documents must be onboard 10 days prior to sailing)	Test Operations Plan finalized
0	Exercise operations conducted	Data analysis performed
Post-test		Quick-look, data analysis, and test reports prepared

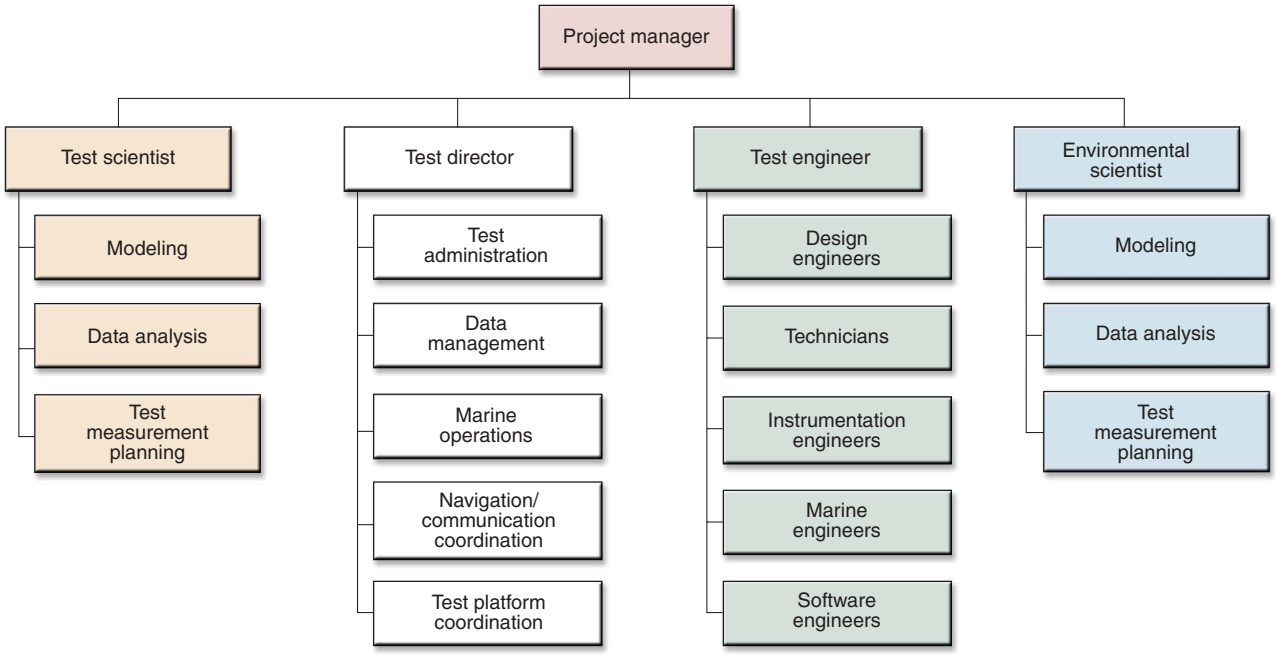

Figure 3. Test team organization.

and military) to develop the required test documentation to support the conduct of the test. During the test, the test operations team coordinates the operation of test platforms to ensure that the test is being executed as planned.

Science Planning

The test scientist and staff are responsible for

- Modeling
- Data analysis
- Test measurement planning

The science planning team coordinates all measurement requests from both NSTD and outside organizations and ensures that the test is designed to meet the project test objectives. During the test, the team provides quality control for test measurements/data collection and responds accordingly to changes to ensure that the test objectives are met.

Environmental Characterization

The environmental scientist and staff are responsible for

- Oceanographic and atmospheric modeling
- Data analysis
- Test measurement planning

This team provides the science planning team with an environmental characterization of potential test sites, including both oceanographic and atmospheric modeling. During test operations, the team is responsible for conducting measurements and providing real-time analysis of the data.

Engineering

The test engineer's team includes

- Electrical and mechanical design engineers
- Electrical and mechanical technicians
- Instrumentation engineers
- Marine engineers
- Software engineers

This team designs unique instrumentation and systems to enable test measurements and provides engineering support for standard instrumentation fielded for most sea tests. Test platform (ships, submarines, and aircraft) and deck and internal instrumentation space layout is also the responsibility of this team. In addtion, they install, operate, and maintain the mechanical and electrical systems throughout the test.

Operational Support

The operational support element includes safeguard considerations imposed through the implementation of the review process, the decision point process (designed within the overall schedule), briefings that are required prior to commencing the exercise, environmental compliance issues (which can involve several state and federal agencies), engineering and fabrication, and post-test support.

Review Process

To ensure a high level of quality control for the testing process, a multilevel review process is held both internal and external to NSTD. As indicated in Table 1, the planning process generally is initiated approximately 1 year prior to the actual test date. However, about 4 months prior to test commencement, an internal Critical Design Review (CDR) and/or Technical Advisory Team (TAT) Review is held.

The TATs, with focused technical disciplines consistent with the department's work, are maintained to provide expert advisory and review functions for ongoing work. Their reviews are designed to enhance the quality of the technical products by executing in-progress project work reviews to ensure responsiveness to sponsor requirements, test and equipment design quality, and cost/schedule efficiency. The TAT discipline areas include

- Acoustics and electromagnetics
- At-sea testing and Fleet operations
- Electromechanical hardware and firmware
- Hydrodynamics and the environment

The TATs function as a team of peer reviewers. They assist program/project development efforts by providing concept reviews and guidance in a variety of areas. They also serve as a means to solicit information, ideas, comments, and constructive criticism based on their experience and good engineering practices.

Approximately 3 months prior to the beginning of the test period, internal and sponsor-level reviews of the draft Test Operations Plan are held. The draft is then submitted to TYCOM for approval.

Decision Point Process

As previously mentioned, the planning of a sea test nominally has a lengthy lead time. Typically, several possible decision points are designed within the overall schedule. Engineering check-out tests may be required approximately 1 year in advance of the primary test to assess the state of readiness of the instrumentation and its various components as well as test procedures such as instrument deployment and recovery. In addition, planned project Preliminary Design Reviews (PDRs) and CDR are held to allow the scientific community to offer constructive criticism on various equipment and/or system designs as the project develops.

Briefings

Briefings are an integral part of the preparation process of field testing. They are prepared and given by the various members of the test team, which could include

program or project managers or the test director and test scientist. Briefings generally occur anywhere from 1 to 12 months prior to exercise commencement (Table 1). Typically, they are held within the continental United States, but can also be held worldwide. Required commands that are included in the briefings are the type, theater, group, squadron, and assets that have been designated as participants.

Pre-Sail Briefings

Pre-sail briefings are done to ensure that all participants have a complete understanding of all operational requirements and procedures as provided within the Test Operations Plan. These briefings are usually prepared and given by the test director, test scientist, or unit coordinators. They are typically held onboard the platform or within the unit's command facility. Officers and crew representatives are the usual attendees. This briefing is nominally given within 2 weeks of the vessel's departure.

Environmental Compliance

At-sea testing using acoustic sources often involves the cognizance of the Navy's Office of Environmental Readiness (CNO-N45) as well as local, state, or federal agencies. All testing activities within U.S. territorial waters must comply with the National Environmental Policy Act (NEPA); complex open ocean field tests must be in compliance with Executive Order 12114. Strong concerns govern how endangered and threatened animal species might be affected during actual implementation or after the test. NEPA requires the preparation of a document to assess the potential impact of test activities. The environmental assessment may contain accepted measures to mitigate the potential impact. Generally the Navy will mandate termination of all testing activities should certain species of endangered or threatened marine life be seen within specific ranges to components of the exercise.

Engineering and Fabrication

The engineering required to support sea tests falls into the following categories:

- Special system development
- Instrumentation preparation and deployment
- Test platform mobilization

Special system development involves the design of specialized sensors and measurement systems to support test requirements. This development can be engineered and fabricated by NSTD personnel using APL facilities, or NSTD can contract to an external organization, with oversight by the department's engineering staff. These engineers also are involved in systems being developed by other organizations participating in the test program.

Instrumentation preparation and deployment includes the test and calibration of all NSTD systems used for data collection during the test. Also involved in this effort is the design and fabrication of any special deployment hardware required for installations on the test platforms.

As noted earlier, test platform mobilization engineering involves the layout of test platforms for installing equipment on the deck of ships and instrumentation internal to the ship. In addition, this area supports special installations on Navy surface combatants, submarines, aircraft, and helicopters. The preparation of test platforms for a sea test requires coordination between NSTD engineers and multiple contractor organizations. Figure 4 shows a recent installation on a chartered R/V.

Post-Test Support

Post-test support considers items designed to take full advantage of the data management process such as test log definitions, online or offline processing on each platform, backup procedures of all intermediate and final data products, and data distribution. Additional considerations include the interpretative process concerned with the general data analysis process

Figure 4. An example of R/V installation showing APL-developed equipment.

and the consideration of test geometries through track reconstruction. Quick-look briefing reports are typically generated within a few weeks of exercise completion, followed by command and asset briefings based on sponsor direction.

CONCLUSION

As indicated in this article, NSTD has planned and conducted at-sea testing in support of a variety of Navy and DoD programs. These tests have involved measurements of ocean surface and subsurface parameters and the use of Navy platforms in support of a variety of phenomenology such as acoustic and nonacoustic projects. Although the planning and conducting of open ocean tests is typically a complex process, the description provided here is usually of the procedures used by the department that have proven so successful throughout the past 25 years.

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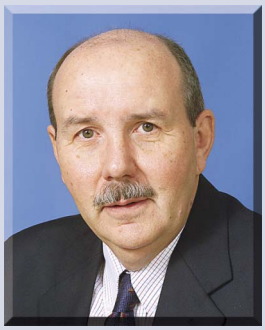

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